Survey report with overlays to analyze gaps and conservation needs of critical nursery and spawning grounds of priority fish species in the Yellow Sea and make recommendations on new MPAs

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1. Introduction

For most marine fishery species, spawning grounds, feeding grounds, overwintering grounds, and migration routes are critical habitats in the life cycle of fishery species, and are of great significance for maintaining their stock size. Spawning and nursery grounds are waters with suitable temperature, salinity and abundant feeds. These waters are not only suitable for the survival and development of the parent fish, but also conducive to the hatching of fertilized eggs and the growth of larvae and juveniles. Generally, these waters mainly locate in the estuary, bay, coast, shallow coastal waters or intertidal zones. Nowadays, Fishery resources has been closely linked to food production and the development of the marine economy. The spawning and nursery grounds for many commercial fishery species support the sustainable recruitment of fishery resources.

The spawning and nursery grounds of many commercial fishery species such as mackerel, anchovy, small yellow croaker, and Spanish mackerel are distributed along coastal waters of the Yellow Sea, which is of great significance to the sustainable use of fishery resources in the Yellow Sea.

Our project is to achieve the goals of conservation-based management and use of the Yellow Sea Large Marine Ecosystem (YSLME) and its watershed by reducing development stress and promoting sustainable exploitation of the ecosystem from a densely populated, heavily urbanized, and industrialized semi-enclosed shelf sea, and the project focuses on sustainable fisheries management and reducing stress to the ecosystem. So, we will assess the gaps and conservation needs of critical nursery and spawning grounds of priority fish species in the Yellow Sea, and give some recommendations in line with the targets of the YSLME Strategic Action Programme.

This report will briefly analyze the problems facing the spawning and nursery grounds of the major commercial fish species in the Yellow Sea and the protection measures adopted by the Chinese government, further make recommendations on new Aquatic Germplasm Resources Conservation Zones.

2. Conservation of spawning, nursery, overwintering grounds of fish species in China

Aquatic Germplasm Resources Conservation Zone refers to water areas, tidal flats and the adjacent insular reefs and land, which are delimited for special protection in major areas, where aquatic germplasm resources with high economic value and hereditary and breeding value, for the purpose of protecting aquatic germplasm resources and the living environment. In China, Aquatic Germplasm Resources Conservation Zone is important to conservation of fishery species, include national and provincial levels. The national level Aquatic Germplasm Resources Conservation Zone already caused wide attention, the target species for conservation is the important and migratory species with high economic value, special ecological service and genetic and breeding value. The

first batch of national level Aquatic Germplasm Resources Conservation Zones were established in 2007, the number of conservation zones increased year by year. By the end of 2018 (there is no marine Aquatic Germplasm Resources Conservation Zone in the 11th batch in 2018), a total of 535 national level Aquatic Germplasm Resources Conservation Zones are established in ocean, estuaries, rivers, lakes and reservoirs. (Table 1). And a total of 53 national marine Germplasm Resources Conservation Zones have been established (Table 1 and 2). These zones are distributed along the coasts of the Bohai Sea, the Yellow Sea, the East China Sea and the South China Sea (Figure 2). Among these conservation zones, 25 zones are located in Yellow Sea, covering the sea area of 14,580 square meters. (Table 3).

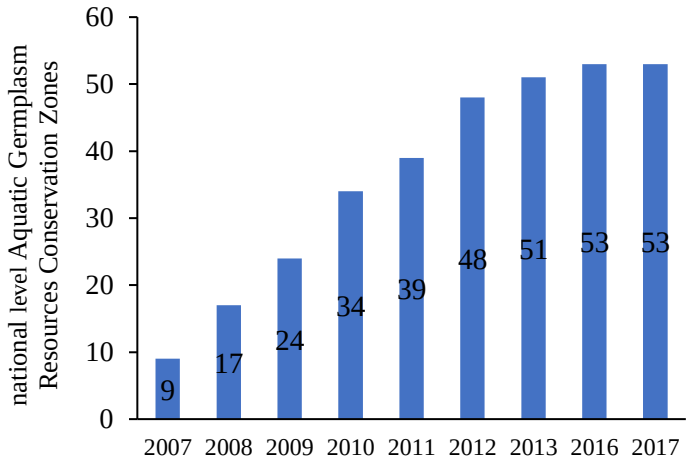

Figure 1 Number of National Aquatic Germplasm Resources Conservation Zones in marine waters in China (2007-2017)

