S8: FUTURE/S-CCME/AP-ECOP Topic Session:
How Can Ecosystem-Scale Information be Used to Improve Our Understanding of Climate Change Impacts, and Support Management and Conservation in the North Pacific?
PICES-2025 : November 8-14, Yokohama, Japan

Investigating the impacts of climate and fishing on fish populations and ecosystems in China's shelf seas using multiple models

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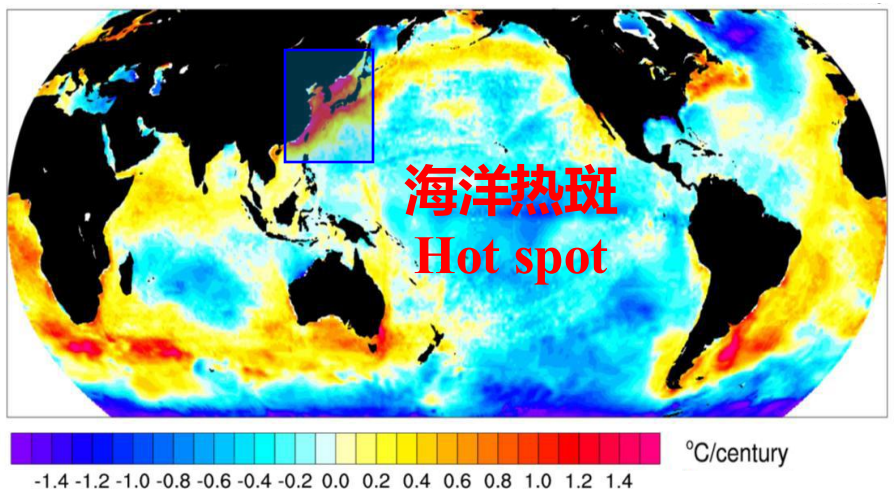
Outlines

1. **Current status of Chinese marine fisheries**

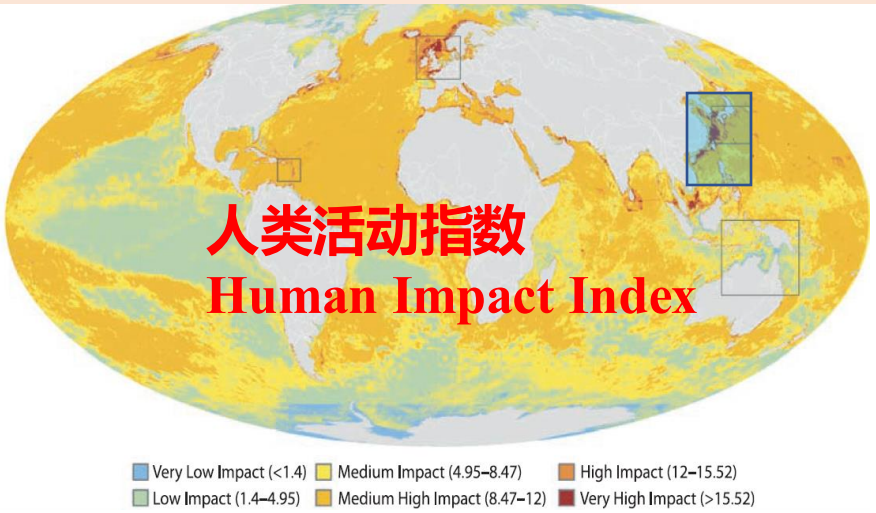
2. **Modeling the response of marine fishery resources to climate change and fishing**

3. **Summary & outlook: Management responses to climate change**

Northwest Pacific under multiple pressures

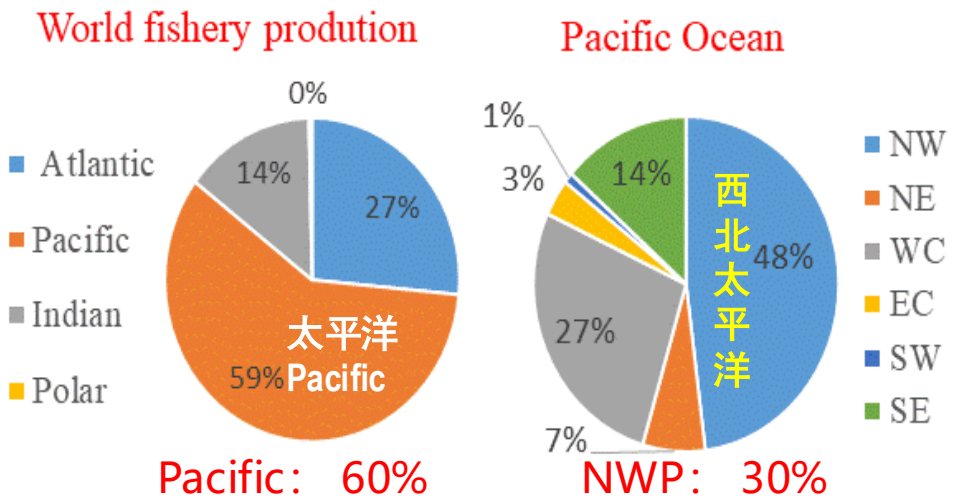


The impact of global change is most pronounced in the Northwest Pacific



High Production

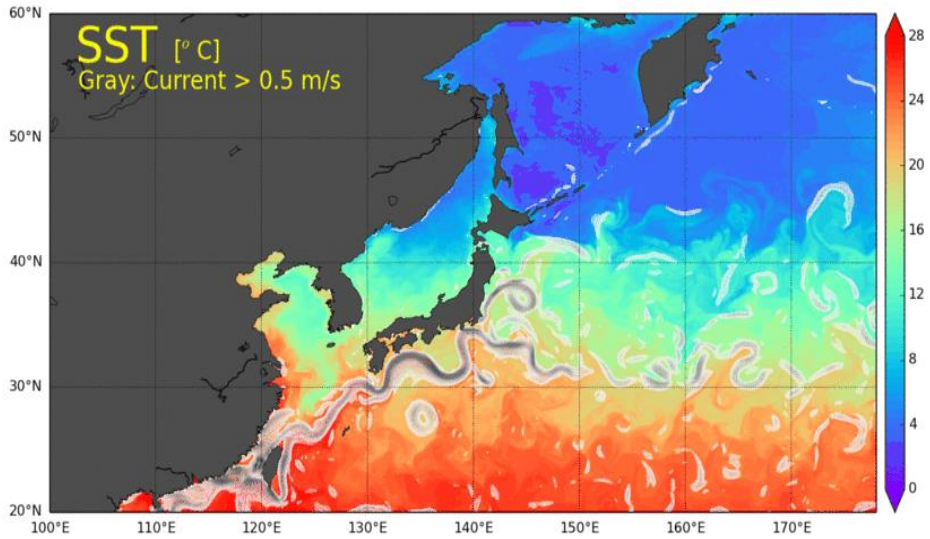
Northwest Pacific contributes to 30% of the total world fishery production (FAO, 2020)



Pacific: 60%

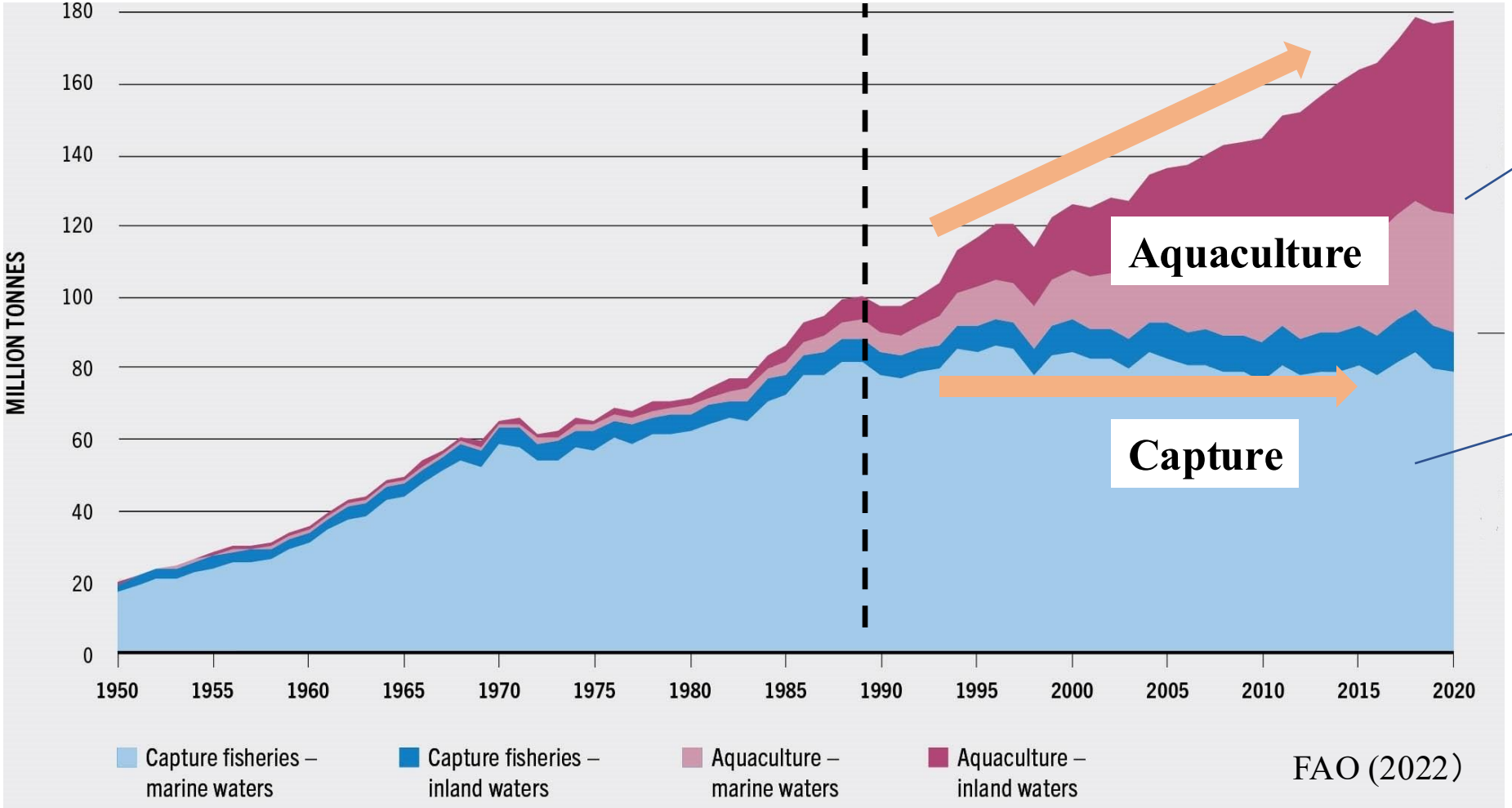
NWP: 30%

Multi-scale, dynamic oceanic systems with linkage to basin-scale climate variability such as PDO, ENSO and AMO.



Chen et al. 2018

Global fisheries production

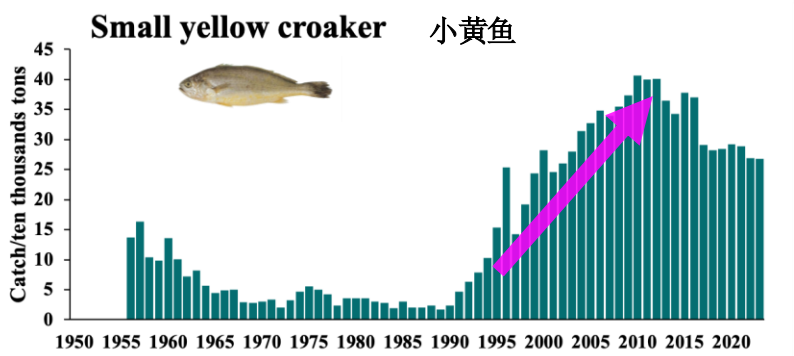


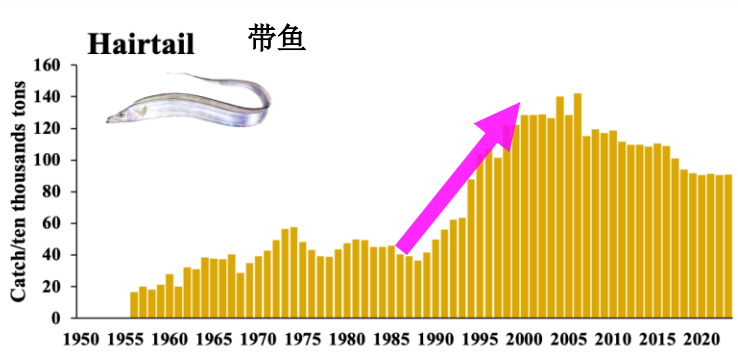
More than 60% from China

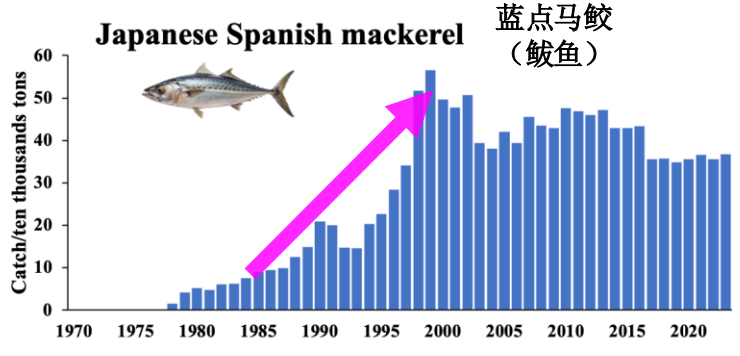
About 20% from China

After the 1990s, global capture fisheries were at a plateau relative to the rapid increase in aquaculture production. China contributes more than 60% of aquaculture production.

