2018 PICES annual meeting 2018.11.01

Climate variability with impacts on habitat suitability of chub mackerel *Scomber japonicus* in the East China Sea

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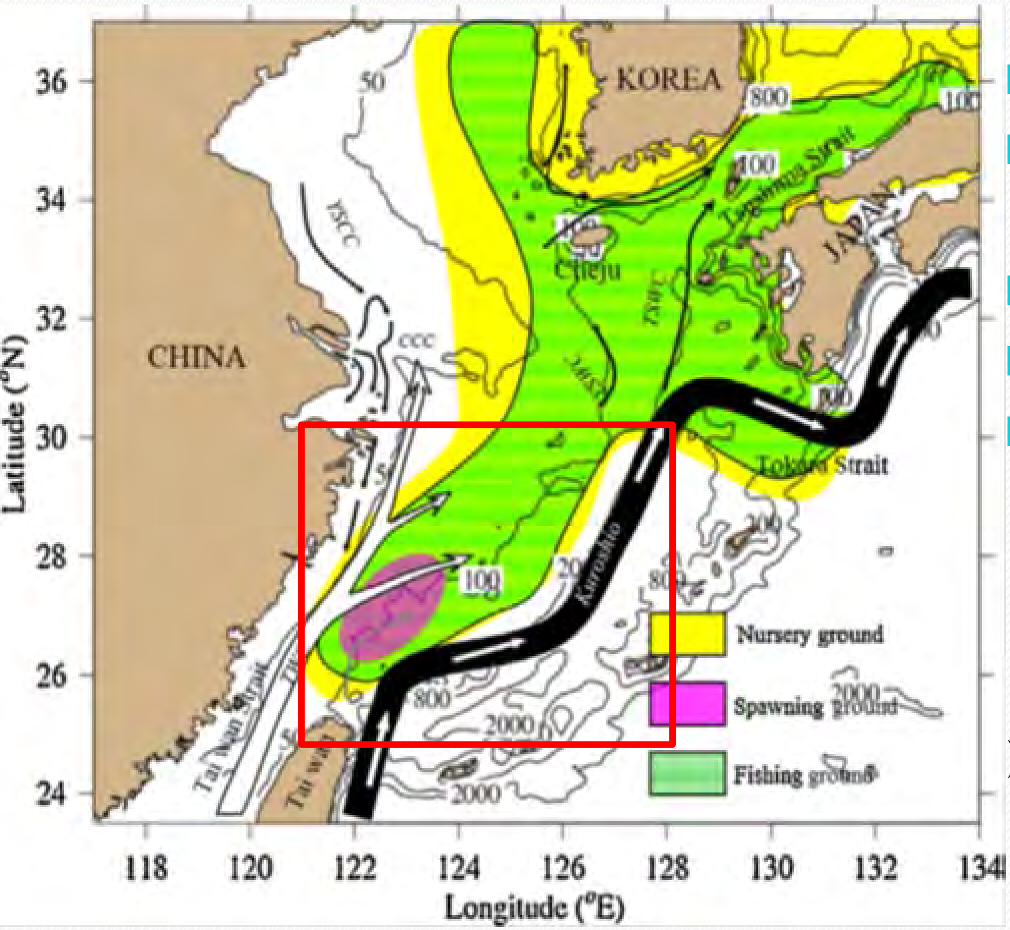
Outline

1. Background

2. Results

3. Summary

Research background



Distribution of nursery, spawning and fishing ground for Tsushima Current chub mackerel stock

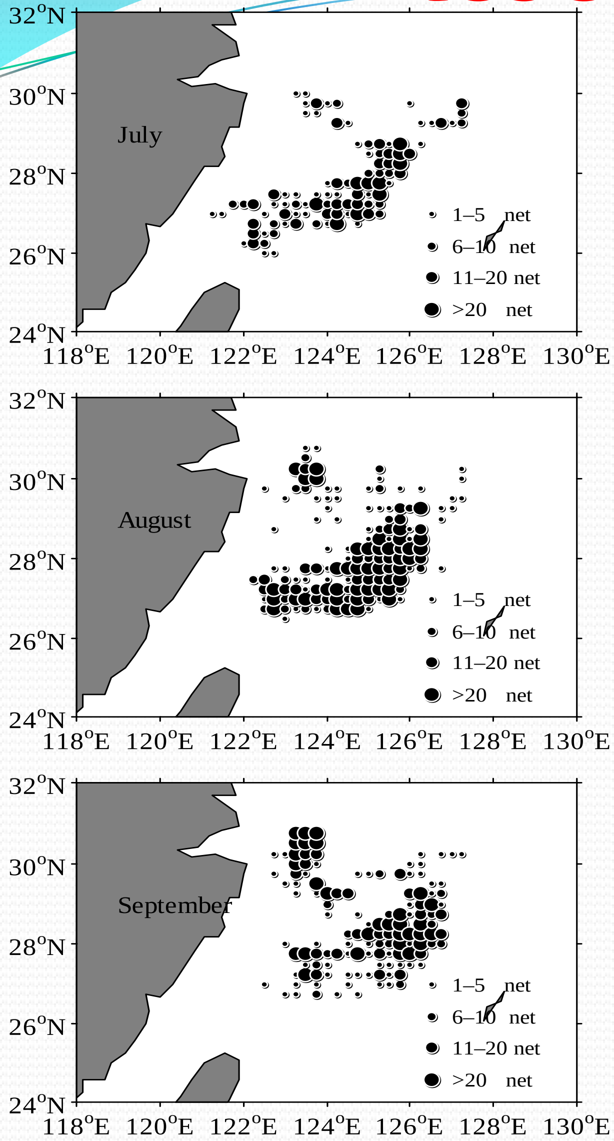
Scomber japonicus

- Coastal-pelagic fish species
- Two stocks: Pacific stock and Tsushima Current stock
- Economically important species
- South-to-north migration
- Subject to complicated environmental changes (ENSO, SST, NPP, SSH, etc.)

