Dynamic responses of key economic species in the Northwestern Pacific to fisheries-induced evolution: A study on different life history strategies

Peiwu Han[1], Xinjun Chen[1,2,3,4], and Zhou Fang[1,2,3,4]

1. College of Marine living Resource Sciences and Management, Shanghai Ocean University, Shanghai 201306, China; 2. National Engineering Research Center for Oceanic Fisheries, Shanghai Ocean University, Shanghai 201306, China; 3. Key Laboratory of Sustainable Exploitation of Oceanic Fisheries Resources, Ministry of Education, Shanghai Ocean University, Shanghai 201306, China; 4. Key Laboratory of Oceanic Fisheries Exploration, Ministry of Agriculture and Rural Affairs, Shanghai 201306, China

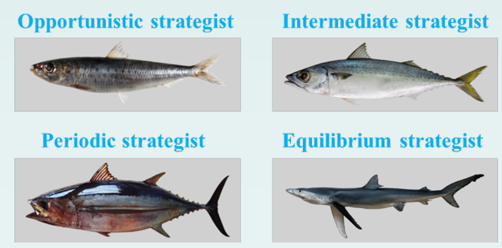
Introduction

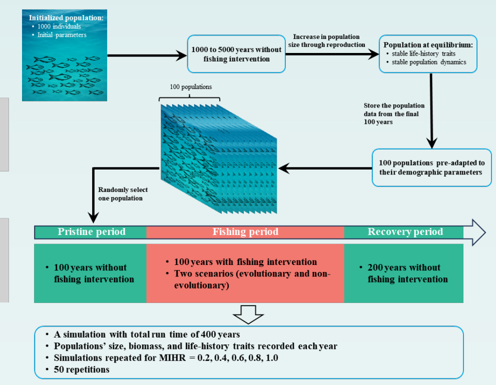
- Increasing evidences suggest that fishing activities can trigger evolutionary changes in fish life history traits and thus affect population dynamics.
- To cope with these fishing pressures and maintain reproductive success, fish populations undergo adaptive evolution, namely, fisheries-induced evolution (FIE).
- most studies primarily focused on the individual or population level and failed to incorporate species with different life history traits, thereby overlooking their diverse responses to overfishing. The goals of the study were (1) to examine the predicted effects of FIE on population dynamics and changes in life history traits and (2) the differences among species with varying strategies.

Methods

Model: An individual-based eco-evolutionary model

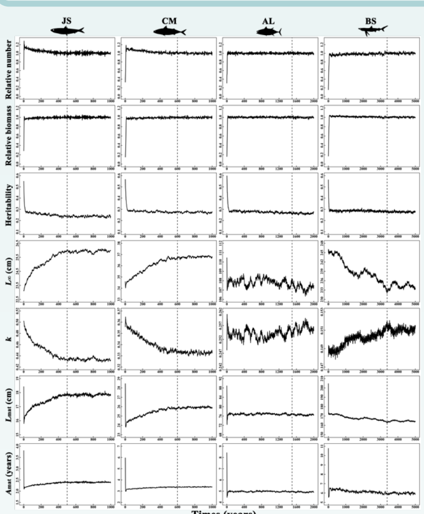
Species: Japanese Sardine (JS), *Sardinops melanostictus*; Chub Mackerel (CM), *Scomber japonicus*; Albacore (AL), *Thunnus alalunga*; blue shark (BS), *Prionace glauca*





Results

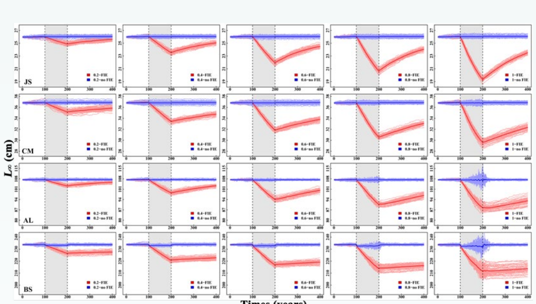
Result 1: Burn-in simulation

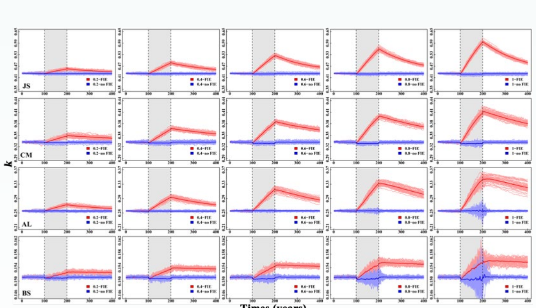


Species		L_∞/cm	k	L_{mat}/cm	A_{mat}/year
Sardinops melanostictus	Max	26.12	0.436	18.12	2.46
	Min	25.83	0.429	17.73	2.37
	Mean	25.97	0.432	17.87	2.40
	SD	0.06	0.001	0.06	0.02
Scomber japonicus	Max	36.92	0.335	26.13	3.45
	Min	36.65	0.330	25.81	3.32
	Mean	36.81	0.333	25.94	3.38
	SD	0.05	0.001	0.07	0.02
Thunnus alalunga	Max	107.87	0.257	76.98	5.01
	Min	106.96	0.254	76.20	4.88
	Mean	107.40	0.256	76.59	4.94
	SD	0.17	0.001	0.18	0.03
Prionace glauca	Max	234.26	0.152	164.71	6.04
	Min	233.12	0.151	163.58	5.85
	Mean	233.65	0.151	164.14	5.94
	SD	0.31	0.000	0.24	0.05