Figure 2 Distribution of National Level Aquatic Germplasm Resources Conservation Zones in marine waters in China

Table 1 The types of National Aquatic Germplasm Resources Conservation Zones in China

Batches	Total	Ocean (covered estuary)	River	Lake	Reservoir
1	40	10	20	10	0
2	63	10	33	18	2
3	57	7	36	14	0
4	60	9	35	15	1
5	62	5	42	13	2
6	86	8	58	20	0
7	60	2	40	12	6
8	36	0	26	10	0
9	28	0	24	4	0
10	31	2	23	6	0
11	12	0	7	5	0
Total	535	53	344	127	11

Table 2: List of National Marine Aquatic Germplasm Resources Conservation Zones in China

No.	The name of protected area	No.	The name of protected area
1.	National Aquatic Germplasm Resources Conservation Zone in Sanshan Island	**28.**	National Aquatic Germplasm Resources Conservation Zone for *Meretrix meretrix* in Yellow River Estuary
2.	National Aquatic Germplasm Resources Conservation Zone in Haiyang Island	**29.**	National Aquatic Germplasm Resources Conservation Zone for *Sebastes schlegeli* in Chang Island
3.	National Aquatic Germplasm Resources Conservation Zone in Dalian Yuan Island	**30.**	National Marine Aquatic Germplasm Resources Conservation Zones for Seaweeds in Chu Island in Rongcheng
4.	National Aquatic Germplasm Resources Conservation Zone in Dalian Zhangzi Island	**31.**	National Aquatic Germplasm Resources Conservation Zone for *Penneropenaeus chinensis* in Rizhao
5.	National Aquatic Germplasm Resources Conservation Zone in Qinhuang Island	**32.**	National Aquatic Germplasm Resources Conservation Zone for *Acetes chinensis* in Wudi
6.	National Aquatic Germplasm Resources Conservation Zone in Changli Sea area	**33.**	National Aquatic Germplasm Resources Conservation Zone for *Octopus variabilis* in Yue Lake
7.	National Aquatic Germplasm Resources Conservation Zone in Nandaihe Sea area	**34.**	National Aquatic Germplasm Resources Conservation Zone for *Penneropenaeus chinensis* in Haizhou Bay
8.	National Aquatic Germplasm Resources Conservation Zone in Liaodong Bay, Bohai Bay and Laizhou Bay	**35.**	National Aquatic Germplasm Resources Conservation Zone for *Bullacta exarate* and *Meretrix meretrix* in Jiangjiasha-Zhugensha sea area
9.	National Aquatic Germplasm Resources Conservation Zone in Shanhai Pass Sea area	**36.**	National Aquatic Germplasm Resources Conservation Zone for *Meretrix meretrix* in Majia River waters
10.	National Aquatic Germplasm Resources Conservation Zone for *Stichopus japonicus* in Kongtong Archipelago	**37.**	National Aquatic Germplasm Resources Conservation Zone for *Solen grandis* and *Antique mactra* in Rudong
11.	National Aquatic Germplasm Resources Conservation Zone for *Haliotis discus* and *Strongylocentrotus nudus* in Chang Island	**38.**	National Aquatic Germplasm Resources Conservation Zone for *Rhopilema esculentum* and *Eriocheir sinensis* in the Shuangtaizi River Estuary
12.	National Aquatic Germplasm Resources Conservation Zone for *Solen grandis* in Haizhou Bay	**39.**	National Aquatic Germplasm Resources Conservation Zone for *Larimichthys polyactis* and *Pampus argenteus* in Lüsi fishing ground
13.	National Aquatic Germplasm Resources Conservation Zone for *Urechis unicinctus* in Laizhou Bay	**40.**	National Aquatic Germplasm Resources Conservation Zone for *Trichiurus haumela* in the East China Sea
14.	National Aquatic Germplasm Resources Conservation Zone for *Trachidermus fasciatus* in Jinghai Bay	**41.**	National Aquatic Germplasm Resources Conservation Zone for *Scomberomorus niphonius* in Xiangshan Bay
15.	National Aquatic Germplasm Resources Conservation Zone for *Paralichthys olivaceus* and *Pseudopleuronectes yokohamae* in Penglai	**42.**	National Aquatic Germplasm Resources Conservation Zone for *Arca granosa* in Yueqing Bay
16.	National Aquatic Germplasm Resources Conservation Zone for *Cynoglossus semilaevis* in the Yellow River Estuary	**43.**	National Aquatic Germplasm Resources Conservation Zone for *Larimichthys crocea* in Guanjingyang
17.	National Aquatic Germplasm Resources Conservation Zone for *Haliotis discus* and *Stichopus japonicus* in Lingshan Island	**44.**	National Aquatic Germplasm Resources Conservation Zone for *Antique mactra* in Zhang Bay
18.	National Aquatic Germplasm Resources Conservation Zone in Jingzi Bay	**45.**	National Aquatic Germplasm Resources Conservation Zone for *Panulirus stimpsoni* in Shangchuan-Xiachuan Islands
19.	National Aquatic Germplasm Resources Conservation Zone in Rushan Bay	**46.**	National Aquatic Germplasm Resources Conservation Zone for *Ostrea rivularis* in Hailing Bay