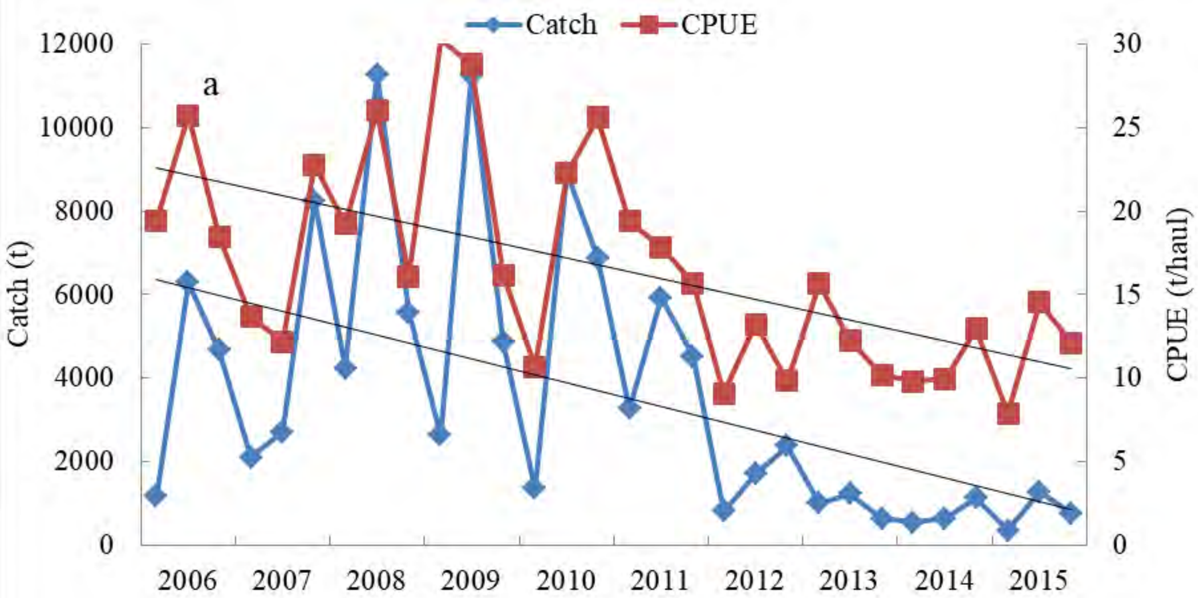
Chinese chub mackerel fishery

- Targeted Tsushima Current stock in the East China Sea by lighting purse seine fishery;
- Fishing ground: 25°-30°N and 120°-130°E from July to September;

Research background



Spatial patterns of fishing effort for the Chinese chub mackerel fishery from July to September during 2006-2015



The catch and CPUE of *Scomber japonicus* from July to September in the coastal waters of China during 2006-2015

Objectives

- Quantify the relationship between the spatial distribution of chub mackerel and environmental variables;
- Evaluate the CPUE and LATG variations in relation to variations in habitat suitability of chub mackerel;
- Understand how the climate variability affects habitat suitability of chub mackerel;

Materials

Fisheries data

Fishing date (year and month);
Fishing location (latitude and longitude);
Catch (unit: tons);
Fishing effort (nets-haul number);
CPUE (t/haul);

Environmental data

SST: NOAA OISST V2

SSH: AVISO

NPP: VGPM Model

Climatic index

The El Niño and La Niña events was defined by the Niño 3.4 SSTA
The intensity for each anomalous climatic event was categorized as weak, moderate, strong or very strong (http://ggweather.com/enso/oni.htm).

Methods

Climate variability

Definition of the El Niño and La Niña events （2006-2015）

Niño 3.4 SSTA
[5°N−5°S, 120°−170°W]

Above or below a threshold of +0.5°C and -0.5°C over at

Definition of the intensity for each anomalous events

0.5≤ONI≤0.9, weak El Niño;
1.0≤ONI≤1.4, moderate El Niño;
1.5≤ONI≤1.9, strong El Niño ;
ONI≥2.0, very strong El Niño;
-0.9≤ONI≤-0.5, weak La Niña ;
-1.4≤ONI≤-1.0, moderate La Niña;

Scenarios	W_{SST}	W_{SSH}	W_{NPP}
Case 1	0	1	0
Case 2	0	0	1
Case 3	0.1	0.8	0.1
Case 4	0.1	0.1	0.8
Case 5	0.25	0.5	0.25
Case 6	0.25	0.25	0.5
Case 7	0.333	0.333	0.333
Case 8	0.5	0.25	0.25
Case 9	0.8	0.1	0.1
Case 10	1	0	0

HSI model development

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SI≤0.2
: 0.2<HSI<0.6
t: HSI≥0.6
t: HSI≥0.8

ormance of
HSI model
e habitat
b mackerel

Environmental data (SST, SSH, NPP)

