SUSTAINABLE FISHERIES MANAGEMENT IN SW ATLANTIC:

A SCIENTIFIC APPROACH

FarFish

MARCH 4TH, 2021

Response of habitat patterns of Argentine shortfin squid (*Illex argentinus*) to Antarctic sea ice changes

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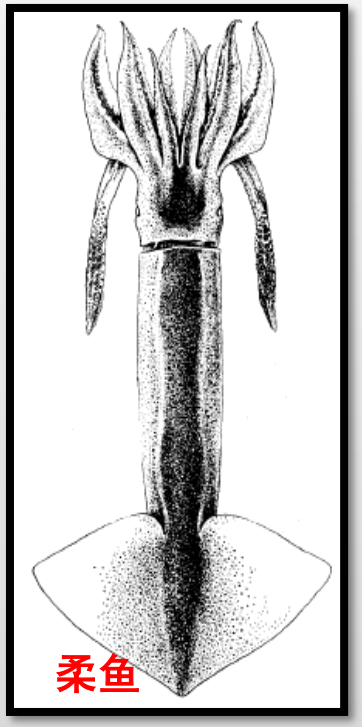
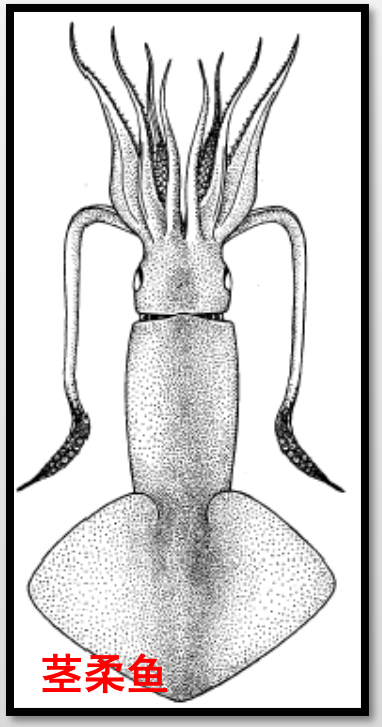
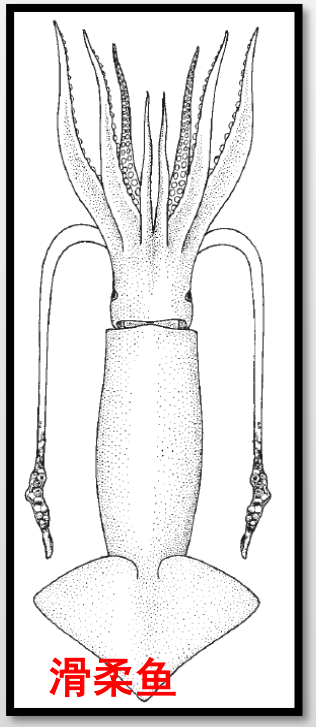
INTRODUCTION



Ommastrephes bartramii
NW Pacific



Dosidicus gigas
SE Pacific

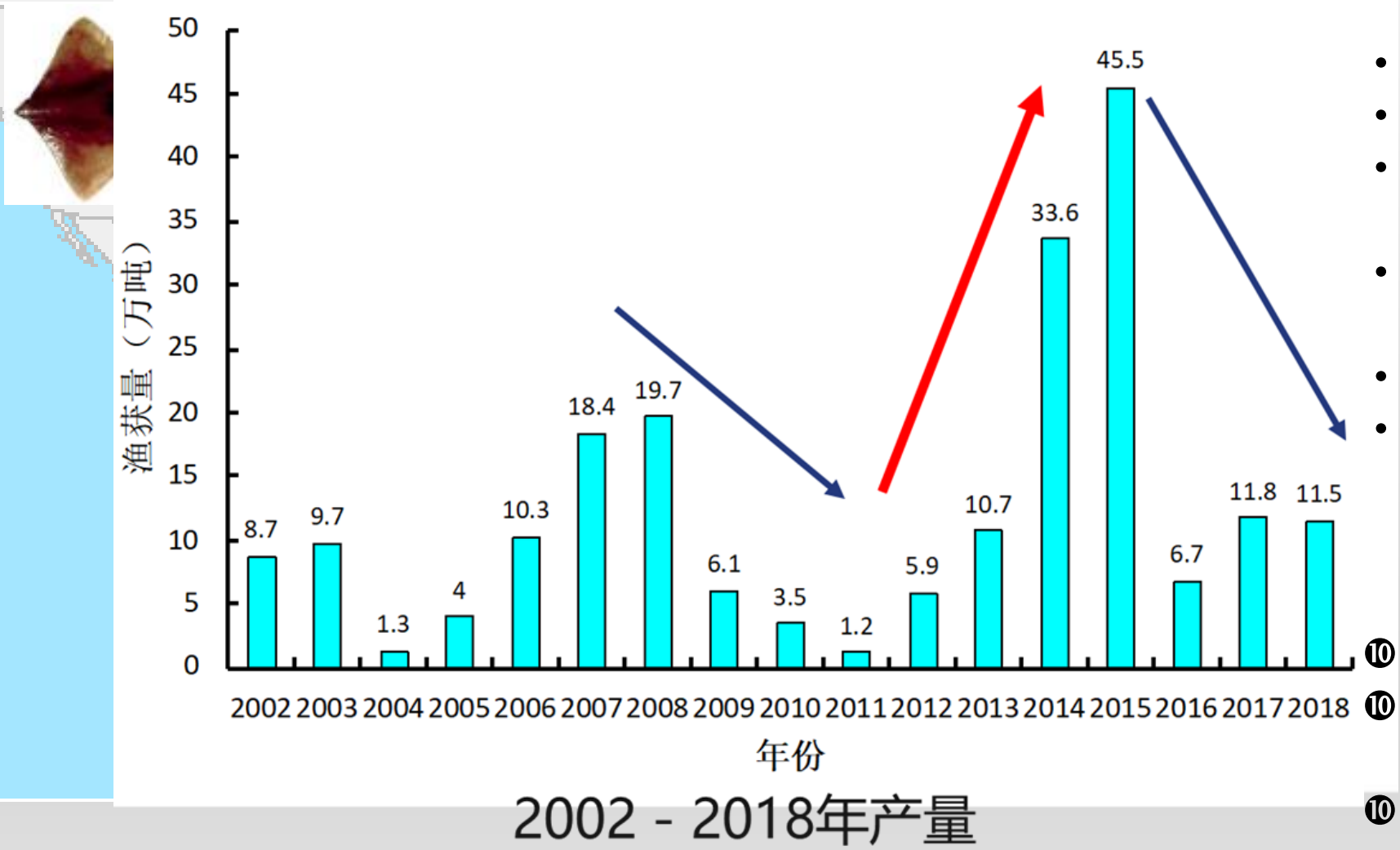


Illex argentinus
Outside the EEZ of Argentina

Todarodes pacificus
East China Sea and the Sea of Japan

- China is the main country fishing, trading and consuming oceanic squids.
- The main targeted squids include neon flying squid, Humboldt squid, Argentine shortfin squid and Japanese flying squid.