20.	National Aquatic Germplasm Resources Conservation Zone in Qiansan Island Sea area	**47.**	National Aquatic Germplasm Resources Conservation Zone for *Sanguinolaria acuta* in Jian River Estuary
21.	National Aquatic Germplasm Resources Conservation Zone in Xiaoshi Island	**48.**	National Aquatic Germplasm Resources Conservation Zone for *Mugil cephalus* and *Penaeus penicillatus* in Jieshi Bay in Shanwei
22.	National Aquatic Germplasm Resources Conservation Zone in Sanggou Bay	**49.**	National Aquatic Germplasm Resources Conservation Zone for *Paragyrops edita* and *Penaeus penicillatus* in Beibu Gulf
23.	National Aquatic Germplasm Resources Conservation Zone in Rongcheng Bay	**50.**	National Aquatic Germplasm Resources Conservation Zone in Yongle Atoll Waters of the Xisha Islands
24.	National Aquatic Germplasm Resources Conservation Zone in Taoer River Estuary Sea area	**51.**	National Aquatic Germplasm Resources Conservation Zone in Dongdao waters of the Xisha Islands
25.	National Aquatic Germplasm Resources Conservation Zone in Qianliyan Sea area	**52.**	National Aquatic Germplasm Resources Conservation Zone in Xiangyun Island sea area
26.	National Marine Aquatic Germplasm Resources Conservation Zone for *Coelomactra antiquata* in Rizhao Sea area	**53.**	National Aquatic Germplasm Resources Conservation Zone in Dalian Yuyanjiao waters
27.	National Marine Aquatic Germplasm Resources Conservation Zone for *Solen strictus* in Guangrao Sea area		

Table 3: List of National Aquatic Germplasm Resources Conservation Zones in the Yellow Sea (to 2018)