between fishing effort and environmental variables

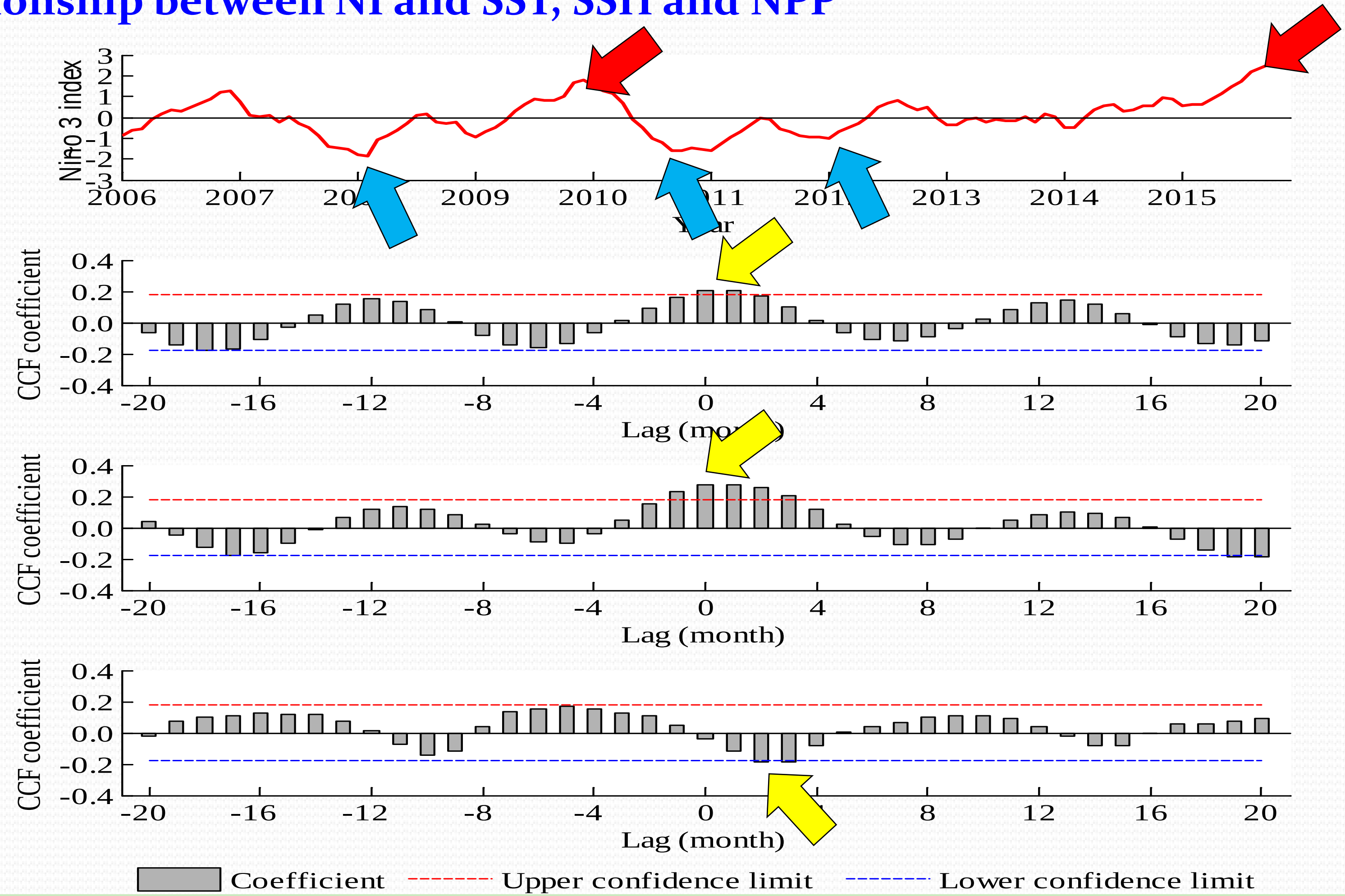
10 different weighting scenarios for SST, SSH and NPP

Habitat Suitability variation

1. Cross-correlation analysis between climate index and environmental conditions on the fishing ground;
2. Interannual variability of catch, CPUE, LATG and habitat suitability;
3. Habitat suitability variations in relation to the El Niño and La Niña events;

Results

1. Relationship between NI and SST, SSH and NPP



(a) Innterannual variability in the Niño 3.4 index (NI) during 2006-2015. The cross-correlation (b) between sea surface temperature (SST) and NI, (c) between sea surface height (SSH) and NI, and (d) between net primary production (NPP) and NI. Red and blue lines indicated the upper and lower confidence limit at the 95% significant level, respectively.