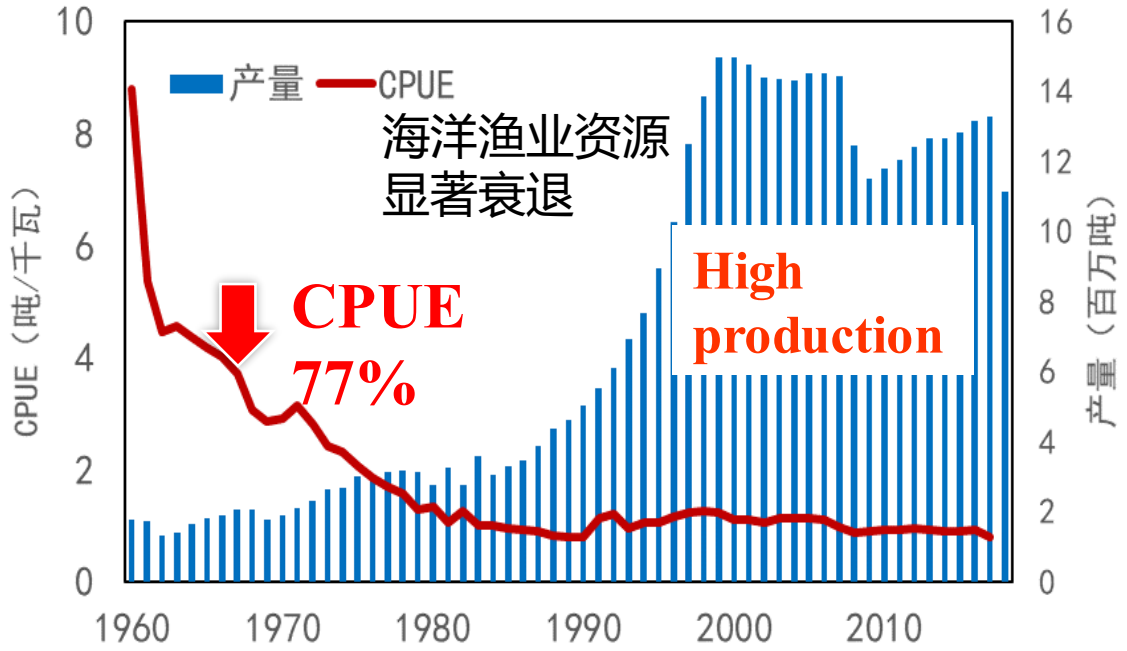
China's marine fisheries face a crisis under over-exploitation



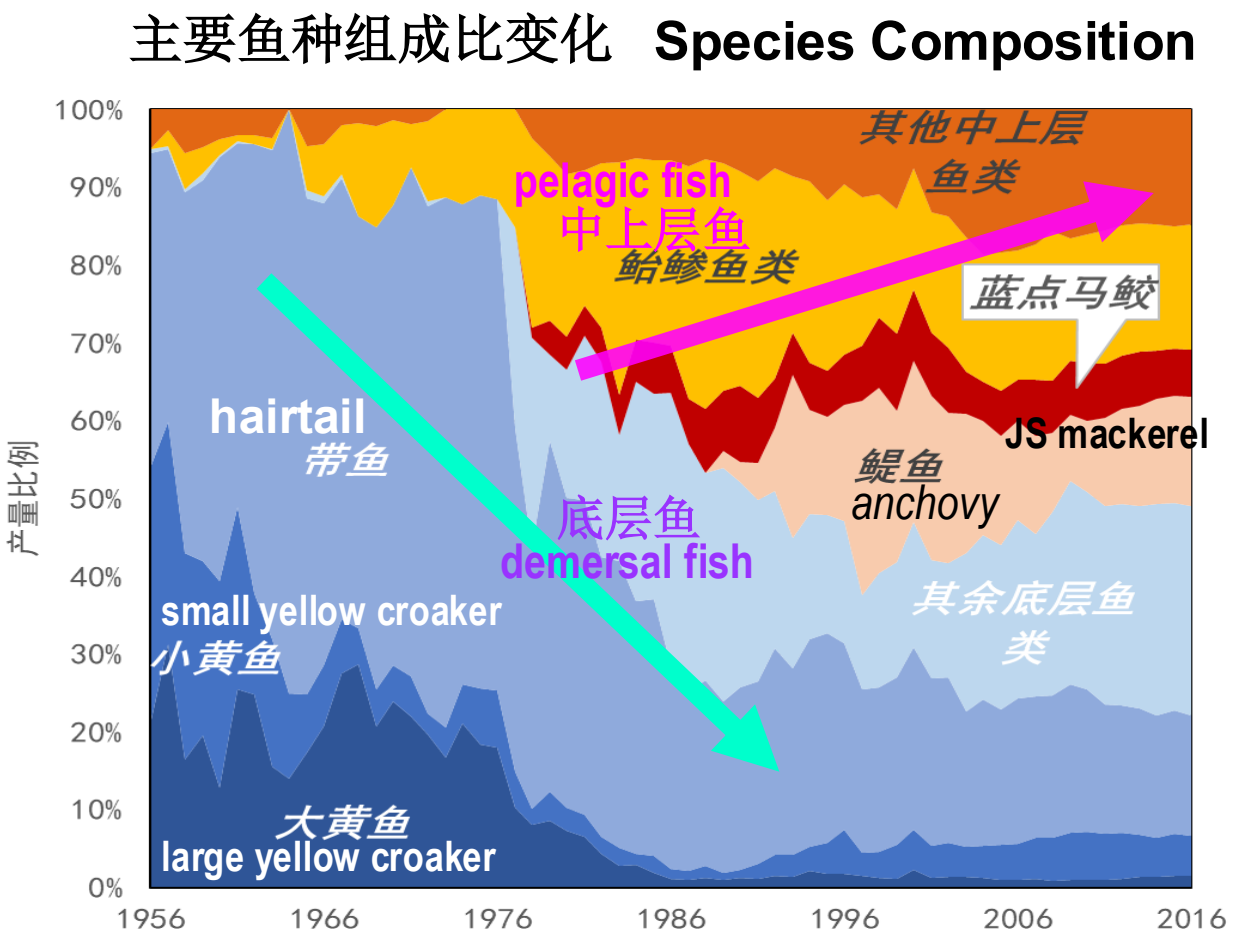


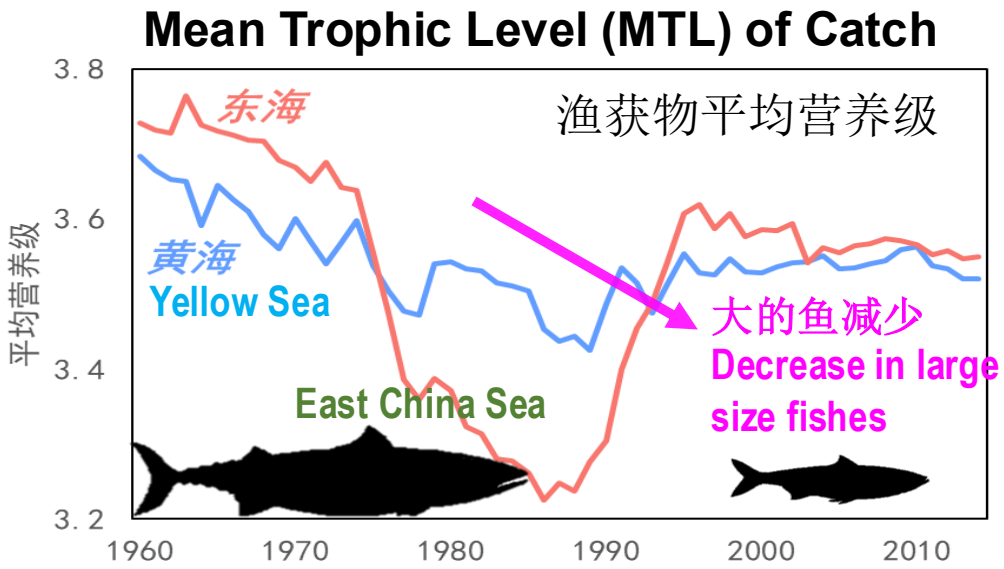


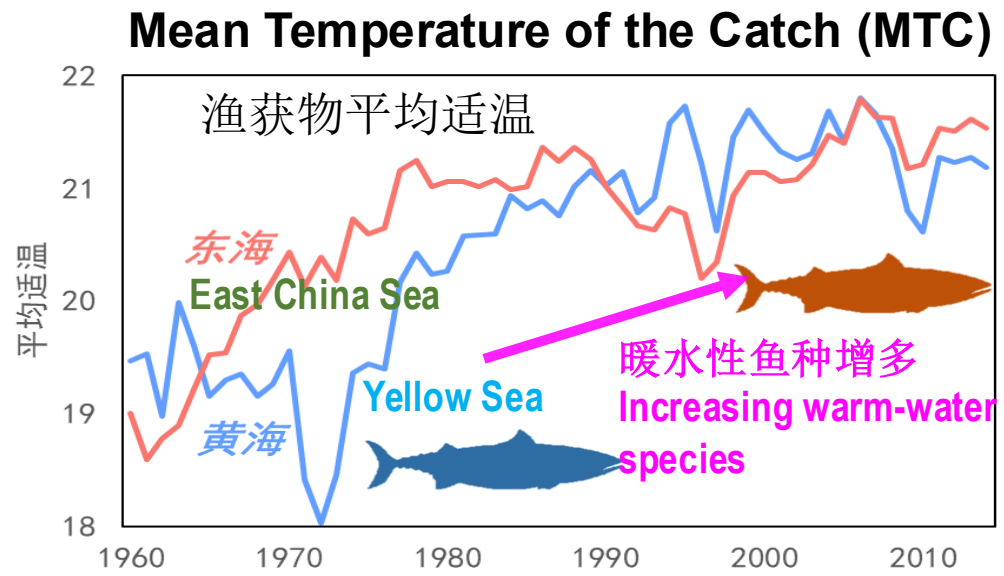
Overexploitation of major fish stocks



Climate change effect on the ecosystem structure





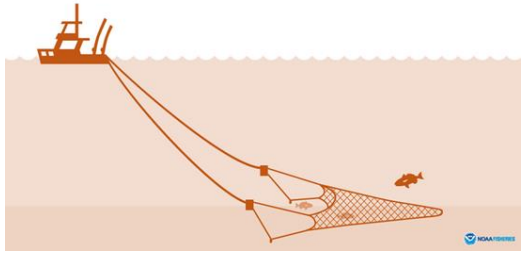


Increases in both pelagic fish such as anchovy and MTC indicate that climate change is having a significant impact on the fish community in China Seas under over-exploitation.

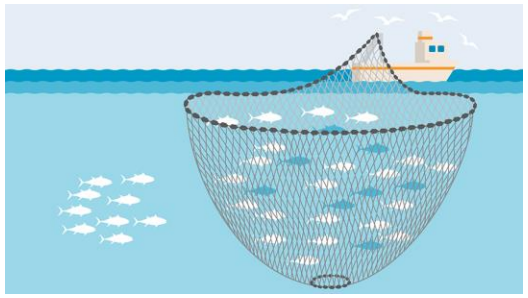
Ma et al., 2019. PiO

Primary fishing gear in China's marine fisheries

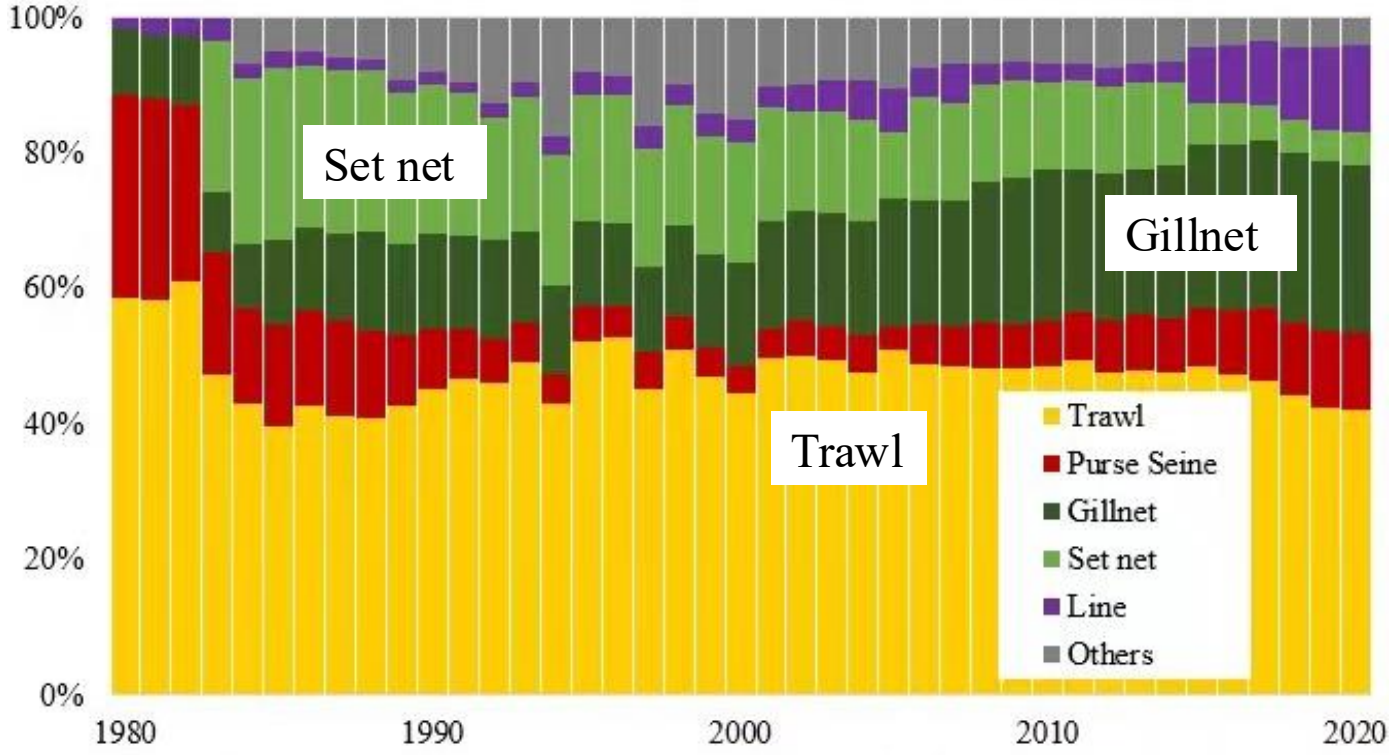
Trawl gillnet and set net are major fishing methods in China Seas