INTRODUCTION



2002 - 2018年产量

Illex argentinus

- Different geographical stocks;
- Widely distribution;
- A cannibalism species with fast growth;
- High catch and economically important;
- 1 year short lifespan;
- Sensitive to climatic and environmental conditions;

Chinese squid-jigging fishery

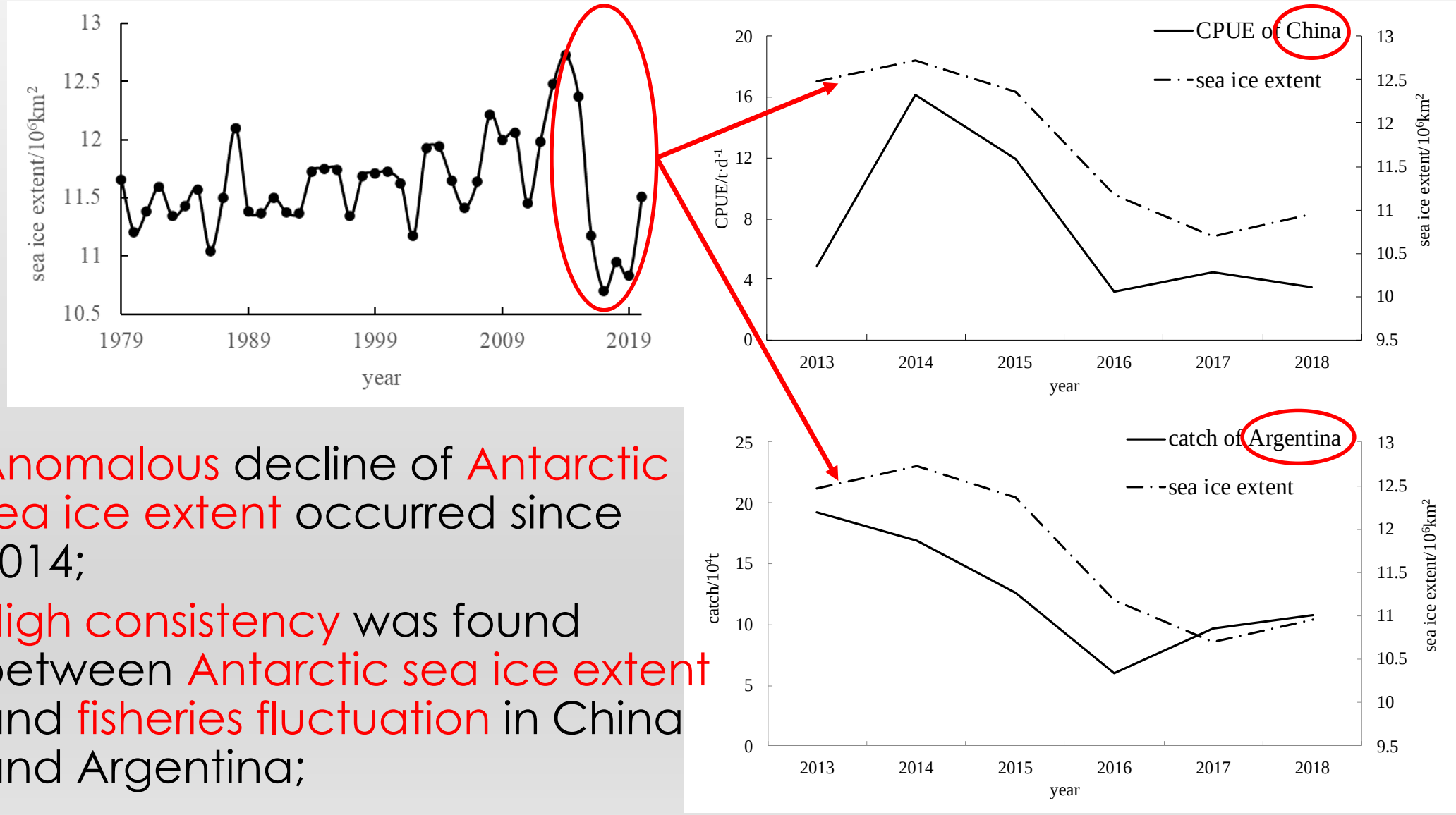
- Started in 2002;
- Important fishing ground outside the EEZ off Argentina;
- Fluctuant catches, number of fishing boats and CPUE;

INTRODUCTION

Antarctic sea ice ← ? → ***Illex argentinus***

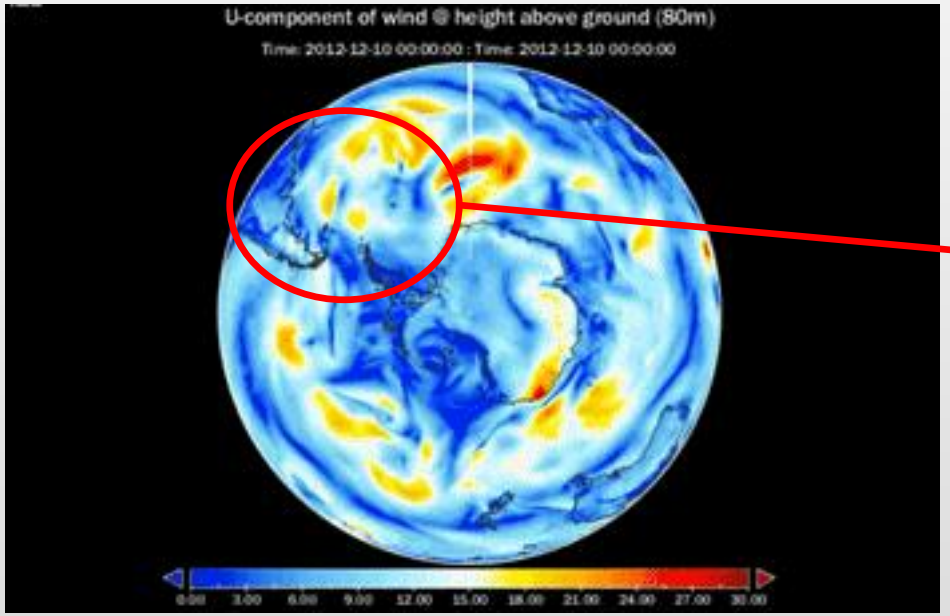
- Why did we link Antarctic sea ice with *I. argentinus*?
- What's the relationship between them?