Results

2. HSI model development and validation

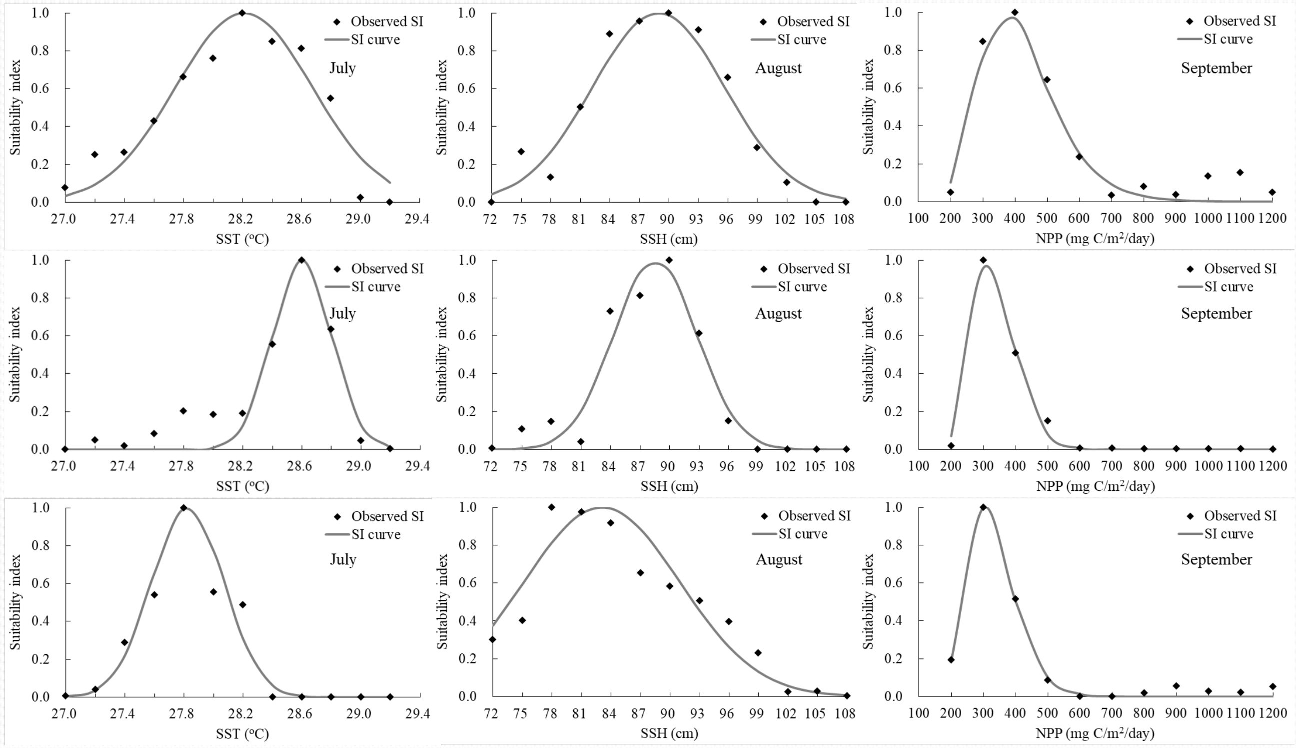


Figure: Fitted suitability index (SI) curves based on the relationship between fishing effort and each environmental variable including sea surface temperature (SST), sea surface height (SSH) and net primary production (NPP).

$$SI_{SST} = \exp\left[a \times (X_{SST} - b)^2\right]$$

$$SI_{SSH} = \exp\left[a \times (X_{SSH} - b)^2\right]$$

$$SI_{NPP} = \exp\left[a \times (\mathrm{Ln}(X_{NPP} / b))^2\right]$$

Table: Monthly fitted suitability index (SI) curve of each environmental variable for *Scomber japonicus* in the East China Sea. a and b were the estimated parameters of SI model. RMSE indicated the Root Mean Squared Error.

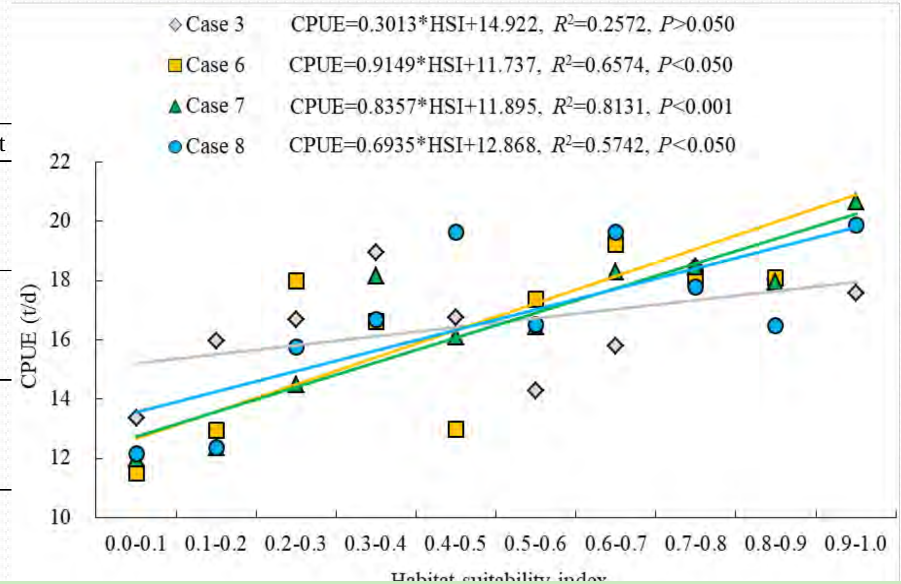
Month	SI model	a	b	RMSE	R^2	*P*
	SI_{SST}	−2.313	28.210	0.013	0.902	<0.001
July	SI_{SSH}	−0.011	88.939	0.007	0.959	<0.001
	SI_{NPP}	−5.946	371.763	0.008	0.949	<0.001
	SI_{SST}	−12.845	28.601	0.010	0.913	<0.001
August	SI_{SSH}	−0.028	88.544	0.009	0.937	<0.001
	SI_{NPP}	−12.282	318.071	0.001	0.991	<0.001
	SI_{SST}	−8.352	27.824	0.010	0.916	<0.001
September	SI_{SSH}	−0.008	83.055	0.016	0.881	<0.001
	SI_{NPP}	−9.321	305.110	0.001	0.992	<0.001

Results

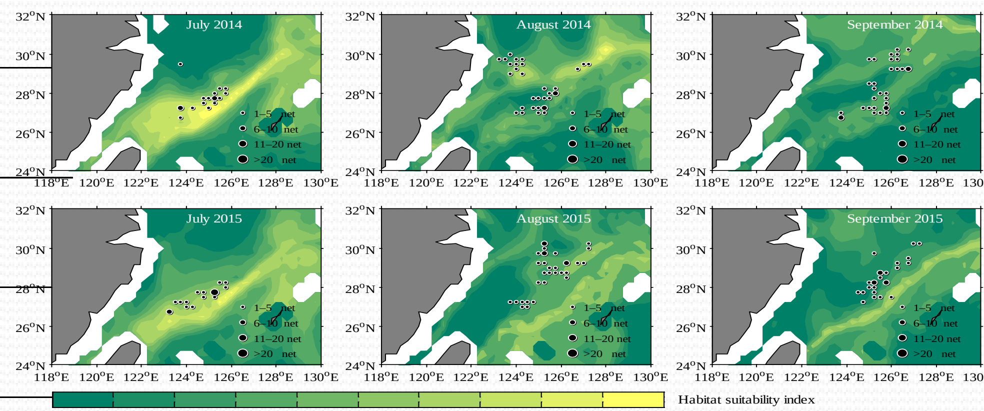
2. HSI model development and validation

The parameters used for each habitat suitability index (HSI) class interval correspond to frequency of catch and frequency of fishing effort under different weighting scenarios