No.	Name	Location	Geographical coordinates	Target species for protection	Total area (Hectare)
1	National Aquatic Germplasm Resources Conservation Zone in Dalian Yuan Island	Liaoning Province	the zone surrounded by 4 sites:(122°09'14"E, 38°41'22"N）, (122°10'14"E, 38°41'22"）, (122°10'14"E, 38°39'45"N）, (122°09'14"E, 38°39'45"N）	*Haliotis discus*, *Stichopus japonicus*, *Strongylocentrotus nudus*, *Gadus macrocephalus*, *Seriola aureovittata*, *Lateolabrax japonicas* etc.	435
2	National Aquatic Germplasm Resources Conservation Zone in Dalian Zhangzi Island	Liaoning Province	122°41′11″E-122°42′50″E, 39°02′31″N-39°03′32″N	*Stichopus japonicus, Neptunea cumingi Crosse, Saxidomus purpuratus, Azumapecten farreri, Haliotis discus hannai, Strongylocentrotus nudus*	207.3
3	National Aquatic Germplasm Resources Conservation Zone in Haiyang Island	Liaoning Province	123º08'10″E-123º10'17″E, 39º04'59″N-39º06'00″N	*Haliotis discus hannai, Stichopus japonicus, Haliotis discus hannai, Strongylocentrotus nudus*	500
4	National Aquatic Germplasm Resources Conservation Zone in Dalian Yuyanjiao waters	Liaoning Province	121°37′32″E-121°40′12″E, 38°33′46″N-38°35′18″N	*Seriola aureovittata, Verasper variegatus, Paralichthys olivaceus, Azumapecten farreri,Strongylocentrotus nudus*	471.95
5	National Aquatic Germplasm Resources Conservation Zone in Sanshan Island	Liaoning Province	121°48'17″E-121°52'48″E, 38°51'00″N-38°55'48″N	*Haliotis discus hannai, Stichopus japonicus, Strongylocentrotus nudus, Neptunea cumingi Crosse, Rapana venosa, Azumapecten farreri, Atrina pectinata, Saxidomus purpuratus* etc.	4017
6	National Aquatic Germplasm Resources Conservation Zone for *Stichopus japonicus* in Kongtong Archipelago	Shandong Province	121°27'30″E-121°36'42″E, 37°32'30″N-37°37'07″N	*Stichopus japonicus* and it's spawning ground	6841

7	National Aquatic Germplasm Resources Conservation Zone in Xiaoshi Island	Shandong Province	121°59'15.00″E-122°01'27.60″E, 37°31'04.00″N-37°32'12.20″N	*Stichopus japonicus*	471
8	National Aquatic Germplasm Resources Conservation Zone in Jingzi Bay	Shandong Province	122°10'48.50″E-122°04'42.29″E, 37°32'23.73″N-37°35'06.53″N	*Lateolabrax japonicus*	2513.251
9	National Marine Aquatic Germplasm Resources Conservation Zones for Seaweeds in Chu Island in Rongcheng	Shandong Province	122°32'20″E-122°34'36″E, 37°01'54″N-37°03'19″N	*Zostera marina, Gelidium amansii, Scagassum* spp.	471.66
10	National Aquatic Germplasm Resources Conservation Zone in Rongcheng Bay	Shandong Province	122°35'50.19″E-122°38'34.55″E, 37°10'53.79″N-37°15'03.46″N	*Azumapecten farreri, Anthocidaris crassispina*	2134
11	National Aquatic Germplasm Resources Conservation Zone for *Octopus variabilis* in Yue Lake	Shandong Province	122°33'09″E-122°34'53″E, 37°20'10″N-37°21'24″N	*Octopus variabilis*	373.69
12	National Aquatic Germplasm Resources Conservation Zone in Sanggou Bay	Shandong Province	122°27'55.15″E-122°30'32.80″E, 37°03'13.80″N-37°04'43.00″N	*Scapharca broughtonii*	1072.9
13	National Aquatic Germplasm Resources Conservation Zone for *Trachidermus fasciatus* in Jinghai Bay	Shandong Province	121°13'01″E-122°13'42″E, 37°00'48″N-37°04'52″N	*Trachidermus fasciatus* and it's spawning ground, overwintering ground and feeding ground	818.89

14	National Aquatic Germplasm Resources Conservation Zone in Rushan Bay	Shandong Province	121°30'39.80″E-121°34'02.15″E, 36°47'53.00″N-36°49'42.70″N	*Sepia esculenta*	203.474
15	National Aquatic Germplasm Resources Conservation Zone in Qianliyan Sea area	Shandong Province	121°21'48″E-121°24'39.69″E, 36°14'48″N-36°17'6″N	*Haliotis discus hannai, Stichopus japonicus*	1766.27
16	National Aquatic Germplasm Resources Conservation Zone for *Sebastes schlegeli* in Chang Island	Shandong Province	120°49'54.31″E-120°51'56.13″E, 38°02'52.45″N-38°05'08.61″N	*Sebastes schlegeli*	1000
17	National Aquatic Germplasm Resources Conservation Zone for *Haliotis discus hannai* and *Stichopus japonicus* in Lingshan Island	Shandong Province	120°08'16″E-120°12'48″E, 35°46'39″N-35°48'42″N	*Haliotis discus hannai, Stichopus japonicus*	2500
18	National Aquatic Germplasm Resources Conservation Zone for *Penneropenaeus chinensis* in Rizhao	Shandong Province	119°58'36″E-120°06'46″E, 35°08'34″N-35°23'50″N	*Penneropenaeus chinensis*	34900
19	National Aquatic Germplasm Resources Conservation Zone for *Solen grandis* in Haizhou Bay	Jiangsu Province	119°27'00″E-119°32'30″E, 35°11'00″N-35°13'30″N	*Solen grandis*	4288
20	National Marine Aquatic Germplasm Resources Conservation Zone for *Coelomactra antiquata* in Rizhao Sea area	Shandong Province	119°41'08″E-119°43'50″E, 35°31'57″N-35°34'10″N	*Coelomactra antiquata*	883