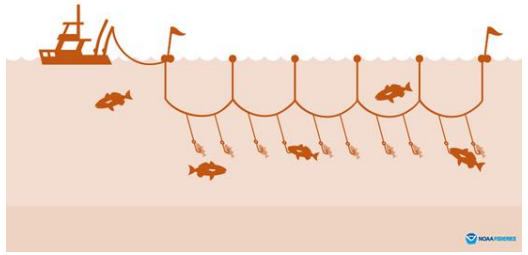


Trawl 拖网

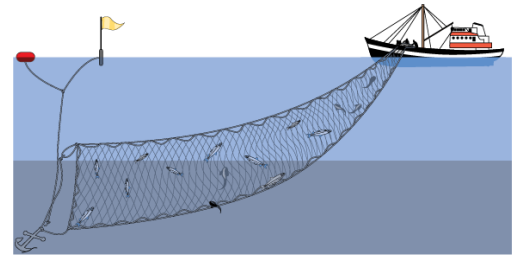


Purse Seine 围网





Longline 延绳钓



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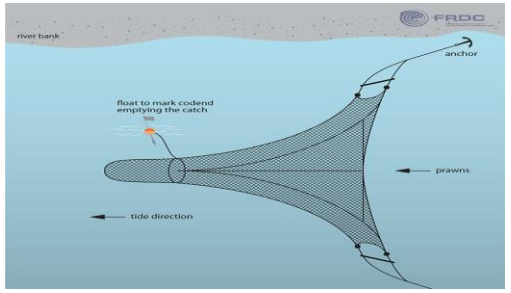
Gillnet 刺网



Set net 定置网

The fisheries management in China Sea is complicated by multi-fishery types and multiple target species.

Outlines

1. Current status of Chinese marine fisheries

2. **Modeling the response of marine fishery resources to climate change and fishing**

3. Summary & outlook: Management responses to climate change

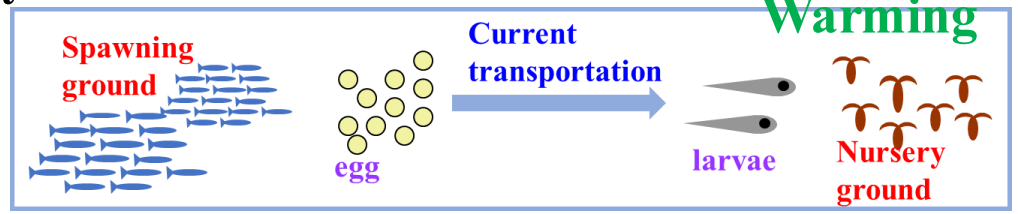
Different process, different scale, different driver, different approach