Scenarios	HSI class interval	Frequency of catch	Frequency of fishing effort
Case 1	Poor habitat (0.0–0.2)	19.0	19.4
	Normal habitat (0.0–0.6)	24.5	25.3
	Suitable habitat (0.6–1.0)	56.5	55.3
Case 2	Poor habitat (0.0–0.2)	29.2	27.8
	Normal habitat (0.0–0.6)	24.9	23.3
	Suitable habitat (0.6–1.0)	45.9	48.9
Case 3	Poor habitat (0.0–0.2)	9.0	7.4
	Normal habitat (0.0–0.6)	32.7	34.7
	Suitable habitat (0.6–1.0)	58.3	58.0
Case 4	Poor habitat (0.0–0.2)	25.4	23.9
	Normal habitat (0.0–0.6)	26.4	25.4
	Suitable habitat (0.6–1.0)	48.2	50.8
Case 5	Poor habitat (0.0–0.2)	6.0	3.8
	Normal habitat (0.0–0.6)	47.9	50.3
	Suitable habitat (0.6–1.0)	46.1	45.9
Case 6	Poor habitat (0.0–0.2)	8.4	5.3
	Normal habitat (0.0–0.6)	40.8	41.8
	Suitable habitat (0.6–1.0)	50.8	52.9
Case 7	Poor habitat (0.0–0.2)	6.3	3.9
	Normal habitat (0.0–0.6)	43.4	44.5
	Suitable habitat (0.6–1.0)	50.3	51.6
Case 8	Poor habitat (0.0–0.2)	7.5	4.7
	Normal habitat (0.0–0.6)	43.4	43.7
	Suitable habitat (0.6–1.0)	49.1	51.7
Case 9	Poor habitat (0.0–0.2)	23.6	19.7
	Normal habitat (0.0–0.6)	29.3	33.1
	Suitable habitat (0.6–1.0)	47.1	47.2
Case 10	Poor habitat (0.0–0.2)	29.3	25.5
	Normal habitat (0.0–0.6)	23.5	24.3
	Suitable habitat (0.6–1.0)	47.2	50.2



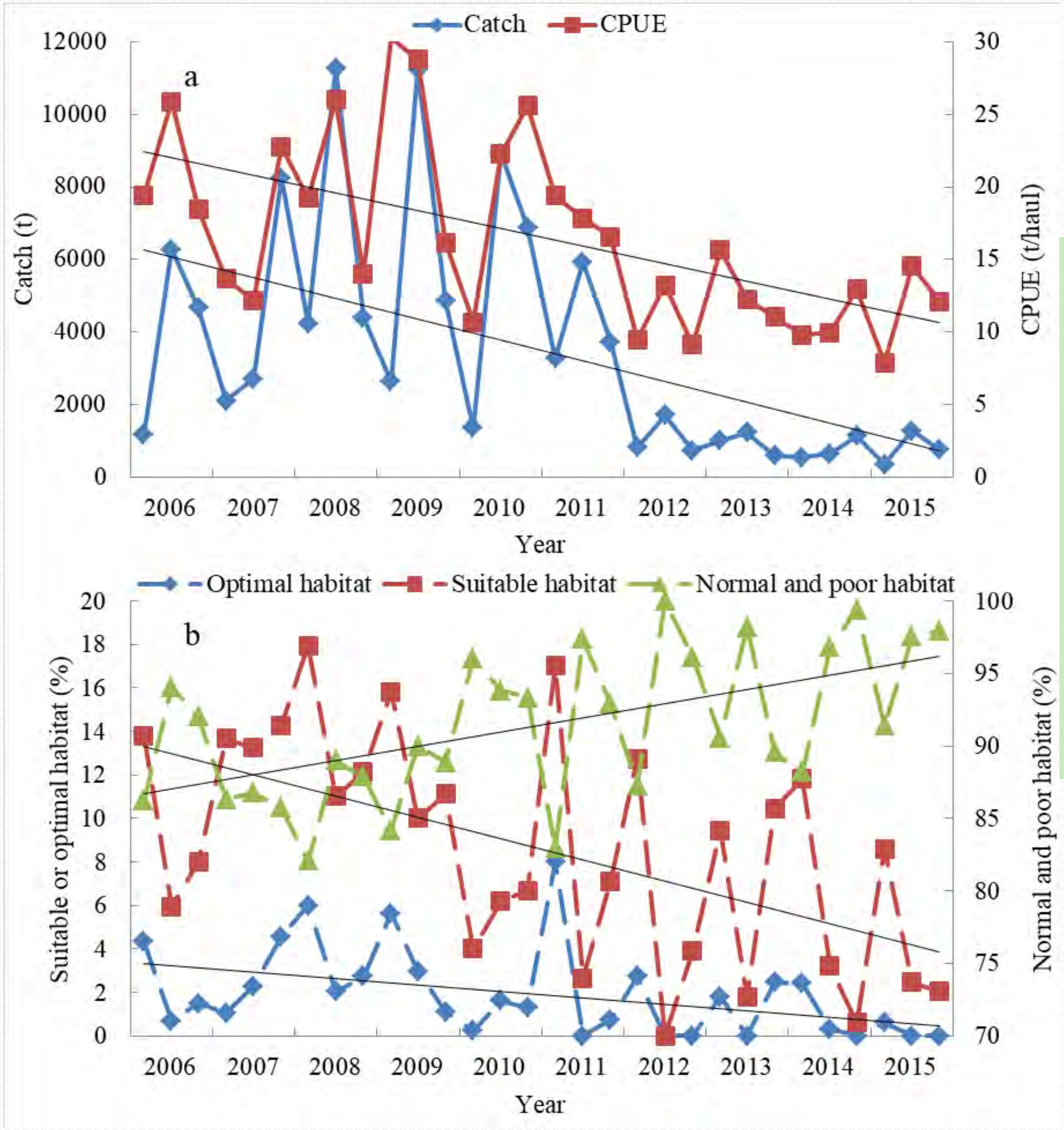
Linear relationship between different class intervals (0-1 interval) of habitat suitability index (HSI) and the mean catch per unit effort (CPUE) of *Scomber japonicas* in each HSI class interval derived from case 3, case 6, case 7 and case 8. Case 7 (0.333 0.333 0.333)



Mapping the predicted habitat suitability index (HSI) values in 2014 and 2015 on the fishing ground overlaid with fishing effort of *Scomber japonicus*.