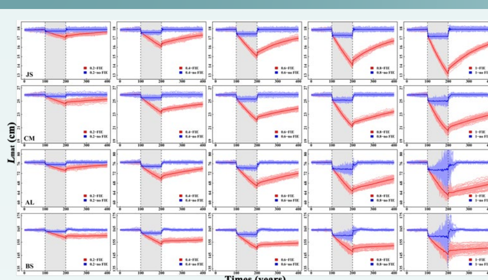
- JS, CM, AL, and BS reached ecological stability respectively after approximately 500, 600, 1500, and 3300 years.
- The simulation results were highly consistent with historical data, validating the accuracy and reliability of the model.

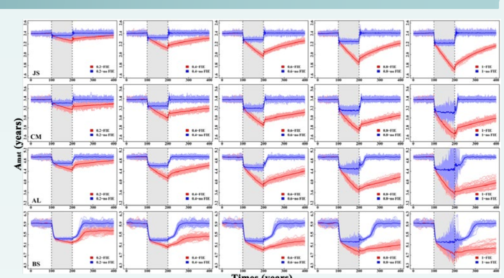
Result 2: Changes in population life history





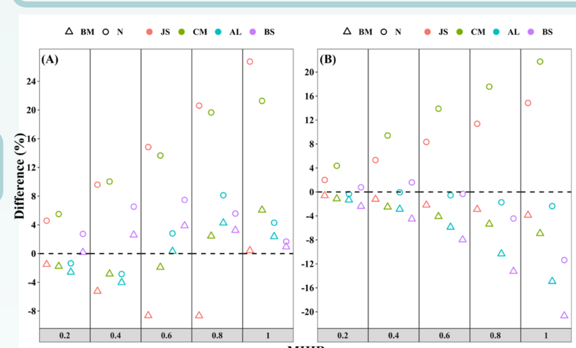
- Dynamic changes in the life history of JS, CM, AL, and BS. The thicker red solid line represents the mean of 50 independent replicates of the scenario with the evolutionary, while the thicker blue solid line represents the mean of 50 independent replicates of the scenario with the non-evolutionary. The vertical dashed lines indicate the start (year 100) and end (year 200) of fishing, and the gray shading represents the 100-year fishing period.



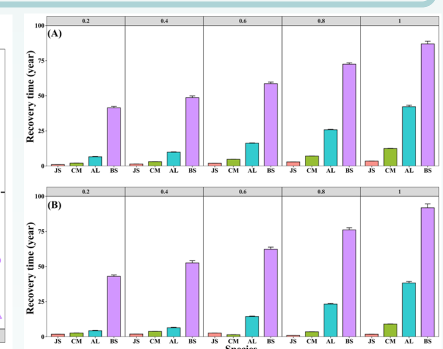


- Reduced body size, accelerated growth, and earlier sexual maturation.
- The evolutionary rates of life history traits in species with different strategies showed extremely significant differences.

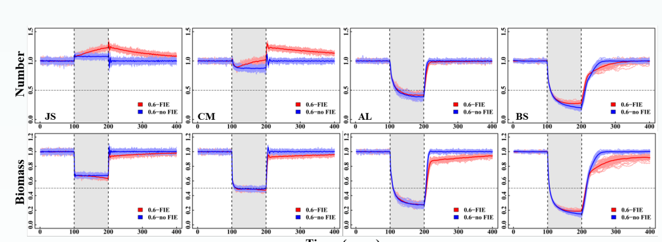
Result 3: Changes in population dynamics



- The difference in relative biomass and abundance between evolutionary and non-evolutionary scenarios. A: fishing phase; B: recovery phase.



- In the non-evolutionary scenario, the recovery time of relative biomass (A) and number (B) for JS, CM, AL, and BS.



- Dynamic changes in the relative number and biomass

- FIE can enhance the resistance of fish populations to overfishing, but it may also reduce their ability to recover under natural fluctuations so that recovery rates lag behind the pace of evolutionary changes.

Acknowledgments

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Contact information

- Email: Peiwu Han: 2718344838@qq.com; Zhou Fang: zfang@shou.edu.cn; Xinjun Chen: xjchen@shou.edu.cn
- Telephone: 86-021-61900304
- Address: Huchenghuan Road 999, Pudong New District, Shanghai 201306, China.