Process & drivers

Approach

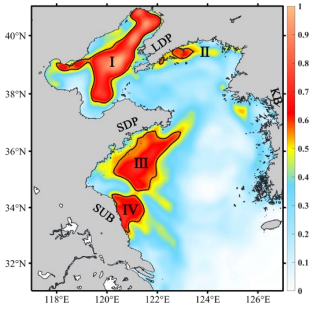
Life history

Early recruitment



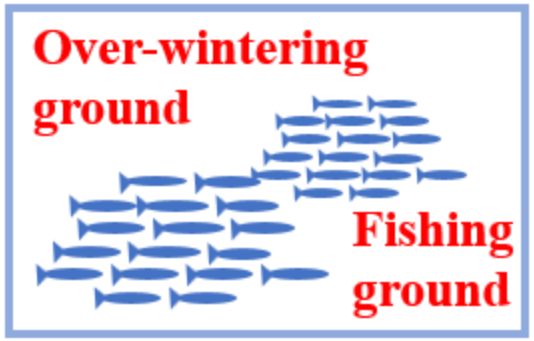
Current
Warming

Larvae transportation model



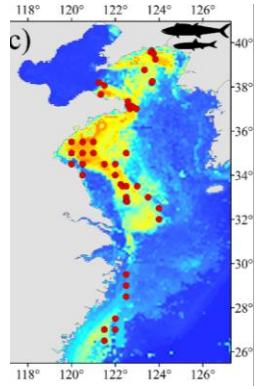
Species

Distribution
Migration
Abundance

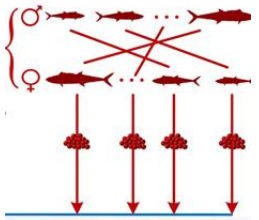


Fishing
Warming
Species interaction

SDM: Species Distribution Model



FIE model

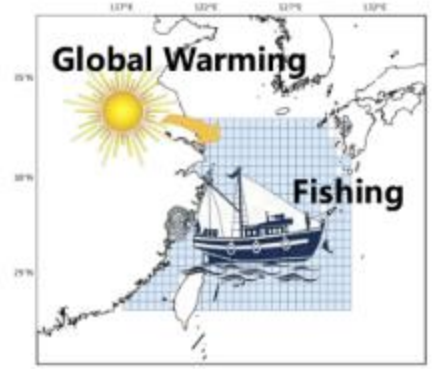


Ecosystem

Ecosystem structure

Population

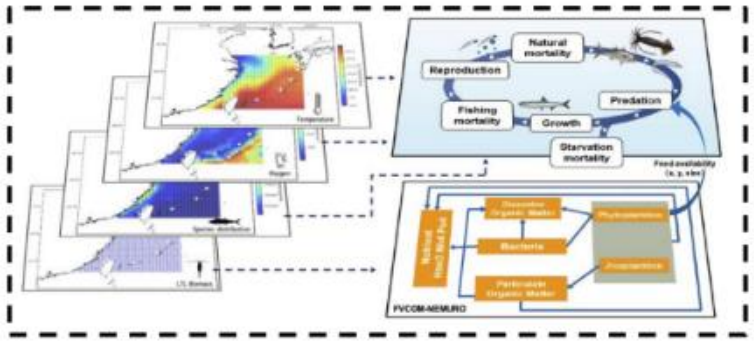
Production



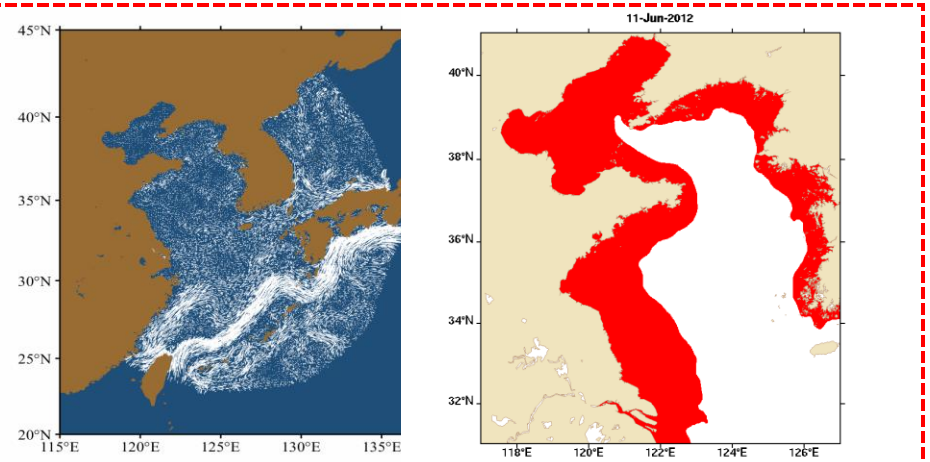
Fishing

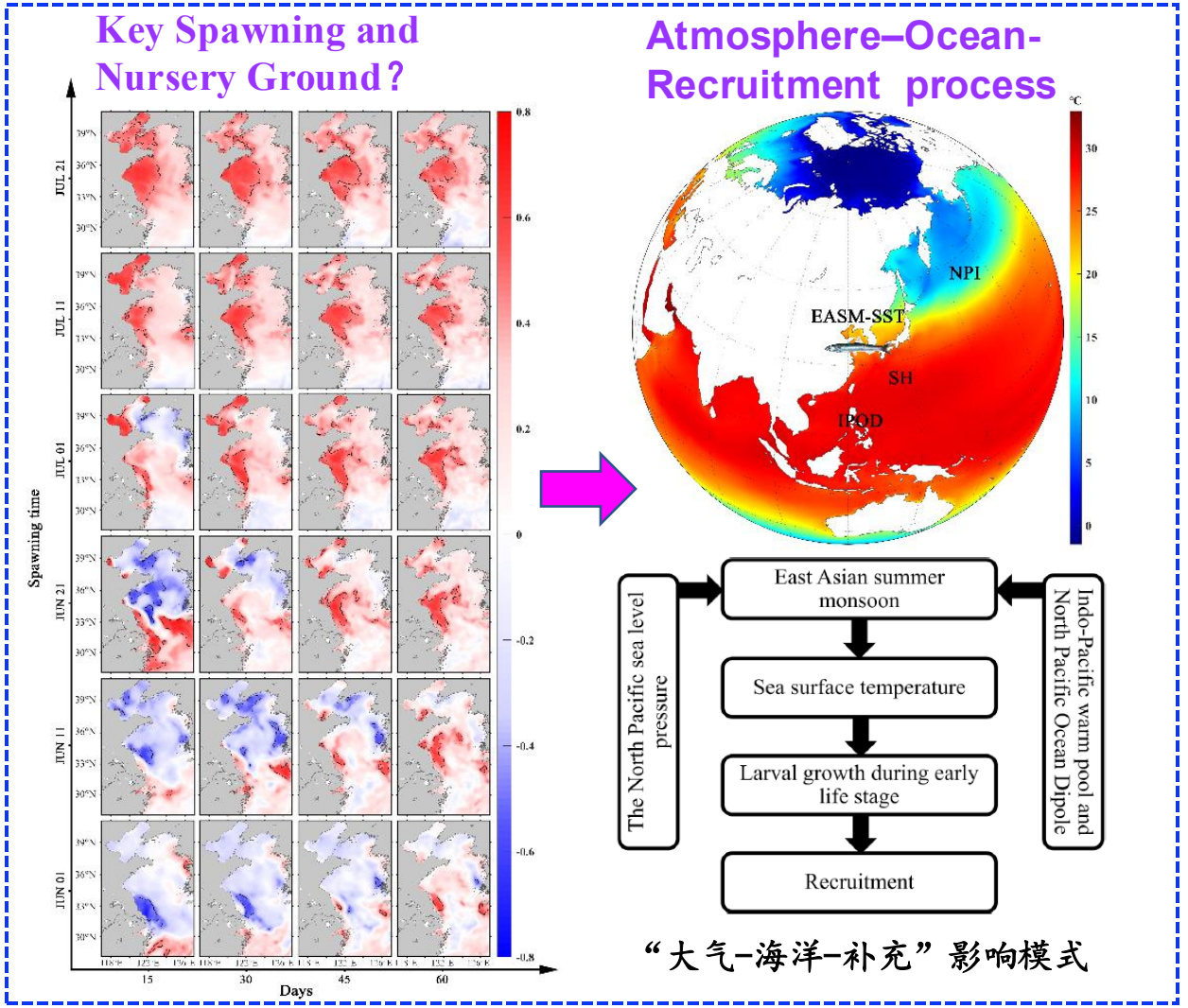
Harvest strategy

OSMOSE



Larvae transport model: Climate variability determines anchovy recruitment



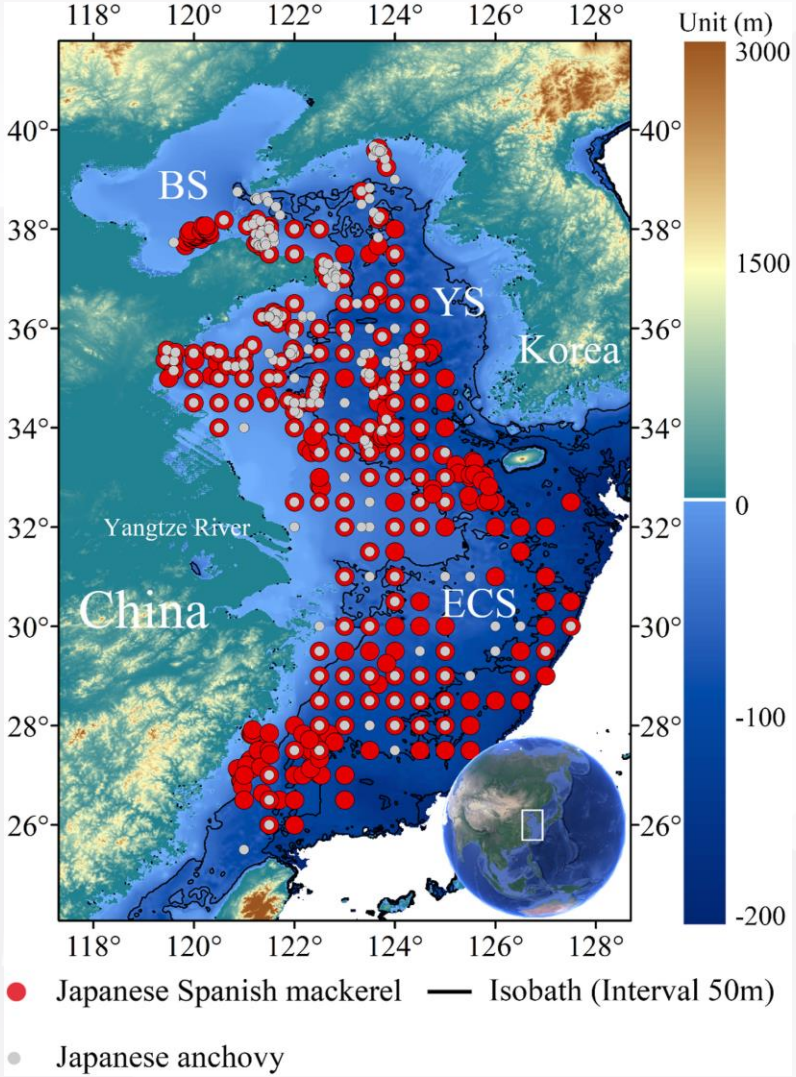


Egg transport model reveal the early recruitment process

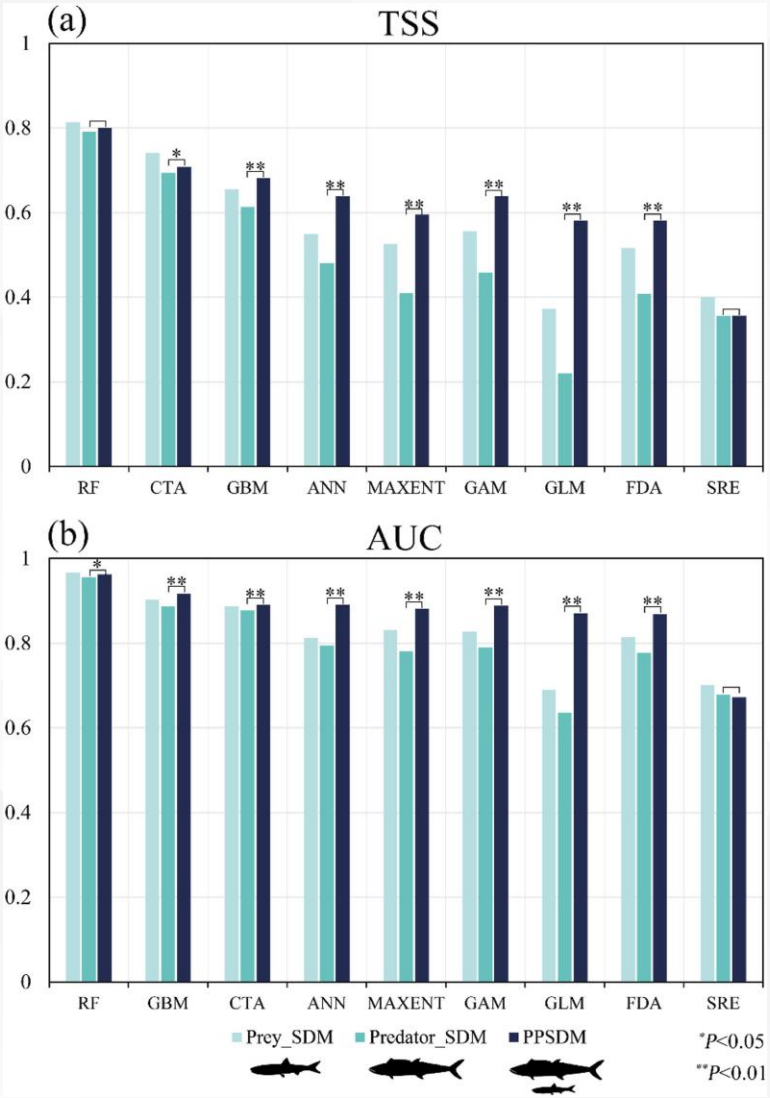
Xing et al. 2020, 2021 Eco.Ind. Yu et al. 2020 JMS

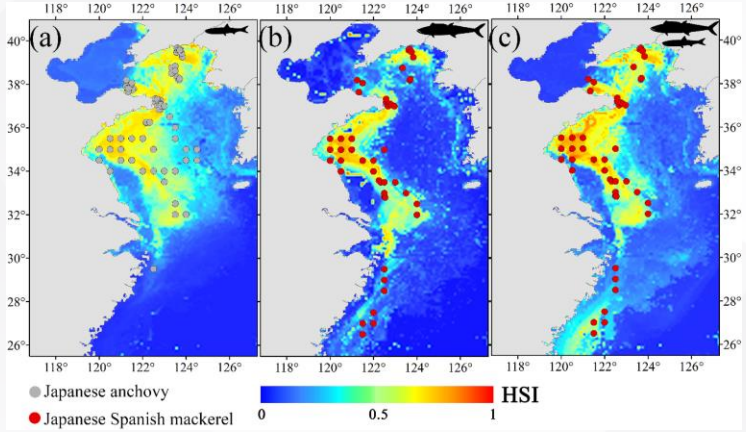
A larval growth index model found that anchovy recruitment is linked to basin-scale climate variability

Prey-Predator SDM model for JS-mackerel



High performance of PPSDM

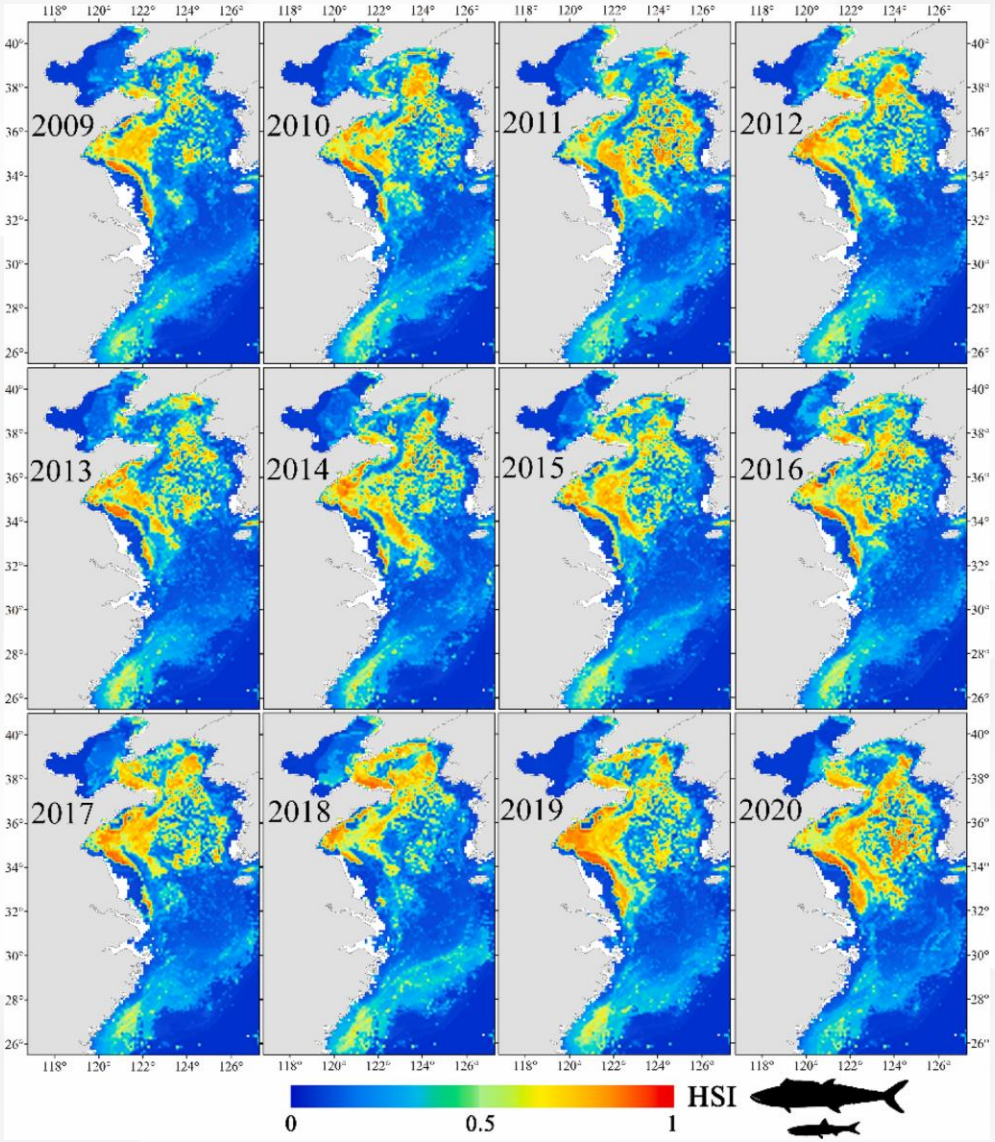




The PPSDM results, which take into account the effect of prey species, well reflected the ontogenetic migration of Japanese Spanish mackerel.

Liu et al., 2022. Deep Sea Research Part II

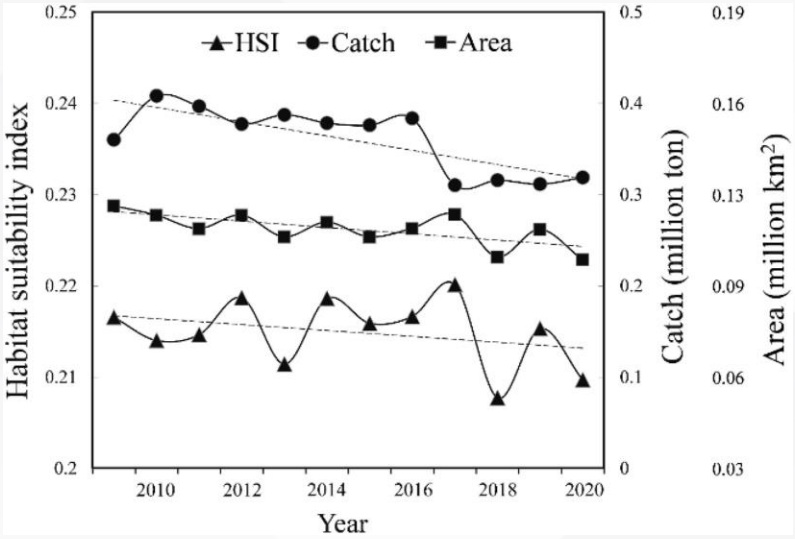
Prediction of warming effect by PPSDM



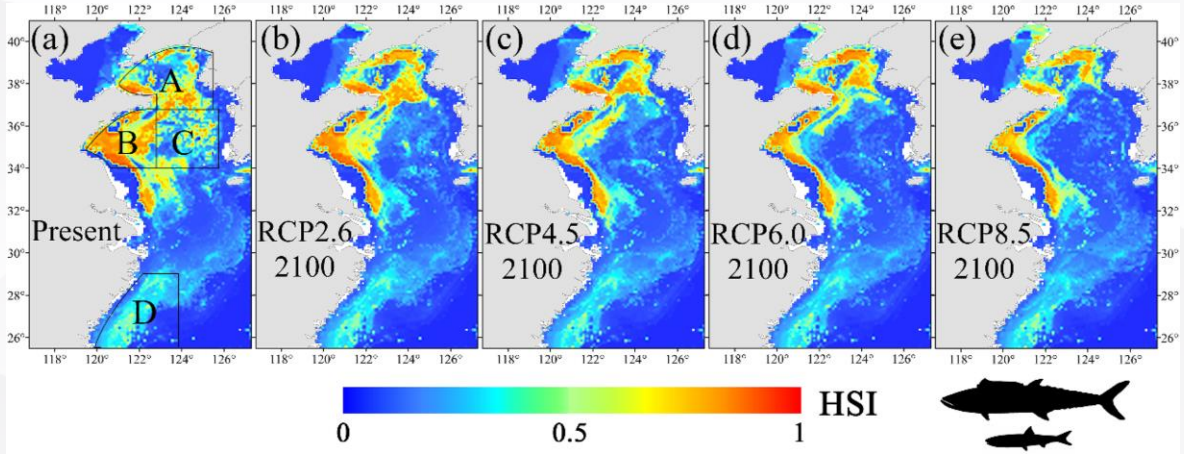
Liu et al., 2022. Deep Sea Research Part II

Historical change

The suitable habitat area and HSI showed a decreasing tendency during 2009–2020, is similar to the trend in the catch.