Results

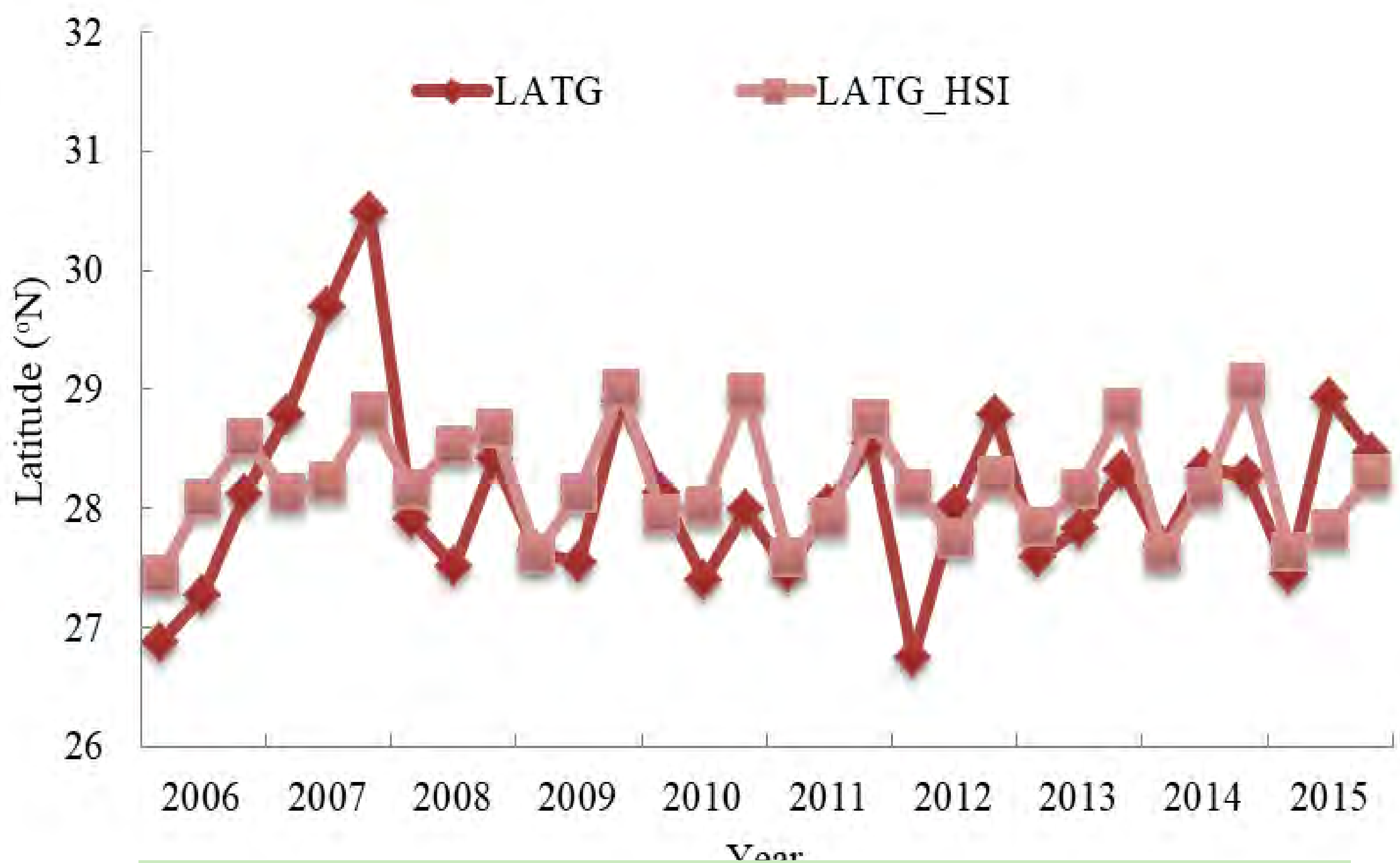
3. Interannual variability of catch, CPUE in relation to habitat suitability



The catch and catch per unit effort (CPUE) of *Scomber japonicus* from July to September in the coastal waters of China during 2006-2015 (Upper panel). The percentage of optimal habitat, suitable habitat, and normal and poor habitat of *Scomber japonicus* from July to September during 2006-2015 (Lower panel).

Results

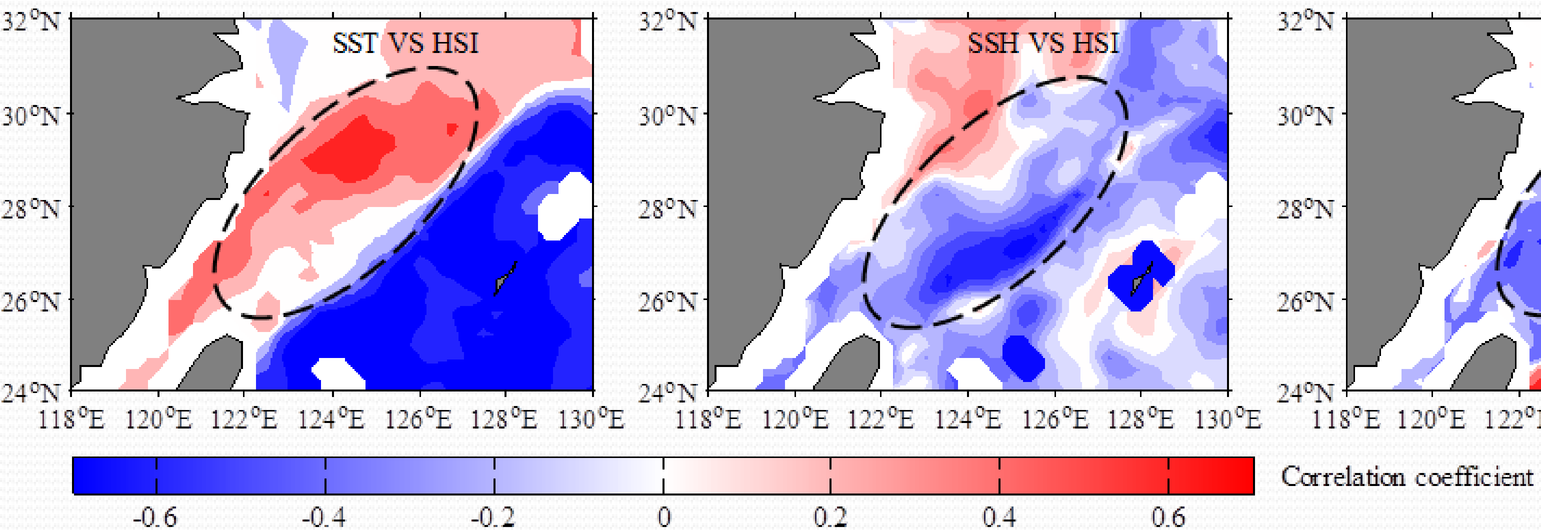
4. Interannual variability of LATG in relation to habitat suitability