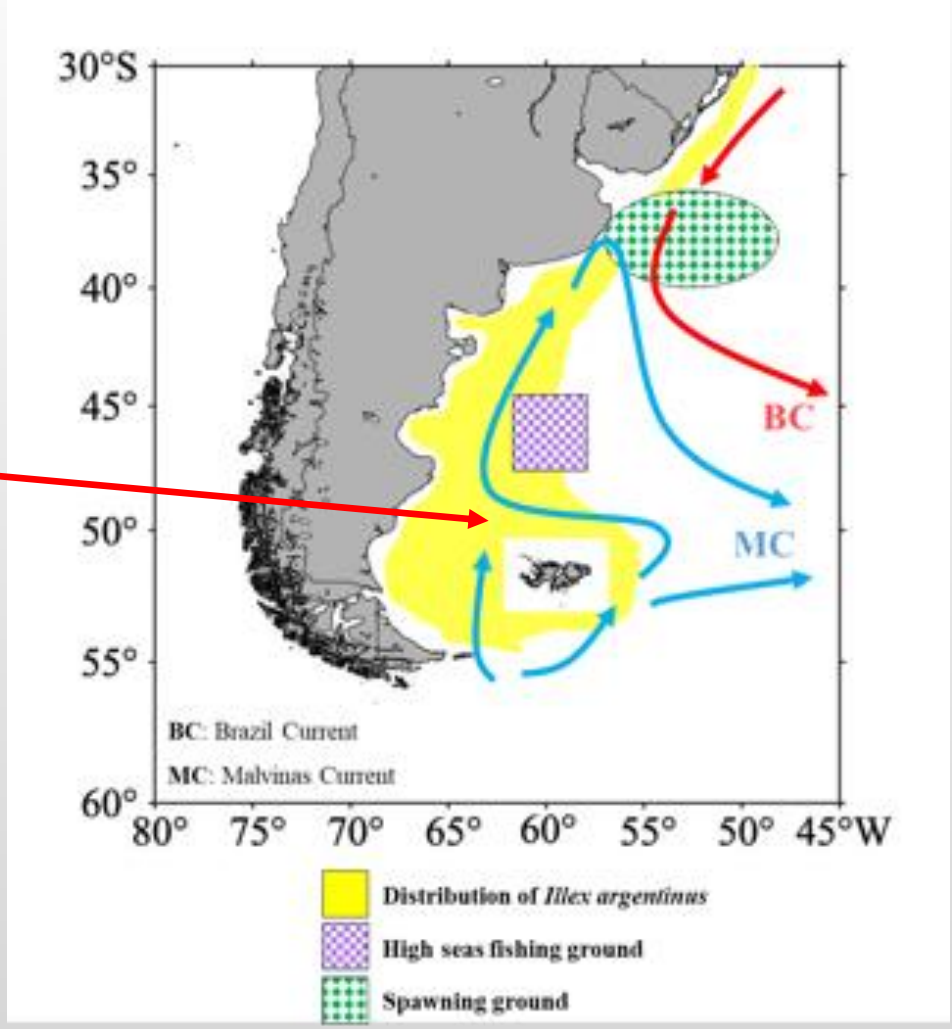
INTRODUCTION



- Anomalous decline of Antarctic sea ice extent occurred since 2014;
- High consistency was found between Antarctic sea ice extent and fisheries fluctuation in China and Argentina;

INTRODUCTION





- The habitat of *I. argentinus* is mainly affected by the Brazil Current and the Malvinas Current;
- The Malvinas Current is a branch of the Antarctic Circumpolar Current;

INTRODUCTION

The objectives of this study are to

- develop an integrated habitat suitability index (HSI) model for *Illex argentinus* based on vertical water temperature at depths of 50 m, 100 m and 200 m;
- Examine the relationship between habitat patterns of *Illex argentinus* and Antarctic sea ice changes;

HYPOTHESIS AND METHODS

Hypothesis:

Antarctic sea ice extent → affected → Th

relationship

The abundanc
I. argentinu

Scenarios	K_{54m}	K_{96m}	K_{193m}
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	0.5	0.25	0.25
case 8	0.333	0.333	0.333
case 9	0.8	0.1	0.1
case 10	1	0	0

Methods:

Compare the changes of sea ice extent and the proportion of suitable habitat from 1979 to 2017 and calculated the spatial correlation

Fishery data

Cross validation (2017)

Establishment of Habitat Suitability Index (HSI) model
poor habitat: HSI≤0.2
normal habitat: 0.2<HSI<0.6
suitable habitat: HSI≥0.6

The change of *I. argentinus* habitat was characterized by the change of proportion for suitable habitat (1979-2017)