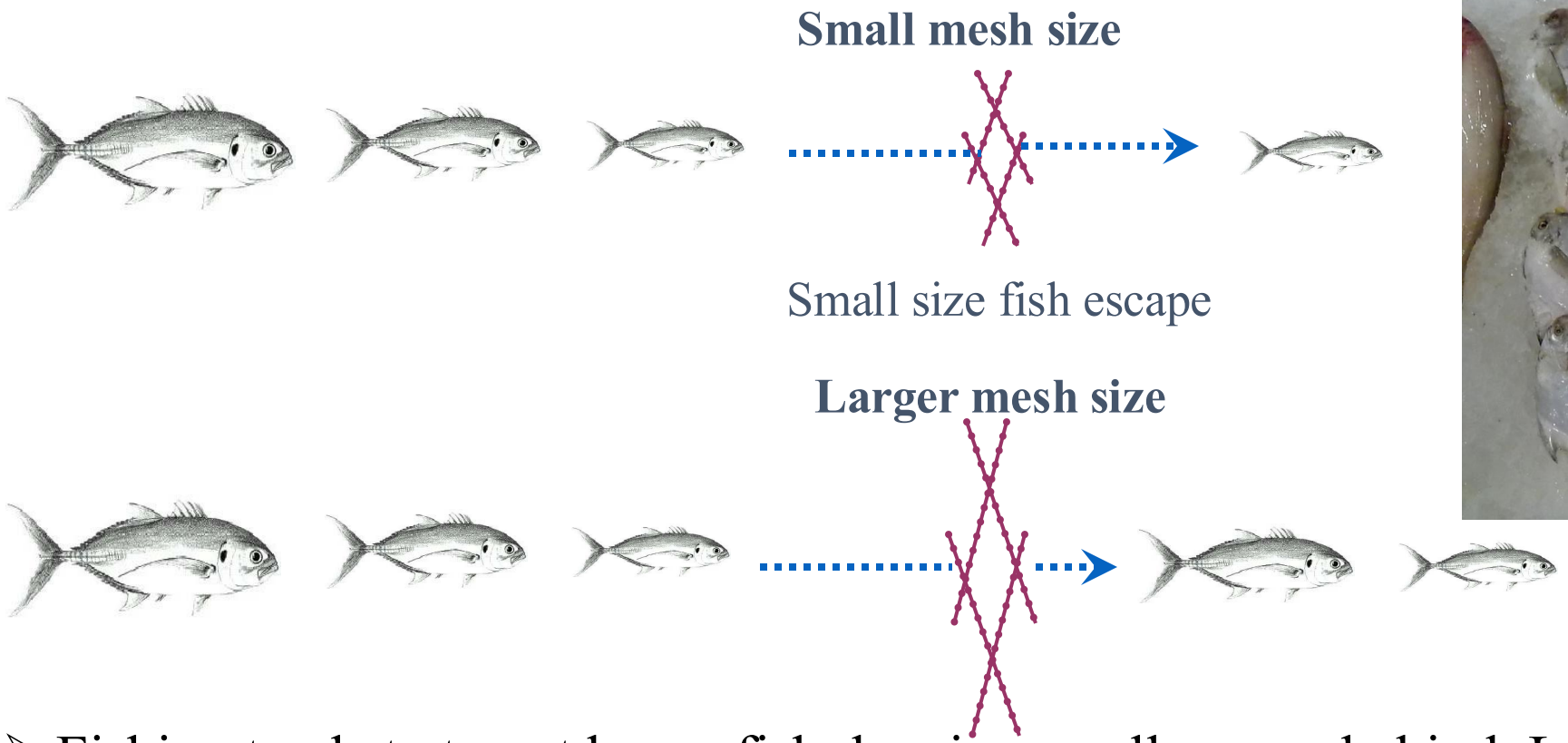


Future warming



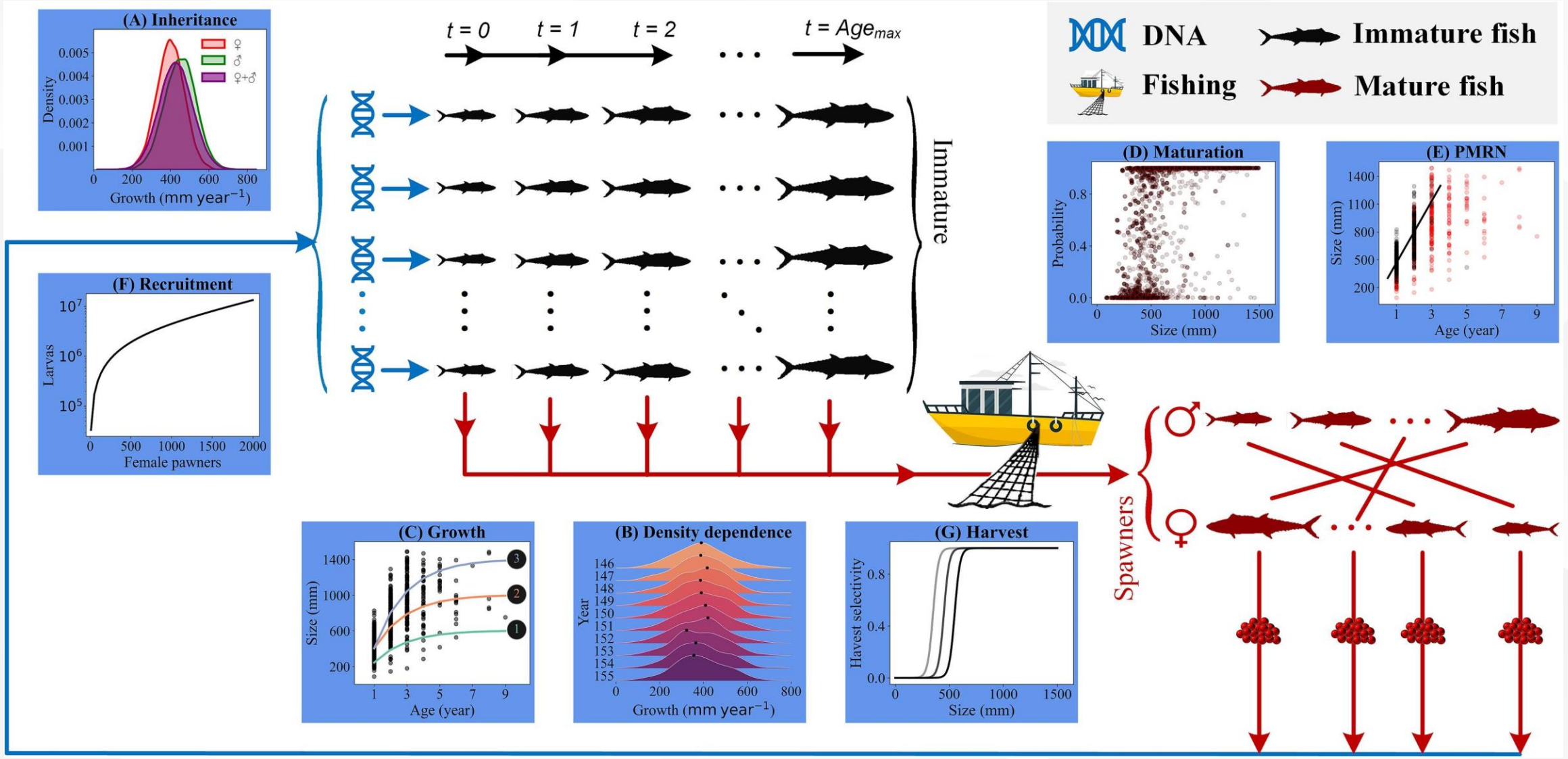
In the future, the suitable habitat of Japanese Spanish mackerel is projected to decrease by 21%, 28%, 36%, and 42%

FIE (Fishing-Induced Evolution): Long-term fishing effect



- Fishing tends to target larger fish, leaving smaller ones behind. Long-term selective fishing can lead to changes in fish populations, such as reduced size and earlier maturation. If these alterations become irreversible, it is termed fishing-induced evolution—FIE, which has a significant impact on both population dynamics and ecosystem structure.

FIE: An individual-based eco-genetic modeling approach

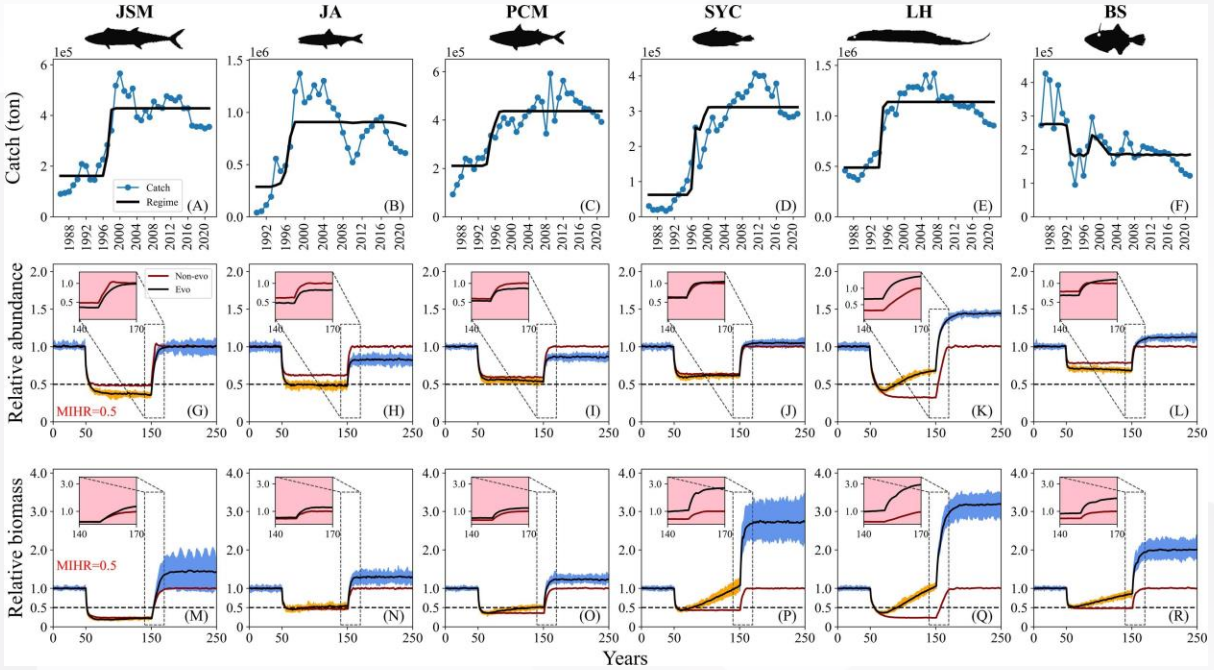


Simulation model functions and dynamics

Liu et al. 2024, Ecological Indicators 168, 112742

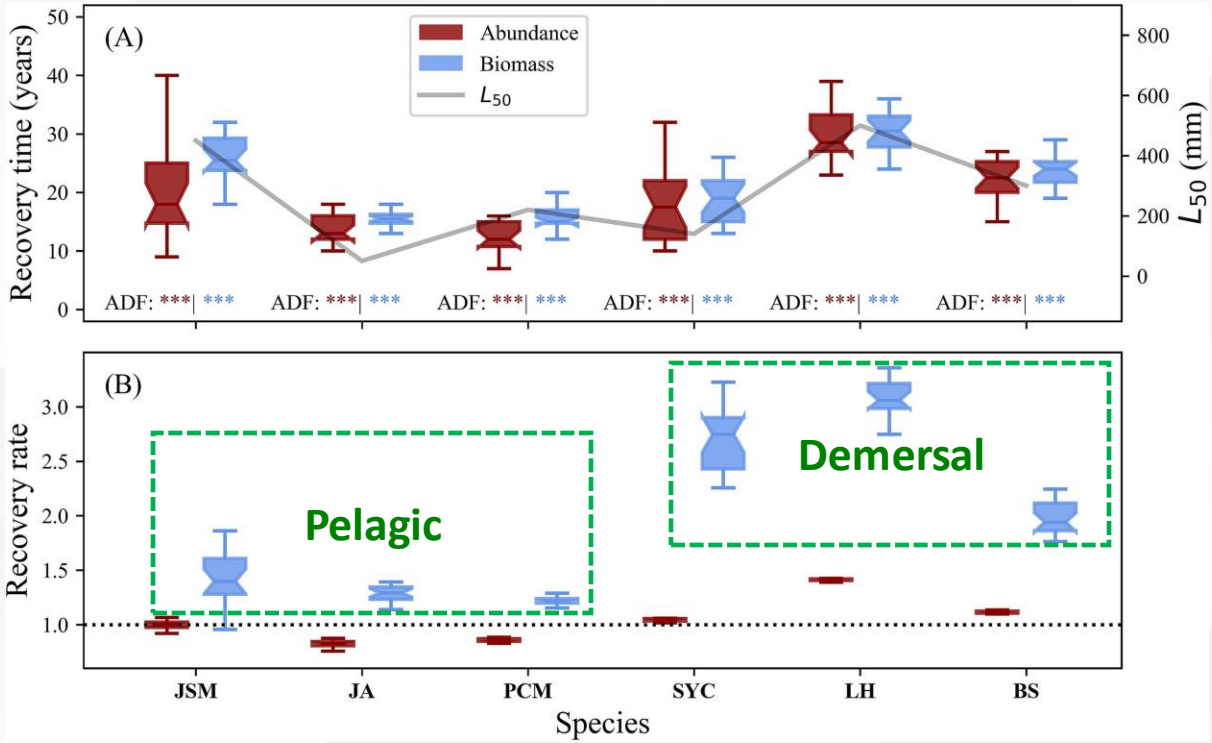
FIE : an individual-based eco-genetic modeling approach

Japanese –Spanish Mackerel | **Japanese Anchovy** | **Chub Mackerel** | **Small Yellow Croaker** | **Largehead Hairtail** | Black **scraper**



Phase shift processes of six commercial fish species in the China Seas. The impact of FIE on abundance (difference between the black and red curves) varies across both phases and species.

Population structure rebuilding efficiency in evolutionary models for six commercial important but rebuilding depleted stocks.