Relationship between the latitudinal gravity center of fishing effort (LATG) and the gravity center of potential habitat (LATG_HSI) from July to September during 2006-2015.

Results

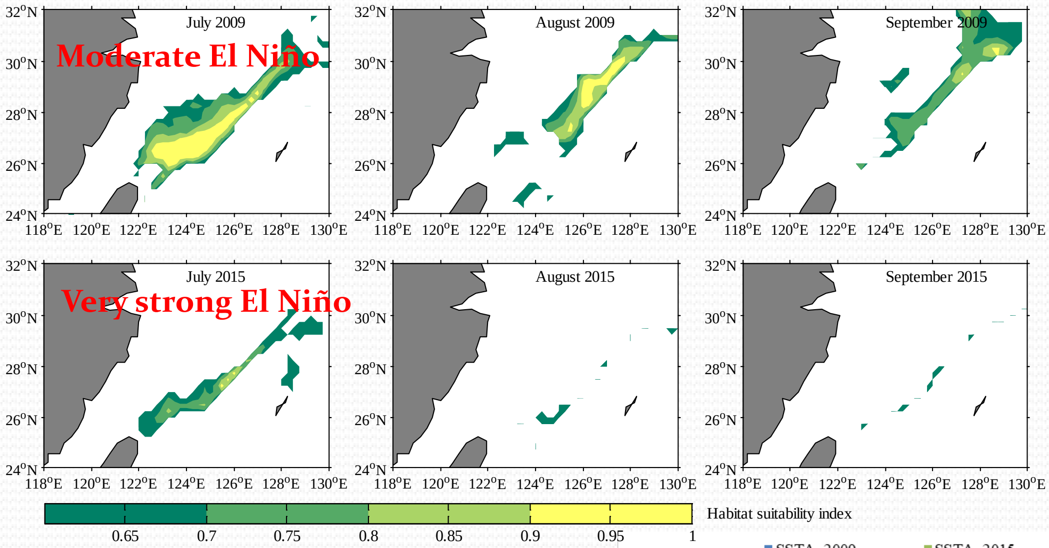
5. Spatial correlation between the habitat suitability and environmental factors

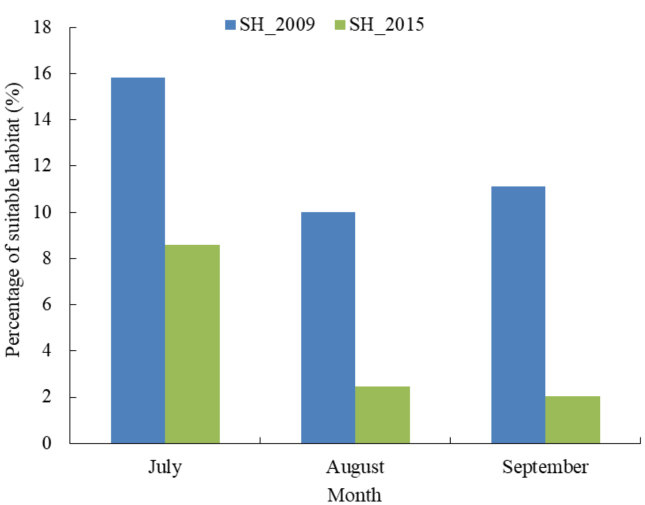


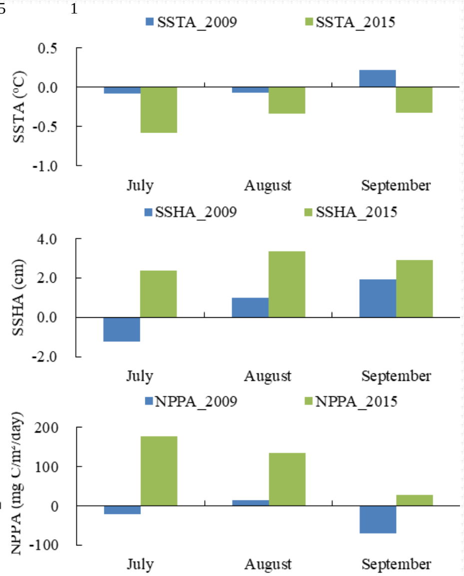
Spatial distribution of the correlation coefficients between the habitat suitability index (HSI) values of *Scomber japonicus* and sea surface temperature (SST) anomaly (left panel), sea surface height (SSH) anomaly (middle panel) and net primary production (NPP) anomaly (right panel) on the fishing ground. The region within the circle is the main fishing locations for Chinese *Scomber japonicus* fishery.