21	National Aquatic Germplasm Resources Conservation Zone in Qiansan Island Sea area	Shandong Province	119°29'10″E-119°33'49.79″E, 35°09'21.47″N-35°10'54.38″N	*Sepia esculenta*	1798
22	National Aquatic Germplasm Resources Conservation Zone for *Penneropenaeus chinensis* in Haizhou Bay	Jiangsu Province	119°27'E-120°02'E, 34°53'N-35°00'N	*Penneropenaeus chinensis*	19700
23	National Aquatic Germplasm Resources Conservation Zone for *Solen grandis* and *Antique mactra* in Rudong	Jiangsu Province	121°23'56″E-121°29'55″E, 32°35'46″N-32°39'03″N	*Solen grandis* and *Antique mactra*	3250.2
24	National Aquatic Germplasm Resources Conservation Zone for *Bullacta exarate* and *Meretrix meretrix* in Jiangjiasha-Zhugensha sea area	Jiangsu Province	121°16'15″5E-121°25'11″E, 32°53'22″N-32°46'40″N	*Bullacta exarate* and *Meretrix meretrix*	17430
25	National Aquatic Germplasm Resources Conservation Zone for *Larimichthys polyactis* and *Pampus argenteus* in Lüsi fishing ground	Jiangsu Province	Form 122 ° 40 'E westward to the boundary line of the forbidding fishing area, 32°12'N-34°00'N	*Larimichthys polyactis, Pampus argenteus, Pseudosciaena crocea, Trichiurus lepturus, Pampus cinereus, Scomberomorus niphonius, Parapenaeopsis hardwickii, Palaemon graviera* etc.	1350000
	Total areas		1,458,046.285(14580.46285 km^2)		

3. Gaps and conservation needs of the nursery and spawning grounds and some suggestions for new conservation zones

3.1 Problems facing in spawning and nursery grounds of major commercial fish species in the Yellow Sea

3.1.1 Pollution

In recent years, with the development of industrial and agricultural production in coastal areas, and the quality of the marine environment has generally deteriorated. In inshore waters, especially in some ports, inner bays, estuaries, pollution (covering heavy metals, organic compounds, oil spill, nutrients, etc.) are particularly serious. According to the "2018 Communique of the State of the Marine Ecology and Environment of China" issued by the Ministry of Ecology and Environment of China, the sea area that did not meet the first category of seawater quality standards in 2018 accounted for 6.5% of the total area (about 26090 km^2) in the Yellow Sea (Fig.3). Because the main fishery species in the Yellow Sea spawned in the coastal waters. The seriously polluted coastal waters destroyed the spawning and nursery grounds (Tian et al, 1996).