Weighted AMM model

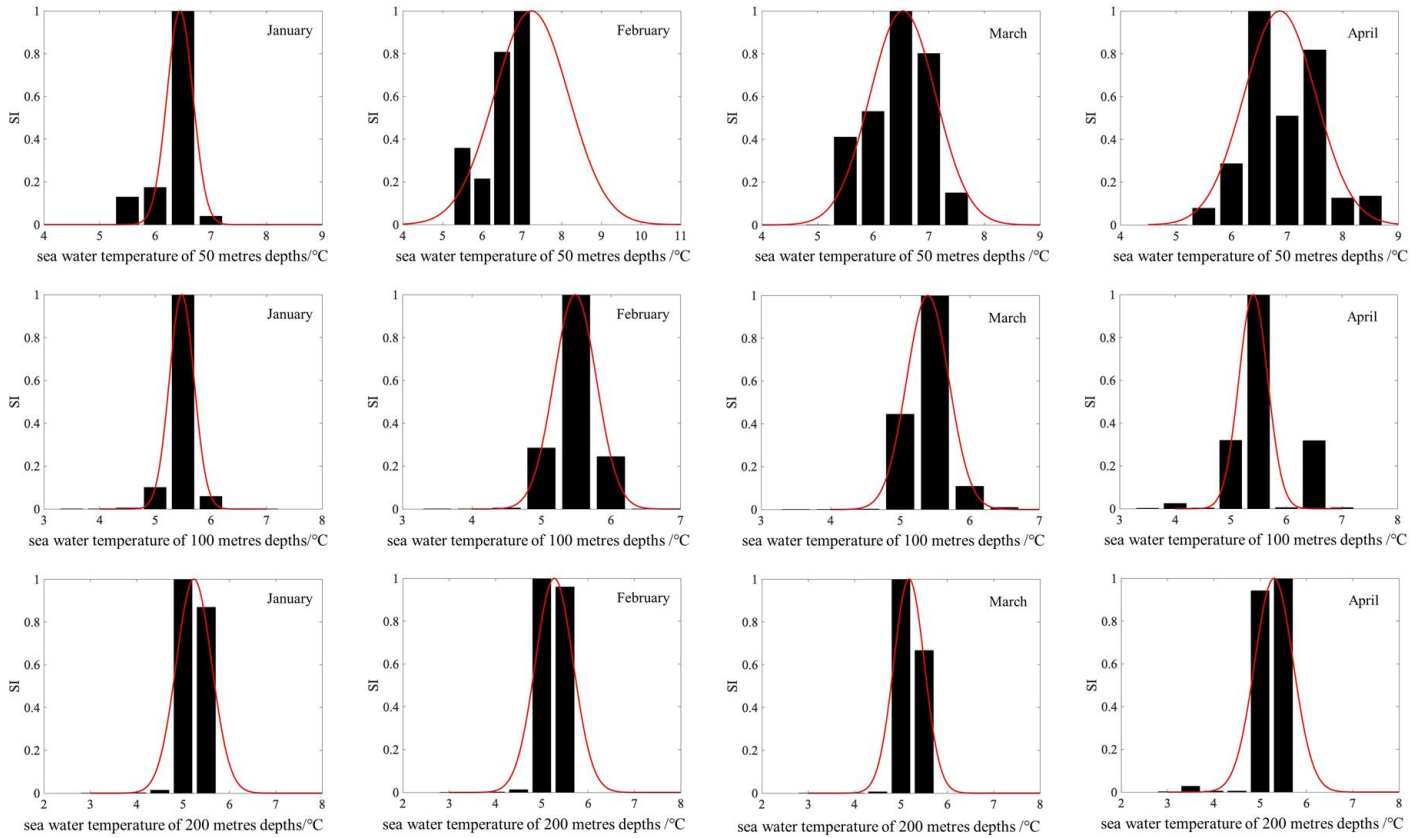
Evaluate the performance of the AMM-based HSI model and predict the habitat suitability

(sea water temperature at depths of 50m, 100m and 200m)

10 different weigh
different sea

Select representative years of sea ice extent and compare habitat differences

FINDINGS



Fitted suitability index (SI) curves based on the relationship between fishing effort and each environmental variable including sea water temperature at depths of 50 m, 100 m and 200 m.

Monthly fitted suitability index (SI) formula of each environmental variable for *Illex argentinus* in the Southwest Atlantic Ocean.

month	SI model	R^2	P
January	$SI_{50m}=\exp[-9.082\times(T_{50m}-6.445)^2]$	0.976	<0.01
January	$SI_{100m}=\exp[-10.162\times(T_{100m}-5.476)^2]$	1	<0.01
January	$SI_{200m}=\exp[-3.404\times(T_{200m}-5.236)^2]$	0.951	<0.01
February	$SI_{50m}=\exp[-0.571\times(T_{50m}-7.239)^2]$	0.805	<0.05
February	$SI_{100m}=\exp[-5.327\times(T_{100m}-5.486)^2]$	1	<0.01
February	$SI_{200m}=\exp[-2.976\times(T_{200m}-5.269)^2]$	0.941	<0.01
March	$SI_{50m}=\exp[-1.430\times(T_{50m}-6.534)^2]$	0.896	<0.05
March	$SI_{100m}=\exp[-5.401\times(T_{100m}-5.397)^2]$	0.995	<0.01
March	$SI_{200m}=\exp[-4.568\times(T_{200m}-5.175)^2]$	0.966	<0.01
April	$SI_{50m}=\exp[-1.192\times(T_{50m}-6.870)^2]$	0.672	<0.05
April	$SI_{100m}=\exp[-7.411\times(T_{100m}-5.405)^2]$	0.869	<0.05
April	$SI_{200m}=\exp[-2.878\times(T_{200m}-5.299)^2]$	0.947	<0.01

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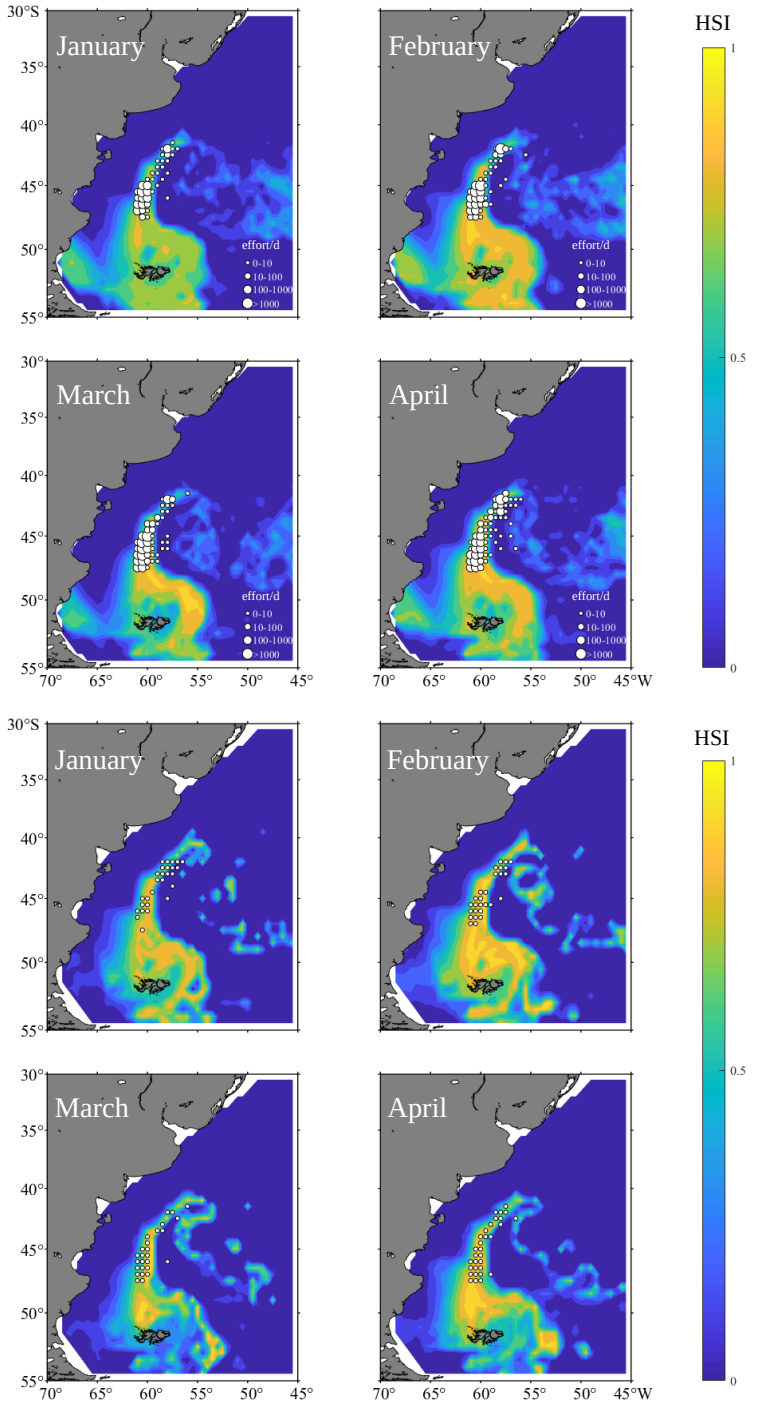
Month	HSI	Case1		Case2		Case3		Case4		Case5	
		catch	effort	catch	effort	catch	effort	catch	effort	catch	effort
January	0.0-0.2	44.35%	39.60%	0.04%	0.19%	18.99%	21.55%	0.04%	0.19%	0.75%	0.87%
January	0.2-0.6	31.92%	32.61%	2.98%	2.13%	54.23%	41.00%	6.45%	7.22%	72.44%	61.36%
January	0.6-1.0	23.73%	27.79%	96.99%	97.68%	26.78%	37.45%	93.51%	92.59%	26.82%	37.77%
February	0.0-0.2	8.73%	15.25%	0.07%	0.15%	8.63%	15.07%	0.07%	0.15%	0.07%	0.15%
February	0.2-0.6	33.56%	32.97%	0.16%	0.35%	29.53%	29.93%	0.16%	0.36%	11.44%	18.98%
February	0.6-1.0	57.71%	51.78%	99.77%	99.50%	61.85%	55.01%	99.77%	99.49%	88.48%	80.87%
March	0.0-0.2	6.76%	9.43%	0.22%	0.25%	4.98%	7.93%	0.22%	0.24%	4.35%	7.43%
March	0.2-0.6	30.53%	27.37%	51.53%	39.84%	30.19%	22.77%	39.48%	31.99%	26.44%	20.86%
Ma										69.20%	71.71%
April										10.02%	6.72%
April										30.87%	30.75%
April										59.11%	62.53%