Results

6. Habitat suitability variations in relation to the El Niño events



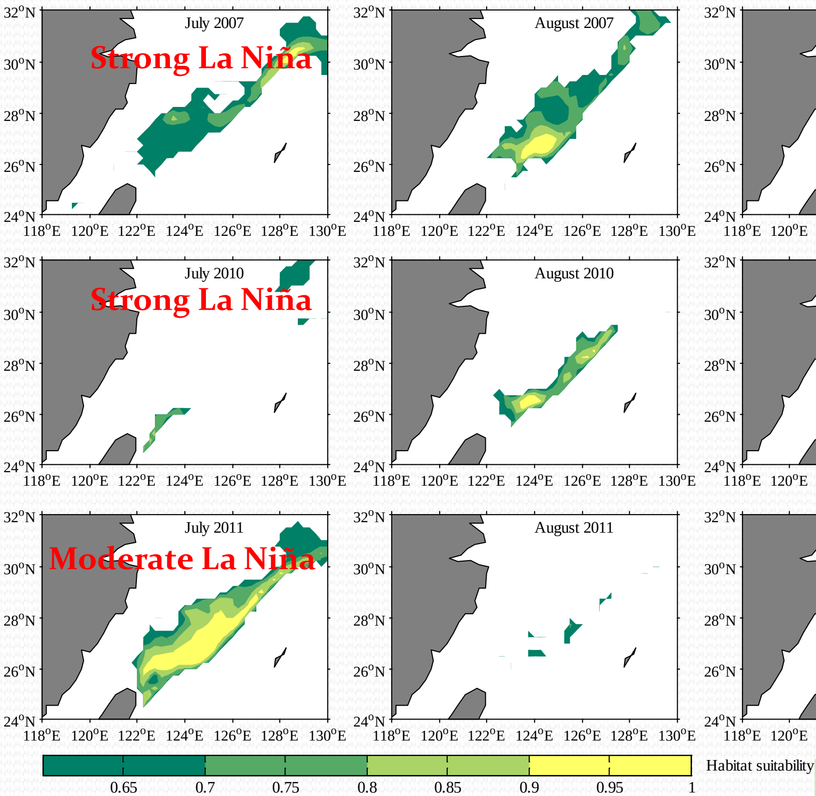


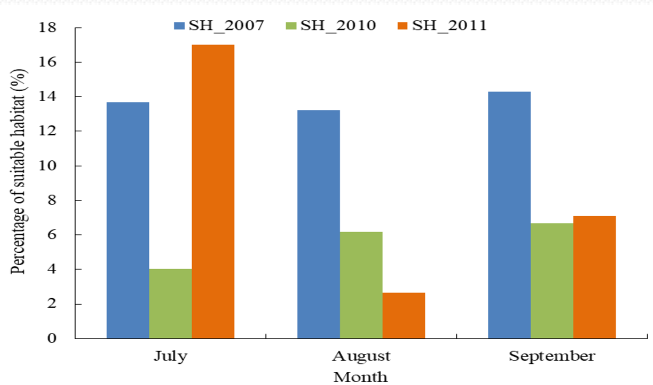


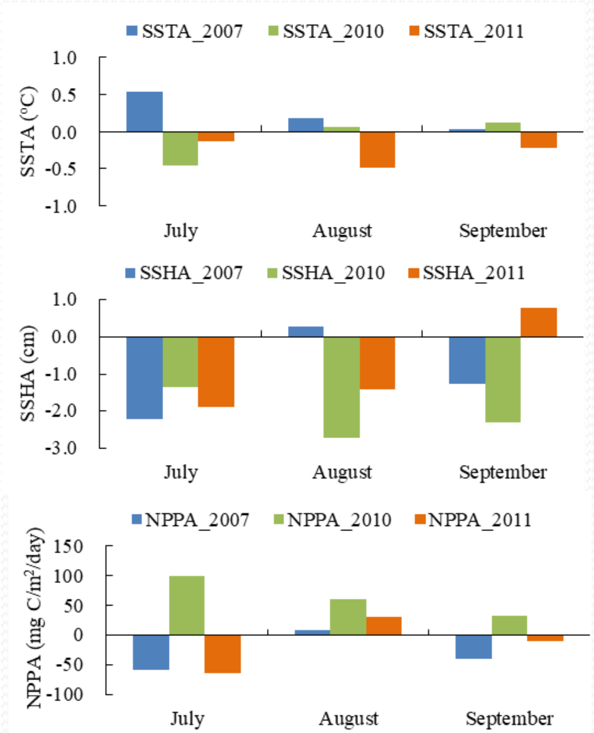
Mapping the predicted suitable habitats (upper panel) and comparison of the percentage of suitable habitats (lower-left panel), and sea surface temperature anomaly (SSTA), sea surface height anomaly (SSHA) and net primary production anomaly (NPPA) (lower-right panel) on the fishing ground of *Scomber japonicus* in the coastal waters of China from July to September in 2009 and 2015. SH indicated the suitable habitat.

Results

7. Habitat suitability variations in relation to the La Niña events







Mapping the predicted suitable habitats (upper panel) and comparison of the percentage of suitable habitats (lower-left panel), and sea surface temperature anomaly (SSTA), sea surface height anomaly (SSHA) and net primary production anomaly (NPPA) (lower-right panel) on the fishing ground of *Scomber japonicus* in the coastal waters of China from July to September in 2007, 2010 and 2011. SH indicated the suitable habitat.

Summary

- The HSI model with the best model performance yielded robust predictions of habitat suitability for *S. japonicus*.
- The decreasing catch and CPUE of *S. japonicus* during 2006-2015 were highly consistent with substantial shrinkage of suitable and optimal habitats, and enlargement of normal and poor habitats.
- Similar movement pattern was found between the latitudinal gravity centers of fishing effort for *S. japonicus* fishery and the latitude of potential habitat.
- The HSI value was significantly positively related to the SST anomaly (SSTA) and negatively correlated with the SSH anomaly (SSHA) and NPP anomaly (NPPA), on the main fishing ground between 25°-30°N and 120°-130°E.
- Comparing to the very strong El Niño, the moderate El Niño events would yield rising SSTA and lowing SSHA and NPPA, leading to dramatically enlarged suitable habitat of *S. japonicus*. The habitat quality in La Niña events with different intensity depended on the local environmental variability on the fishing ground.

Thanks for your attention

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