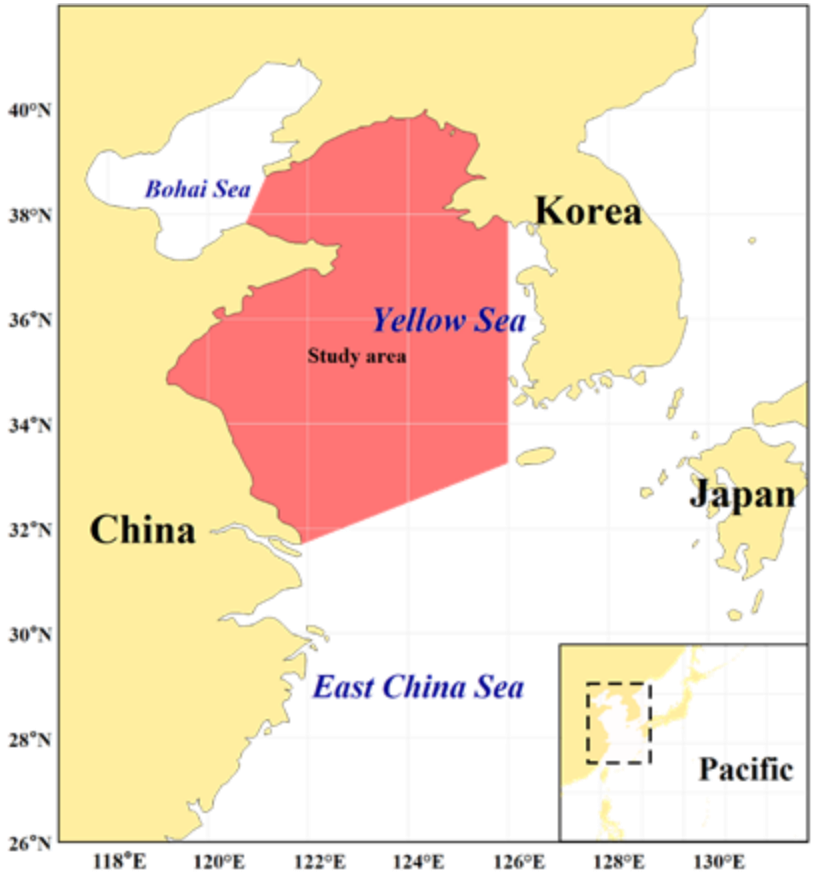


Recovery rate was significantly different between in pelagic and demersal species, with reduced fishing pressure being more conducive to the recovery of demersal fishes.

Liu et al. 2024, Ecological Indicators 168, 112742

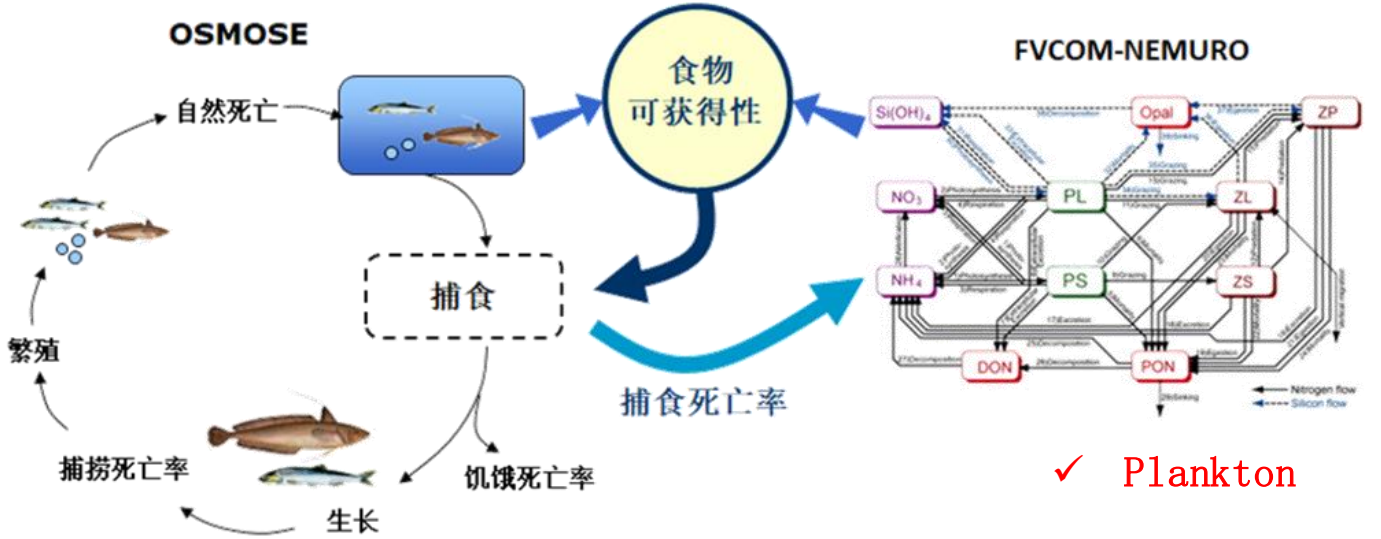
OSMOSE-YS: OSMOSE (Object-oriented Simulator of Marine Ecosystems)

Yellow Sea Large Marine Ecosystem



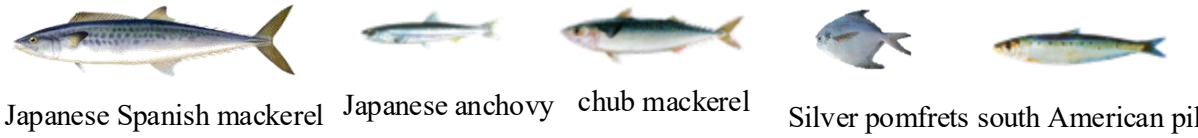
Study area of OSMOSE-YS

黄海渔业生态系统 (OSMOSE-YS)



✓ Plankton

✓ **Pelagic**



Japanese Spanish mackerel | Japanese anchovy | chub mackerel | Silver pomfrets | south American pilchard

✓ **Demersal**

largehead hairtail | small yellow croaker | Pacific cod | yellow striped flounder | Pacific sandlance

✓ **Invertebrate**

Japanese flying squid | swimming crab | southern rough shrimp

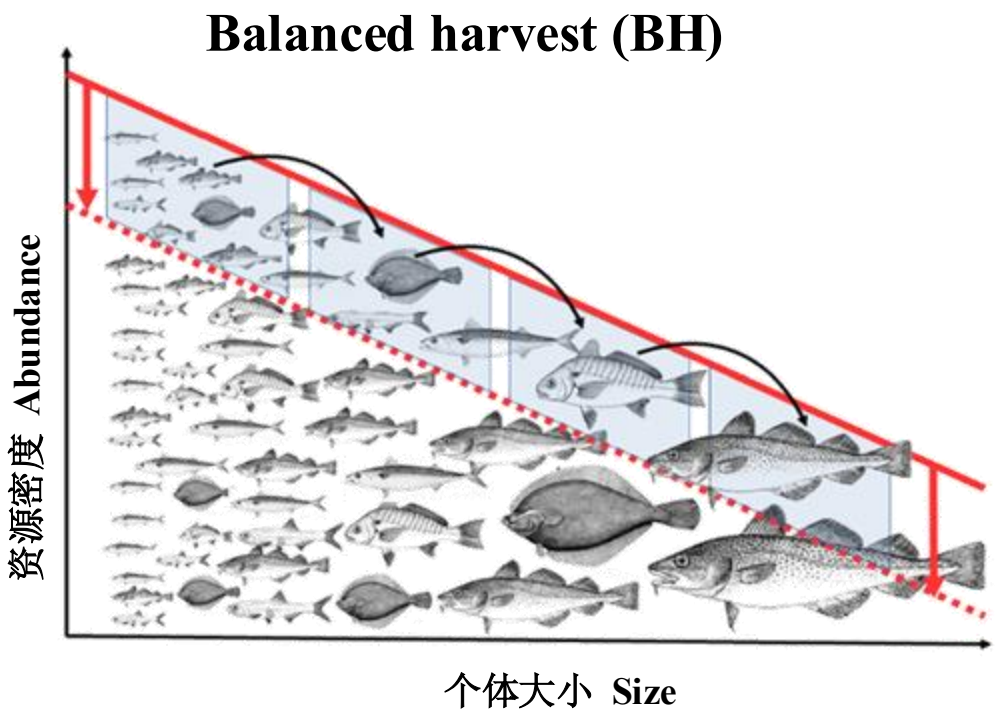
To simulate effect of different fishing strategy

(Sun et al. 2024 JMS)

(Sun et al. 2023 ICES J MAR SCI)

Fisheries management——Balance Harvest (BH) Strategy

平衡捕捞策略 BH



平衡捕捞概念图

(Zhou et al., 2019 PNAS)

- 物种水平 species-level (*sBH*)
- 物种个体大小水平 species- and size–level (*ssBH*)

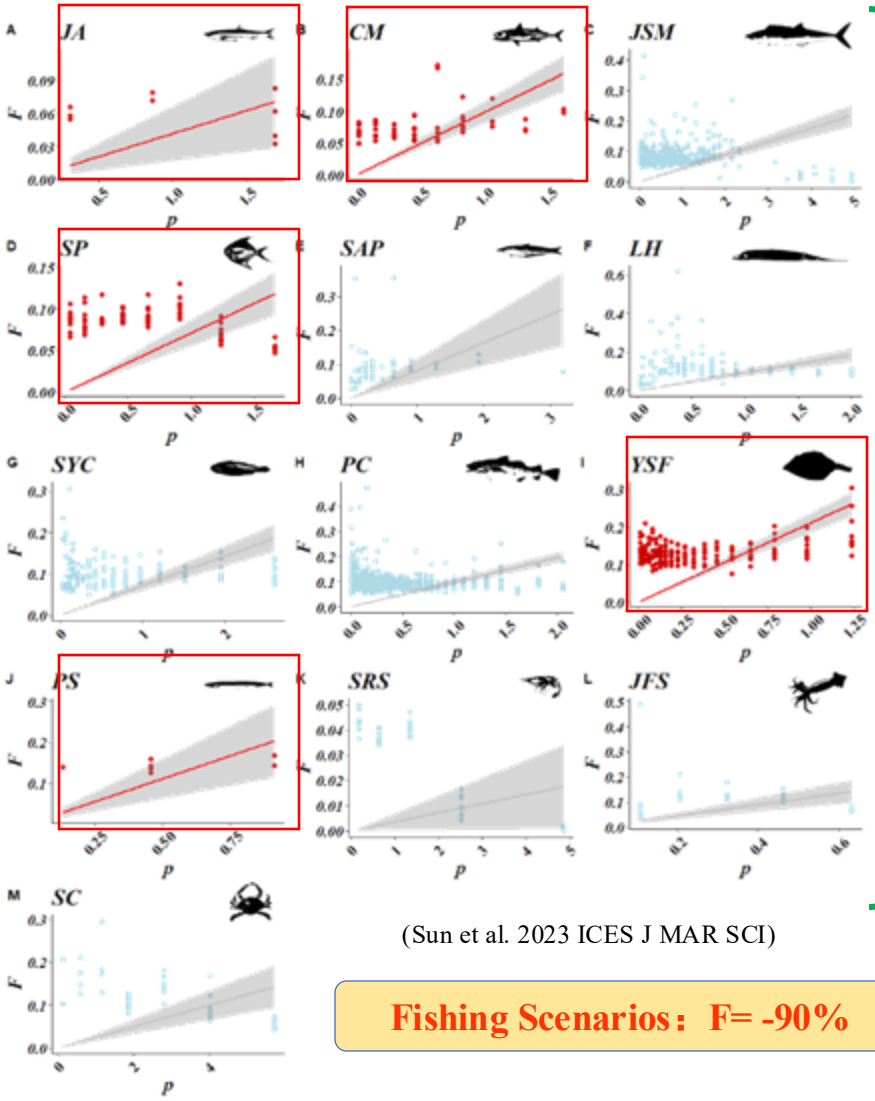
Objectives of Balance Harvest

Minimize the impact of fishing operations on marine ecosystem structure

Achieve sustainable high productivity

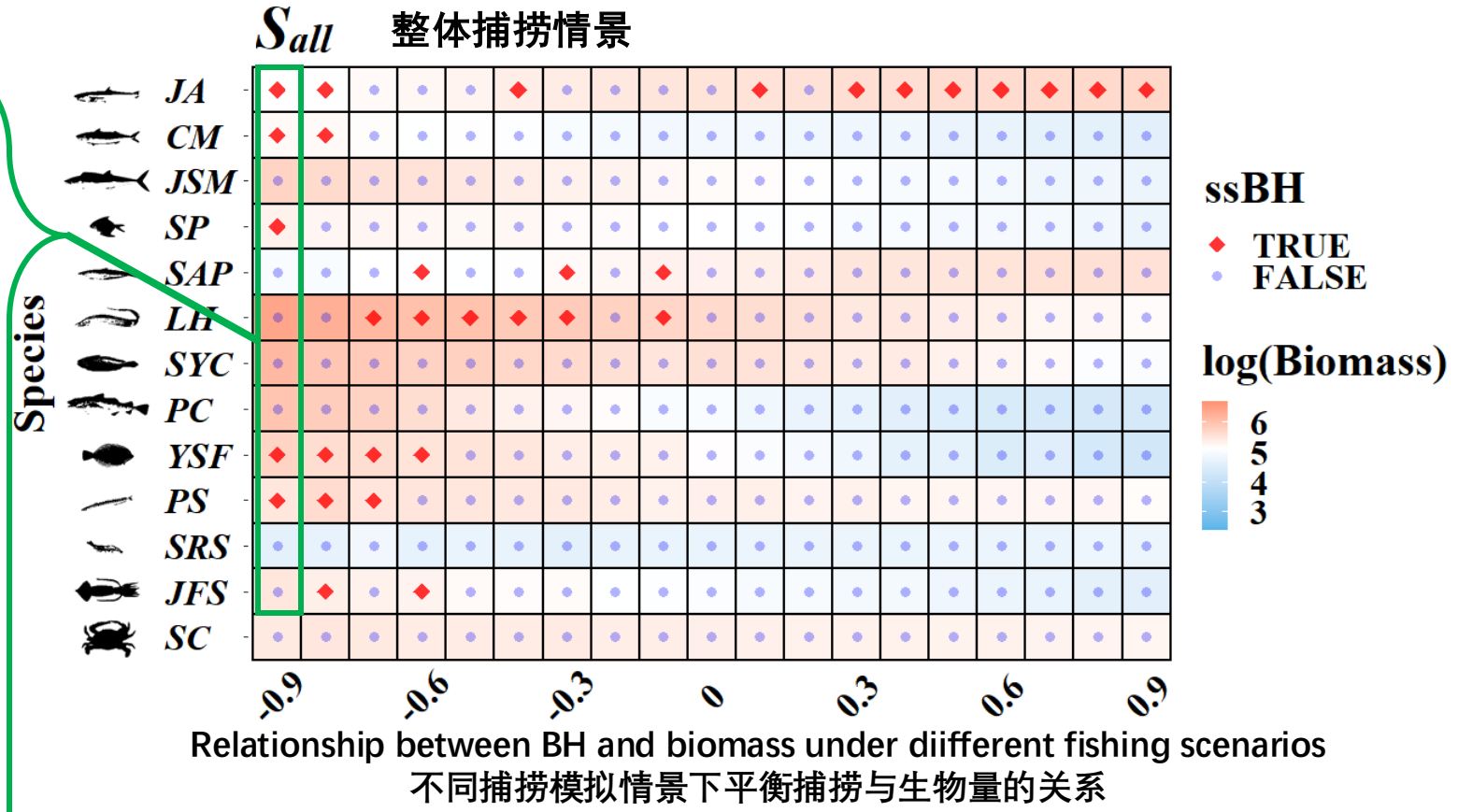
Balanced harvest (BH) proposes moderate fishing mortality rates across all species or sizes in proportion to productivity, serving as a possible strategy for ecosystem-based fisheries management.