Month	HSI	Case10	
		catch	effort
January		32.42%	40.74%
January		41.45%	30.01%
January		26.13%	29.26%
February	0.0-0.2	0.07%	0.15%	0.07%	0.14%	0.07%	0.14%	0.03%	0.05%	0.01%	0.01%
February	0.2-0.6	0.18%	0.48%	1.54%	3.27%	1.49%	3.08%	20.15%	17.09%	29.65%	23.18%
February	0.6-1.0	99.74%	99.37%	98.39%	96.60%	98.43%	96.78%	79.82%	82.86%	70.35%	76.81%
March	0.0-0.2	0.13%	0.15%	1.01%	0.50%	1.03%	0.53%	1.04%	0.54%	1.04%	0.54%
March	0.2-0.6	38.81%	32.90%	25.21%	26.17%	31.02%	28.17%	22.89%	24.26%	26.29%	29.75%
March	0.6-1.0	61.06%	66.96%	73.78%	73.33%	67.95%	71.30%	76.06%	75.20%	72.67%	69.71%
April	0.0-0.2	1.86%	1.47%	0.13%	0.11%	0.22%	0.16%	0.15%	0.13%	13.49%	8.45%
April	0.2-0.6	18.59%	21.49%	34.29%	34.09%	26.94%	28.49%	35.75%	36.55%	31.49%	34.59%
April	0.6-1.0	79.55%	77.05%	65.58%	65.81%	72.84%	71.35%	64.09%	63.32%	55.02%	56.96%

Mapping the predicted habitat suitability index (HSI) values in 2013-2016 and 2017 on the fishing ground overlaid with fishing effort of *Illex argentinus*

2013-2016

2017



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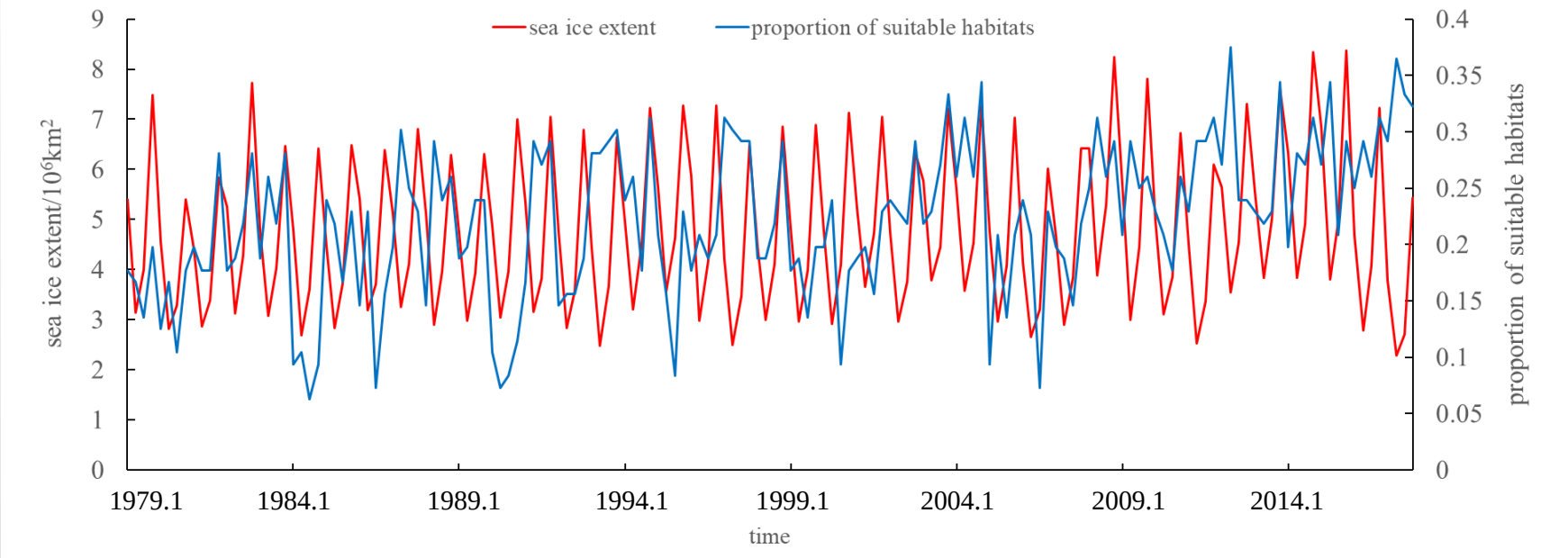

- The environmental data from 1979 to 2017 were included into the comprehensive HSI model to calculate the proportion of suitable habitats from January to April in 1979-2017.

- The Antarctic sea ice extent from 1979 to 2017 was matched with the proportion of suitable habitats, and the correlation coefficient was 0.17. The results showed that there was a significant positive correlation between the them with $P < 0.05$, implying that the higher the Antarctic sea ice coverage, the larger the suitable habitat area.

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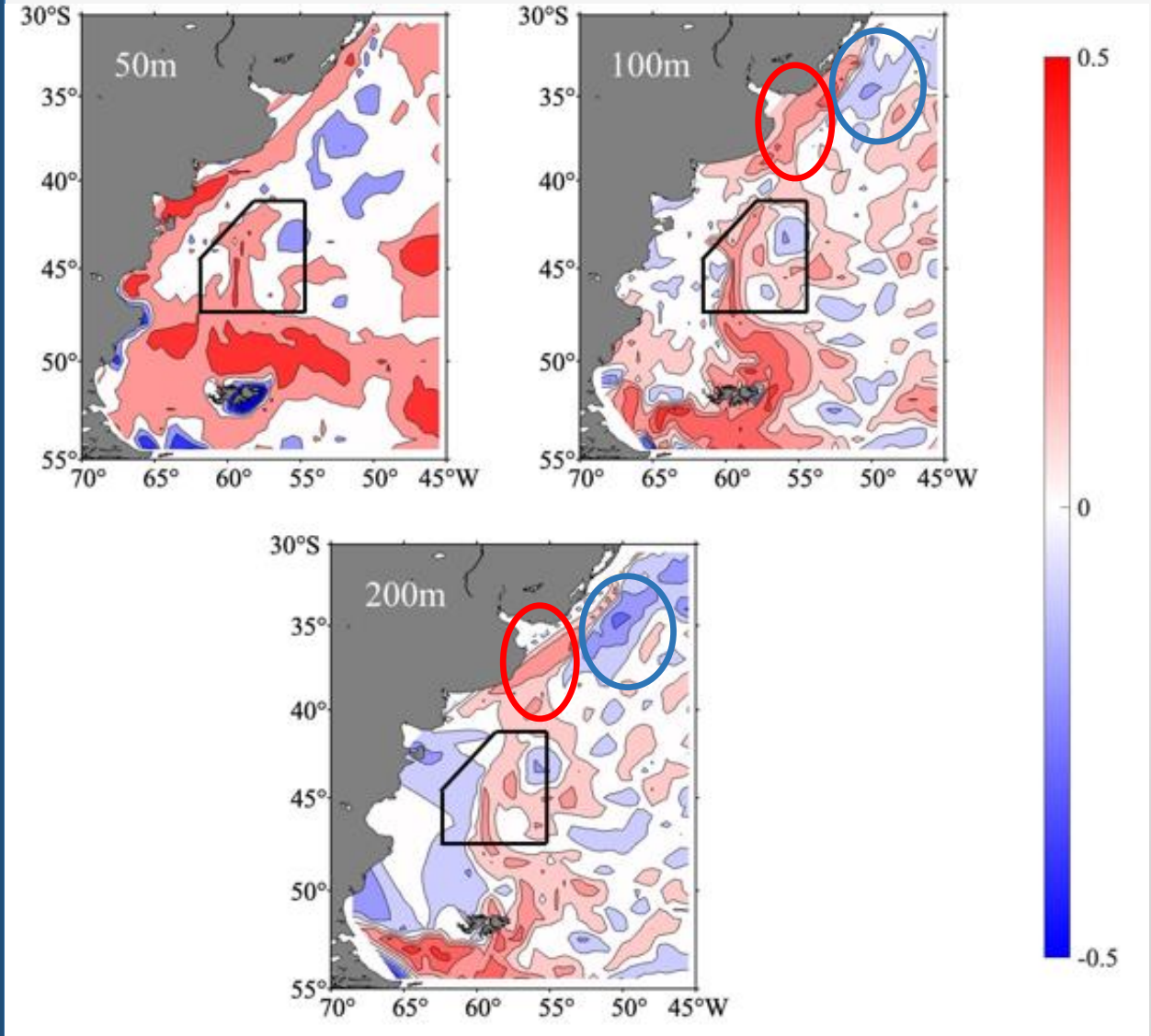

- Mapping the spatial distribution of the correlation coefficients between Antarctic sea ice extent and sea water temperature at different depths from January to April in 1979-2017. The results showed that there was a positive correlation between Antarctic sea ice extent and sea water temperature in most of the high seas fishing grounds (black trapezoidal area) in the southwest Atlantic Ocean.

- At the water depth of 100 m and 200 m, the correlation difference was obvious in the Brazil-Malvinas Confluence near the mouth of La Plata River. The temperature of Brazil Current in the north is negatively correlated with the Antarctic sea ice extent, while the temperature of Malvinas Current in the south was positively correlated with the Antarctic sea ice extent.

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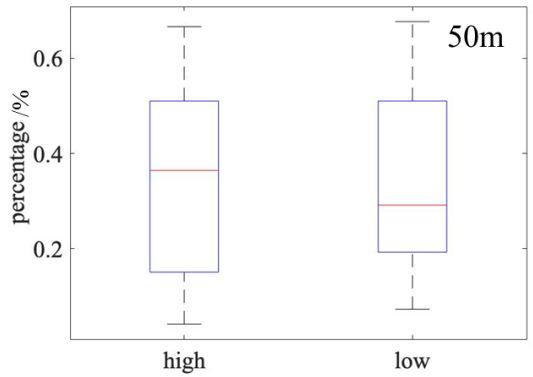