How to achieve balance harvest （BH）？



(Sun et al. 2023 ICES J MAR SCI)

Fishing Scenarios：F= -90%



Relationship between BH and biomass under diifferent fishing scenarios
不同捕捞模拟情景下平衡捕捞与生物量的关系

(Sun et al. 2023 ICES J MAR SCI)

The occurrences of BH depended on fishing pressure and targeted functional groups; the benefits of BH could be potentially achieved by adjusting fishing pressure for certain functional groups based on the existing fishing pattern in over-exploited ecosystems.

Outlines

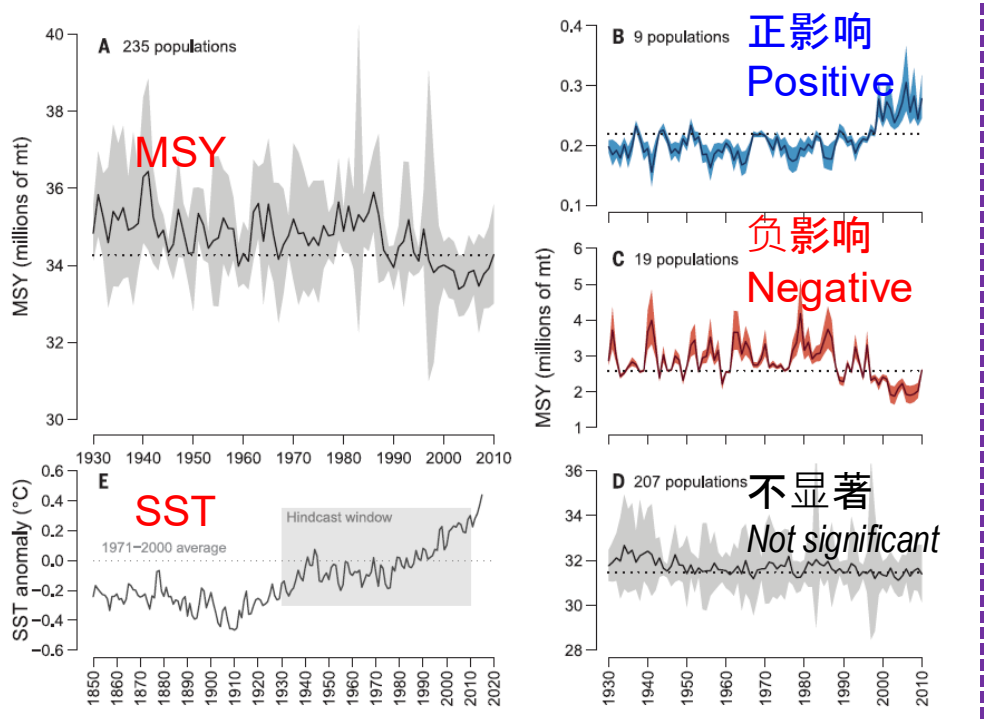
1. Current status of Chinese marine fisheries

2. Modeling the response of marine fishery resources to climate change and fishing

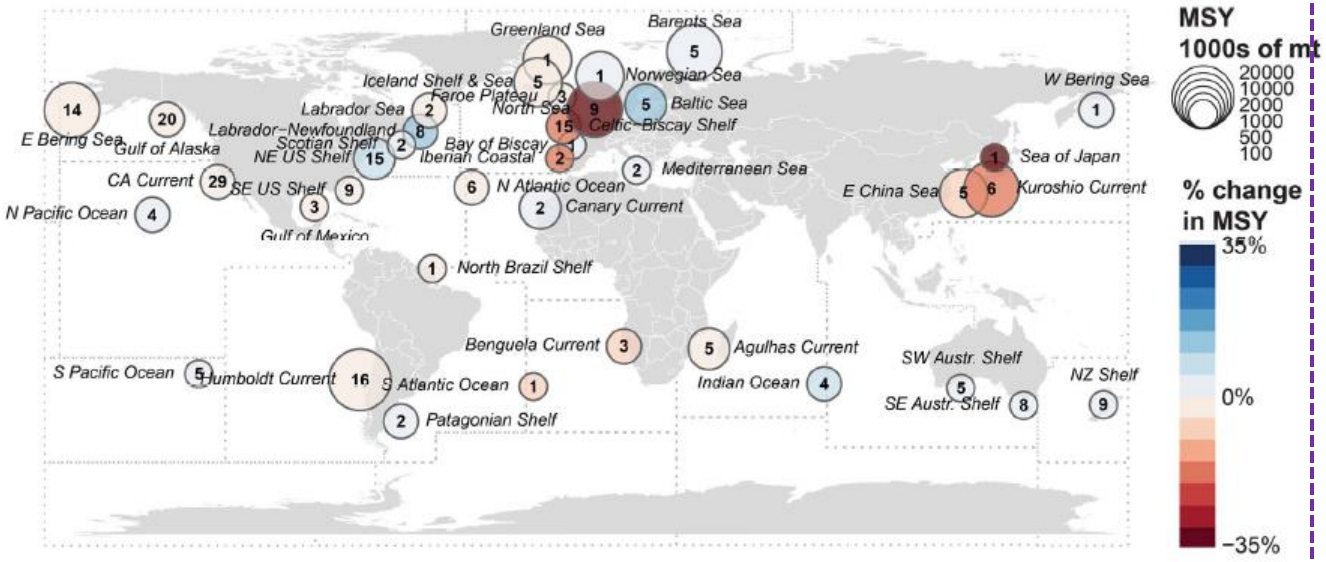
3. **Summary & outlook: Management responses to climate change**

Impacts of historical warming on marine fisheries production

Historical changes of temperature-dependent MSY for 235 populations



Percent change in mean MSY between the period of 1930s and 2000s by ecoregion



Free et al. 2019 Science

The impact of historical SST warming on MSY of 235 fish populations varies. Changes in MSY in the 2010s compared to the 1930s varied considerably between ecoregions. Significant reductions in MSY were observed in both the Northwest Pacific and Northeast Atlantic ecoregions (effects of increasing SST and fishing?)

Global fisheries risk assessments

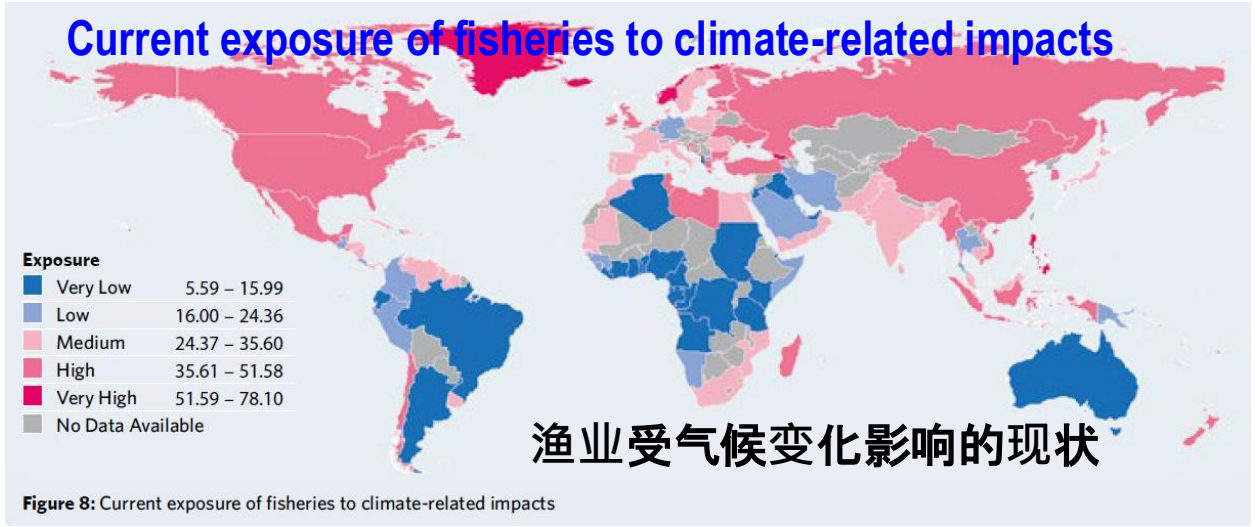


Figure 8: Current exposure of fisheries to climate-related impacts

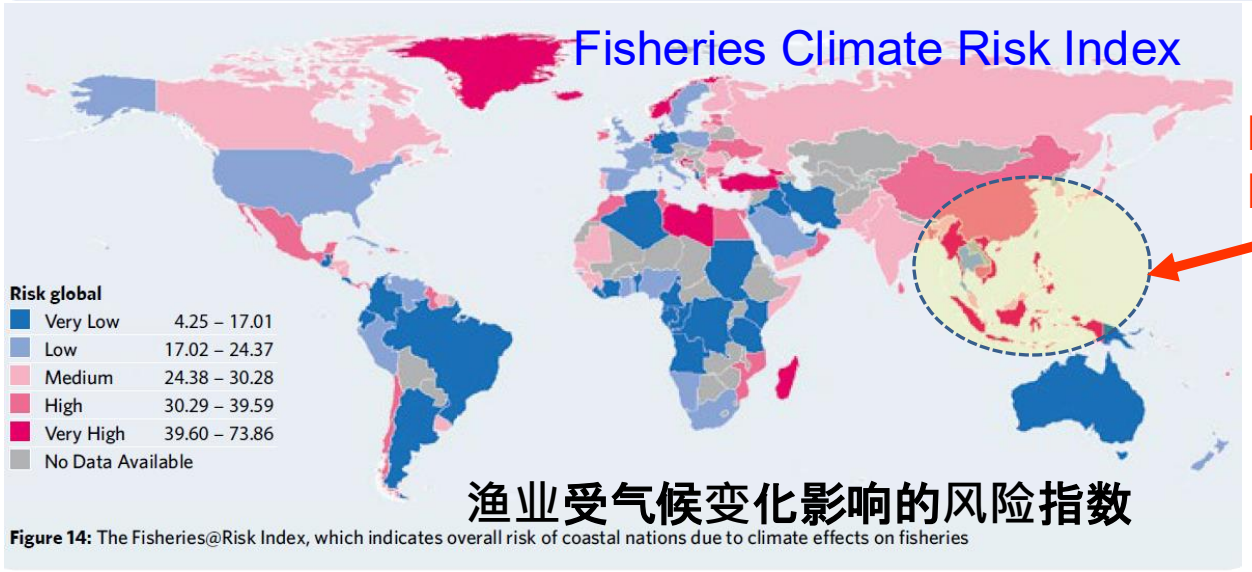
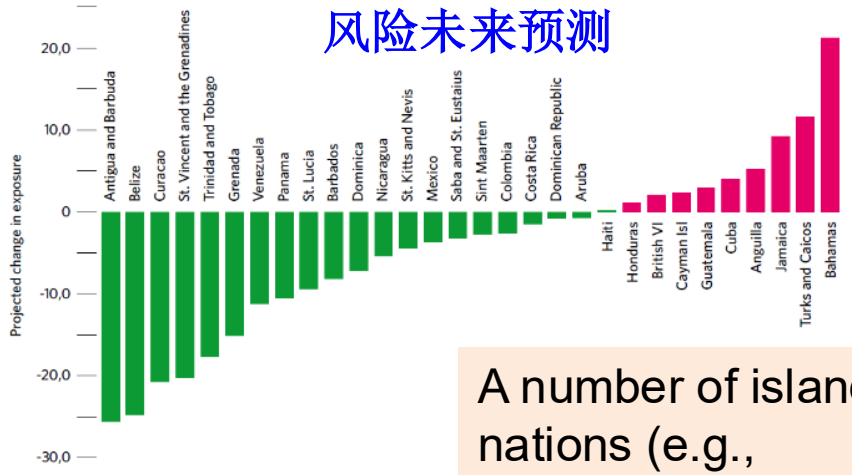


Figure 14: The Fisheries@Risk Index, which indicates overall risk of coastal nations due to climate effects on fisheries