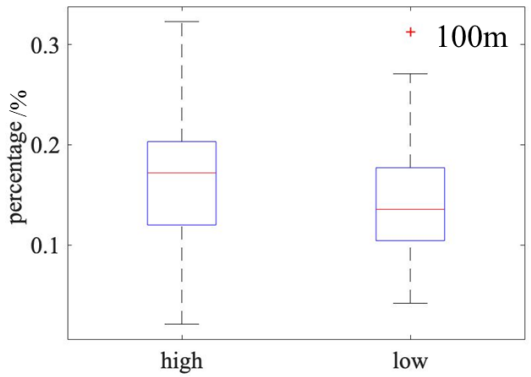

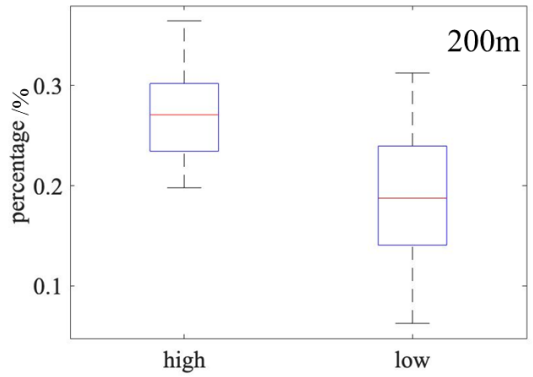

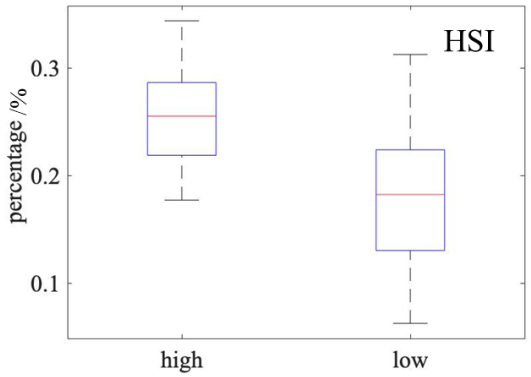

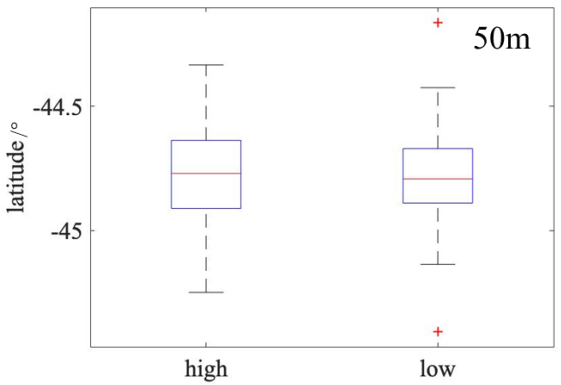

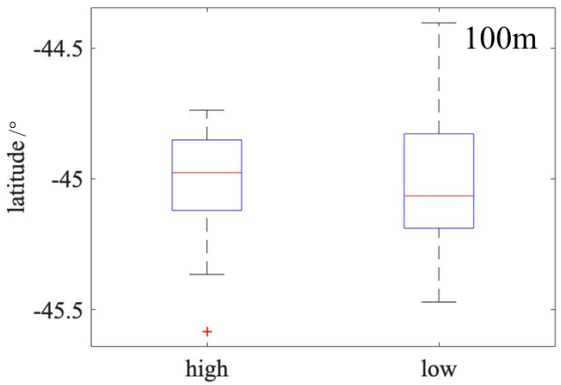

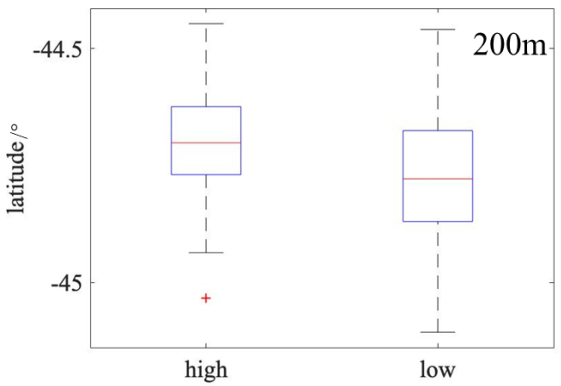

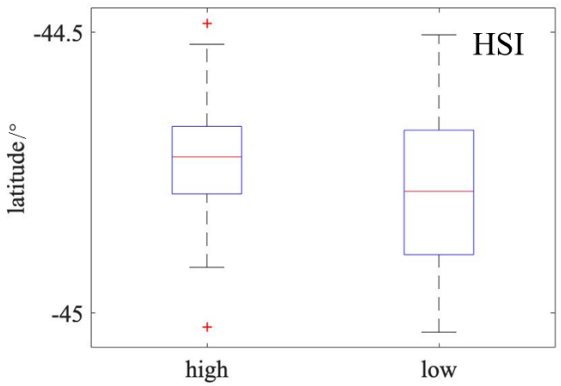

The boxplot comparing the areas of SI > 0.6 and HSI > 0.6 in the two groups of years with high and low sea ice extent. The results showed that the higher the sea ice extent, the larger the proportion of suitable habitat area, that was, the sea ice extent was positively correlated with the proportion of suitable habitat area.

The boxplot comparing the latitudinal gravity centers of SI and HSI in two groups of years with high and low sea ice extent. The results showed that when the sea ice extent was higher, the latitudinal gravity centers of suitable habitat moved northward.

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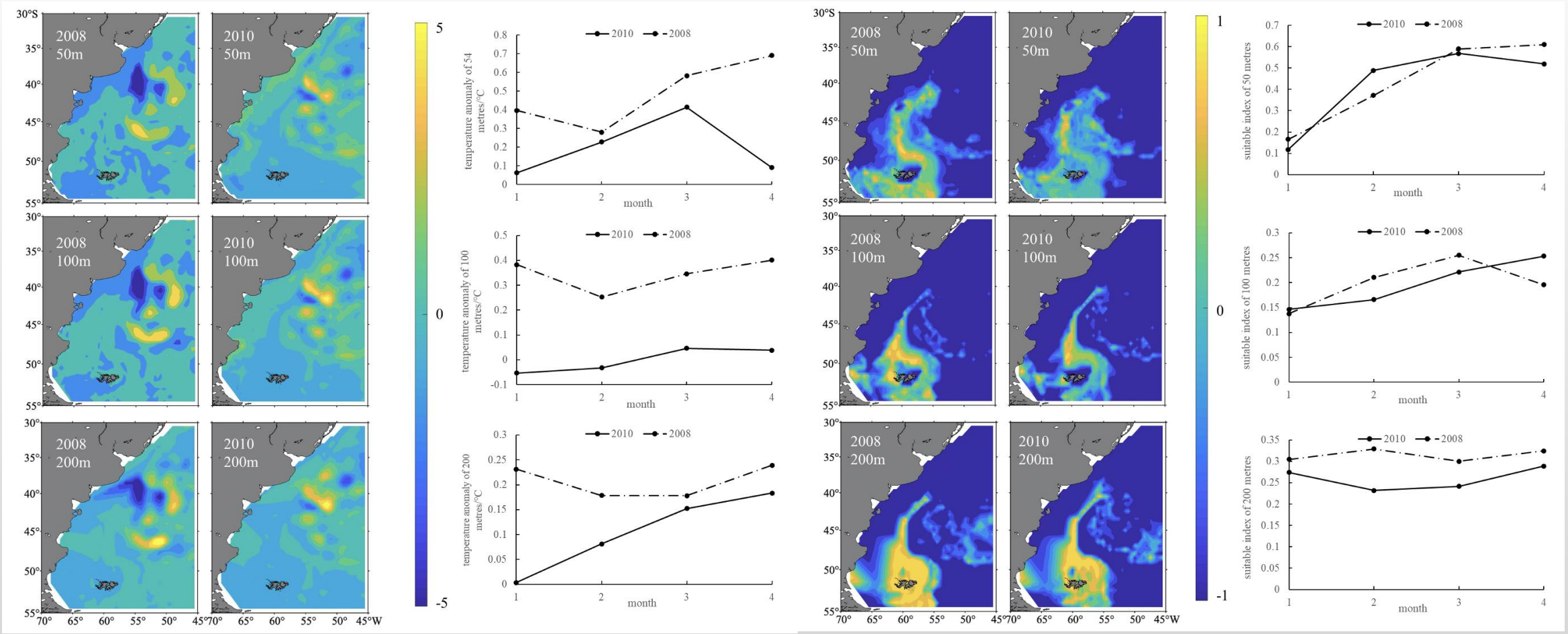

2008 with high sea ice extent and 2010 with low sea ice extent were selected as representative years.
There was a positive correlation between Antarctic sea ice extent and sea water temperature anomaly in different water

In the years with high sea ice extent, the suitable habitat area of different water depths (SI > 0.6) was large, that was, the Antarctic sea ice extent was positively correlated with the suitable habitat area at different water depths.

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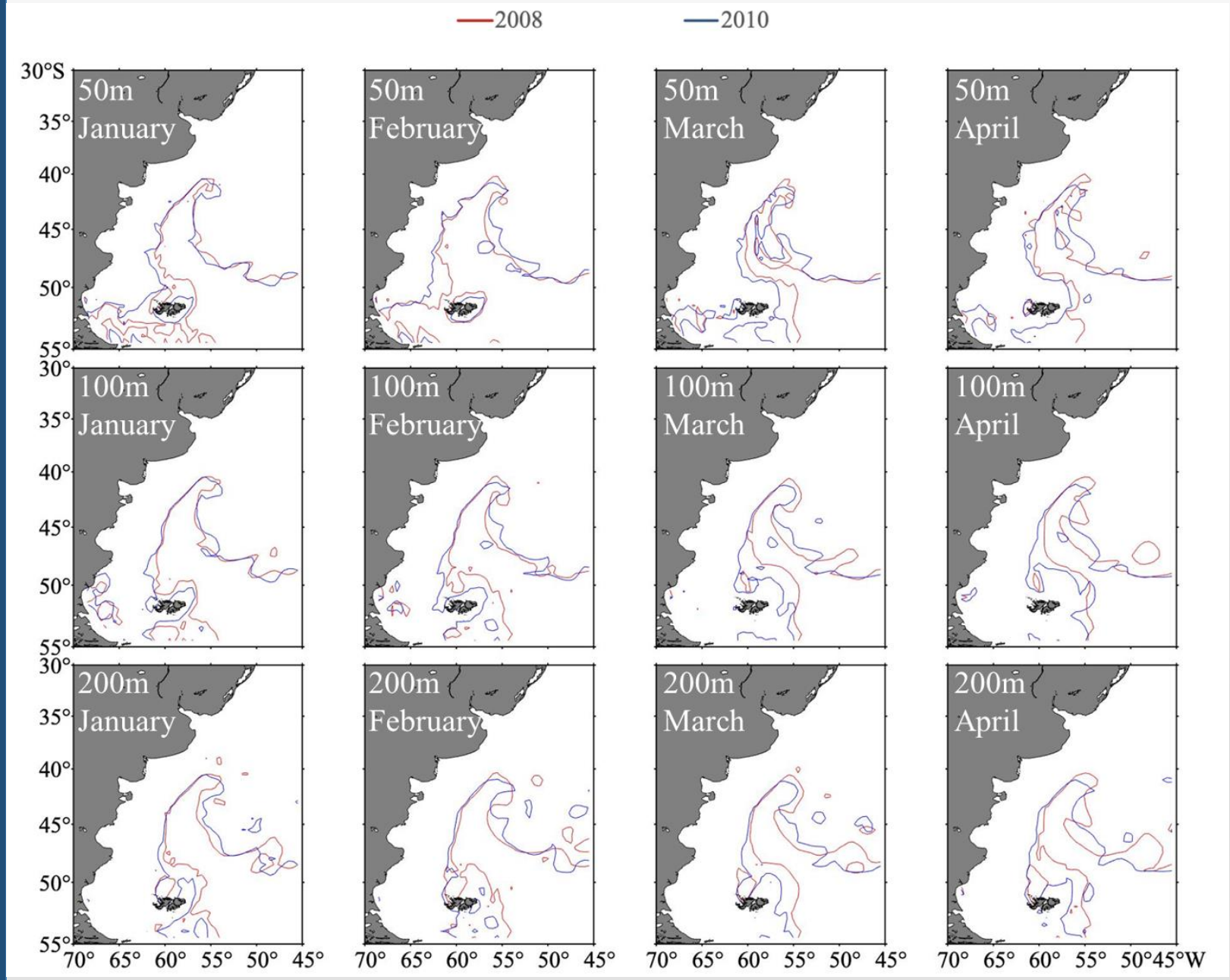

The distribution of the contour lines of the preferred temperature at depths of 50 m, 100 m and 200 m from January to April in 2008 and 2010 was shown in the left figure. The contour lines in 2008 with high sea ice extent was located in the northern waters compared with 2010.

CONCLUSION

- The HSI model with the best model performance could yield robust predictions of habitat suitability for *Illex argentinus*.
- Spatial correlation analysis suggested that there was a positive correlation between Antarctic sea ice extent and vertical water temperature at depths of 50 m, 100 m and 200 m in the high seas fishing grounds.
- In the years with high Antarctic sea ice extent, the sea water temperature anomaly at different depths was higher, yielding favorable temperature conditions. Thus, the proportion of suitable habitats enlarged. In addition, the contour lines of the preferred water temperature at different depths moved northward, leading to the northward movement of the latitudinal gravity centers of suitable SI and HSI. The situation was opposite in the years with low Antarctic sea ice extent.

RESEARCH NEEDS, INTERESTS AND PRIORITIES

- Research needs: international cooperation on data sharing. Especially sharing the fisheries and biological data within and outside the EEZ off Argentina and the Falkland Island.
- Research interests: biological characteristics including population structure, age and growth, feeding and spawning behavior, migration, etc; habitat pattern; population dynamics; fishing ground prediction; fisheries management; relationship with climatic and environmental conditions at different spatial and temporal scales; fisheries stock assessment;
- Research priorities: population structure; age and growth; habitat pattern; relationship with climatic and environmental conditions; fisheries stock assessment and management;