High Risk

Overall risk of coastal nations due to climate effects on fisheries

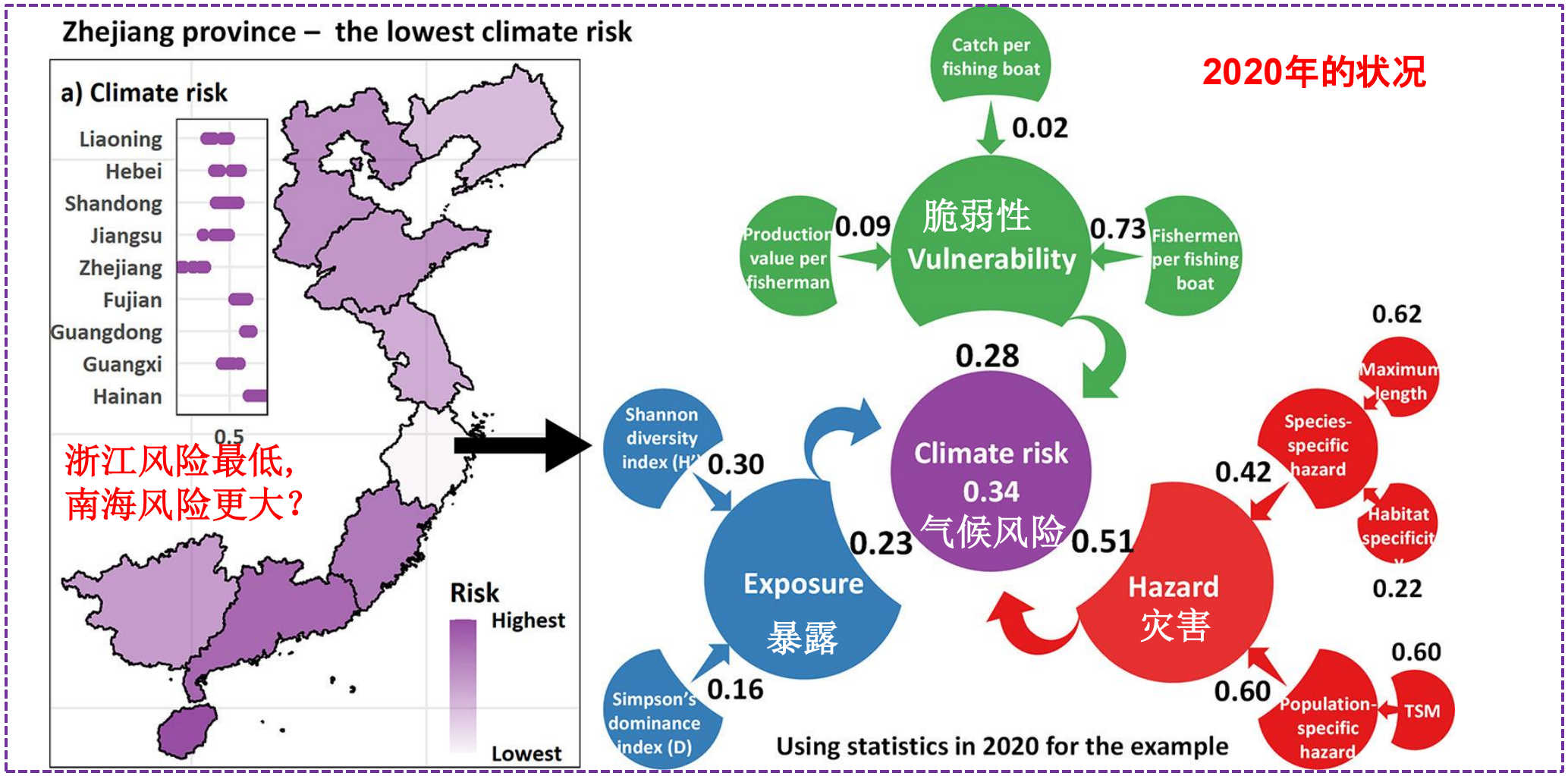
Future Projection of Climate Risk
风险未来预测



A number of island nations (e.g., Bahamas, Jamaica, Anguilla, Cuba) as well as multiple countries on the mainland (e.g., Guatemala, Honduras) are likely to see an increase in exposure

Climate risks to fishing species and fisheries in the China Seas

如何评估中国的渔业和鱼种面临的气候风险?



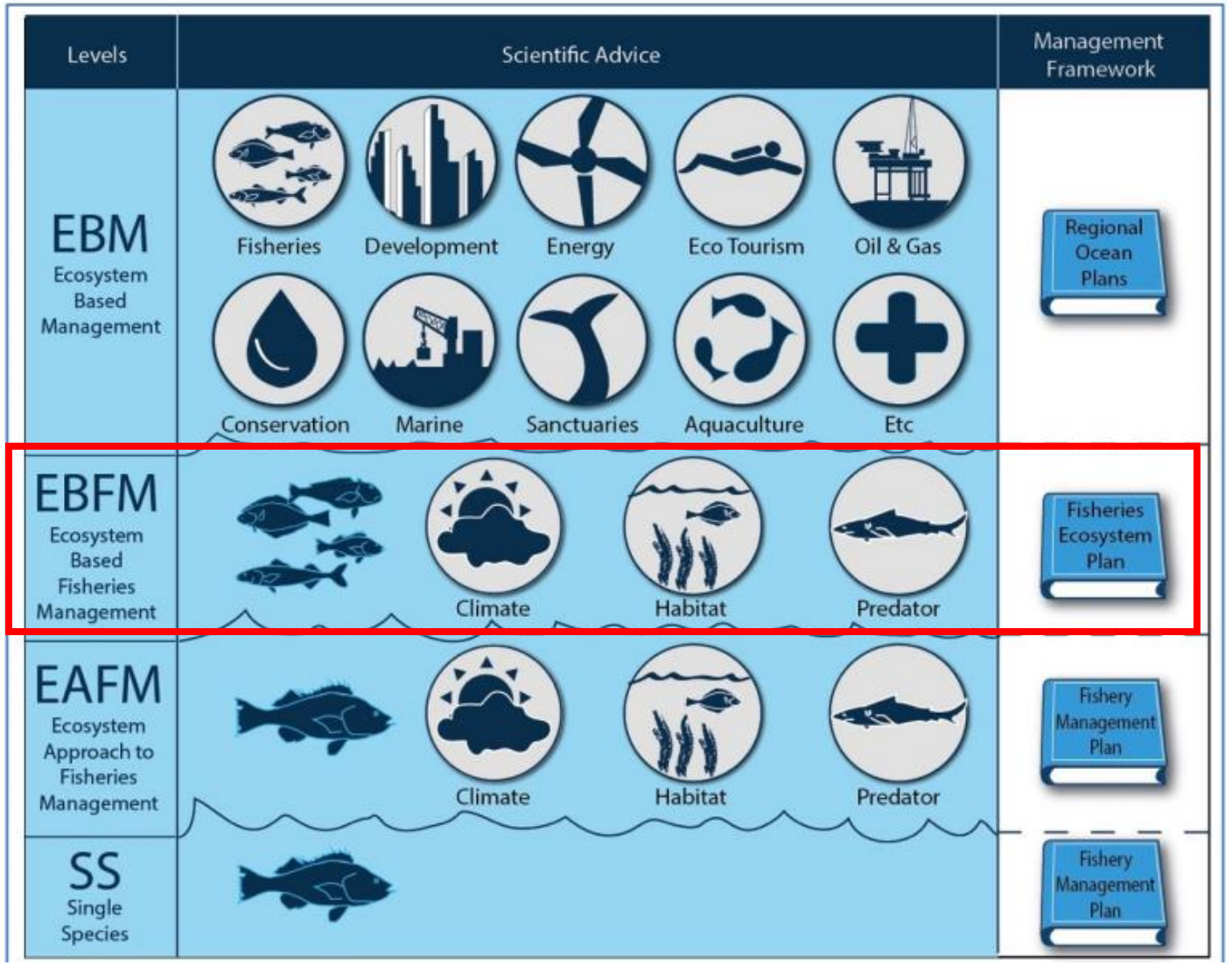
A climate risk assessment framework is used to assess risks to species and fisheries. Future warming would degrade the habitats of most fishing species in China. Risks on fisheries are heterogeneous considering hazard, exposure and vulnerability. Climate adaptation strategies need to be tailored considering provincial realities.

Ma et al. 2023 STOTEN

Toward EBFM: considering the FIE and climate impacts

- Ecosystem-based fishery management (EBFM) aims to sustainably manage the marine fisheries.
- It complements and builds off-of traditional single species fishery management. This approach considers social, economic, and ecological trade-offs across multiple fisheries and habitats.
- Making decisions depends on access to reliable, accurate, and actionable ecological, social, and economic information, tools, approaches, and models.

Fisheries management: from Single Species to Ecosystem Based



Source: http://www.st.nmfs.noaa.gov/ecosystems/ebfm/ebfm-myths#

Summary

- *Changes in the characteristics of fish stocks in the China Seas demonstrate the effects of overfishing and FIE, while the impact of climate change on the structure of fish communities is also significant.*
- *Modelling approaches are useful for investigating the response to fishing (FIE) and climate change at levels ranging from the early stages of life history and species distribution to the ecosystem level.*
- *Climate warming benefits pelagic fish. The recovery rate differs significantly between pelagic and demersal species, with reduced fishing pressure being more conducive to the recovery of demersal fish.*
- *The responses of individual species, fish communities and ecosystems in the China Seas to climate change and fishing are non-linear and species-specific, posing a challenge to fisheries management.*
- *Stock assessment and ecosystem-based fisheries management (EBFM) must consider the impact of climate change; fisheries in coastal nations are particularly vulnerable to future climate change.*

Anchovy Larvae Transport Mode

Ecological Indicators 116 (2020) 106479

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

A comprehensive model-based index for identification of larval retention areas: A case study for Japanese anchovy *Engraulis japonicus* in the Yellow Sea

Qinwang Xing[a,1], Huaming Yu[b,c,1], Haiqing Yu[a,*], Peng Sun[a], Yang Liu[a], Zhenjiang Ye[a], Jianchao Li[a], Yongjun Tian[a,d,e,*]

Ecological Indicators 122 (2021) 107301

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Using a larval growth index to detect the environment-recruitment relationships and its linkage with basin-scale climate variability: A case study for Japanese anchovy (*Engraulis japonicus*) in the Yellow Sea

Qinwang Xing[a,1], Haiqing Yu[a,1], Shin-ichi Ito[b], Shuyang Ma[a], Huaming Yu[c], Hui Wang[d,e], Yongjun Tian[a,f,g,*], Peng Sun[a,*], Yang Liu[a], Jianchao Li[a], Zhenjiang Ye[a]

JS-Mackerel SDM PPSDM

Deep-Sea Research II 207 (2023) 105227

Contents lists available at ScienceDirect

Deep-Sea Research Part II

journal homepage: www.elsevier.com/locate/dsr2

Development of a prey-predator species distribution model for a large piscivorous fish: A case study for Japanese Spanish mackerel *Scomberomorus niphonius* and Japanese anchovy *Engraulis japonicus*

Shuhao Liu[a], Yongjun Tian[a,b], Yang Liu[a,b,*], Irene D. Alabia[c], Jiahua Cheng[d], Shin-ichi Ito[e]

Science of the Total Environment 955 (2024) 176854

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Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Climate change drives fish communities: Changing multiple facets of fish biodiversity in the Northwest Pacific Ocean

Shuhao Liu[a,b], Yang Liu[a,c,*], Qinwang Xing[d], Yuru Li[e], Hao Tian[a], Yanping Luo[a], Shin-ichi Ito[f], Yongjun Tian[a,c]

FIE Model

Ecological Indicators 168 (2024) 112742

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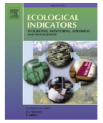

Pelagic and demersal fish population rebuilding in response to fisheries-induced evolution in exploited China Seas

Guankui Liu[a], Peng Sun[a,*], Jin Gao[b], Fabian Zimmermann[c], Yongjun Tian[a,d], Mikko Heino[e,f]

frontiers in Ecology and Evolution

ORIGINAL RESEARCH
published: 28 February 2022
doi: 10.3389/fevo.2022.844693

The Effects of Selective Harvest on Japanese Spanish Mackerel (*Scomberomorus niphonius*) Phenotypic Evolution

Peng Sun[1,2†], Yangke Shang[1], Runlong Sun[1†], Yongjun Tian[1,2†] and Mikko Heino[3,4,5†]*

Yellow Sea OSMOSE Model

ICES Journal of Marine Science, 2023, 0, 1–14
DOI: 10.1093/icesjms/fsad023
Original Article

ICES CIEM International Council for the Exploration of the Sea / Conseil International pour l'Exploration de la Mer

Exploring balanced harvest as a potential strategy for highly exploited multispecies fisheries

Runlong Sun[1], Peng Sun[1,*], Caihong Fu[2], Guankui Liu[1], Zhenlin Liang[3], Yunne-Jai Shin[4], Nicolas Barrier[4] and Yongjun Tian[1,5,6]

Journal of Marine Systems 242 (2024) 103946

Contents lists available at ScienceDirect

Journal of Marine Systems

journal homepage: www.elsevier.com/locate/jmarsys

Exploring fishing impacts on the structure and functioning of the Yellow Sea ecosystem using an individual-based modeling approach

Runlong Sun[a], Peng Sun[a,*], Haiqing Yu[b], Peilong Ju[a], Shuyang Ma[a], Zhenlin Liang[c], Mikko Heino[d,e,f], Yunne-Jai Shin[g], Nicolas Barrier[g], Yongjun Tian[h,i]

Thank You!

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