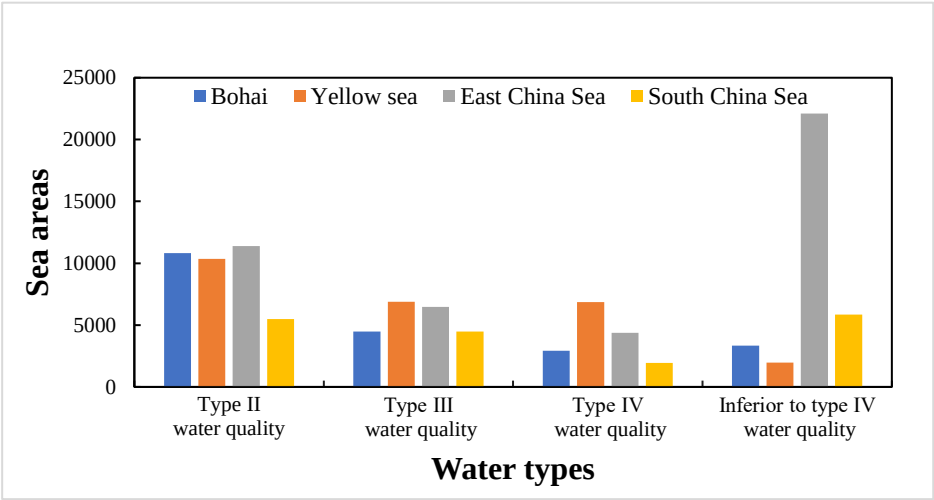

Fig.3 Water quality standards in China coastal waters in 2018

Industrial waste, mine sludge and waste gas, and agricultural wastewater are the main sources of offshore heavy metal and organic compound pollution. They accumulated through the food chain and food web in marine ecosystem. Organic pollution is usually measured by chemical oxygen demand (COD). According to survey data from the Yellow Sea, the average value of COD in this area in 2015 was about 1.10 ppm, of which Dalian Bay was higher than that in other areas, and the Yalu River Estuary, the coast of the northern Yellow Sea, and some waters along Jiangsu province also was beyond the standard.

Oil spill on ships, excessive discharge of oily sewage, and offshore oil extraction usually lead to oil pollution. The oil film floating on the sea will reduce the amount of solar radiation in the surface water, hinder the reproduction of phytoplankton, and cause to decrease the biomass of phytophagous and omnivorous juveniles. In addition, the oil

film can adhere to floating eggs and planktonic juveniles, which can suffocate the juveniles or deform the hatched larvae. According to statistics data, the total area of oil pollution in the Yellow Sea in 2015 was 26 000 km^2. The results showed that the northern Yellow Sea is more seriously polluted, especially in Dalian Bay, and Jiaozhou Bay was more seriously polluted by oil in the southern Yellow Sea.

3.1.2. Overfishing

Although marine fisheries in China accounted for nearly 20% of the global total catch, due to the rapid development of China marine fishery industry, marine catch had become a pillar industry in the development of the marine economy. At the same time, major economic fishery resources has been fully exploited or overexploited in China coastal waters. For example, since the 1980s to the 2000s, the fishing pressure has increased sharply in the Yellow Sea, and the catch of small yellow croaker increased rapidly, caused great decline of fishery resource, leading to the emergence of biological problems, such as simpler age structure, shorter life cycles and earlier sexual maturity (Shan et al, 2011).

3.1.3. Climate change

Global climate change will also impact offshore and inshore fishery resources. It makes sea temperature rise, which change the spatial and temporal distribution of phytoplankton and zooplankton, further changed the primary and secondary production, and indirectly brought some effects on the distribution and stock size of fishery species. At the same time, the changes of the sea temperature will directly change the fishing ground, the migration time and routes of some fishery species. For example, the Spanish mackerel has a strong sensitivity to water temperature, it has different requirements for the water temperature in the different developmental stage of their life history: the earlier fishing period for Spanish mackerel is the early and mid-April, the temperature is 9-11℃; and from late April to early May, the temperature is 11-14℃ during the fishing period; and the optimal temperature for its spawning is 14-16℃. The temperature will affect the growth, feeding, spawning, migrating, physiological activities of fishery species, and further change the quantity and quality of fishery resources.

On the other hand, global warming has caused sea level rise, resulting in the changes of the physical structure of near-shore and inner-bay waters, and then change the habitat of inshore fish species. These changes will bring great impacts on global fisheries.

3.2 Main measures of the Chinese government to protect marine fishery resources

With the fragmentation of spawning and nursery grounds of major commercial fishery species, the replenishment and sustainability of fishery resources have been impaired, and the depletion of marine fishery resources has increasingly restricted the sustainable

development of the marine economy. More and more coastal countries and regions are conducted the effective measures to conserve fishery resources. The main measures taken by China are to start from the management and conservation of fishery resources, and environmental protection of fishery waters.

3.2.1. Management of offshore fishery resources

(1) Formulating laws related to fisheries management

The Chinese government promulgated the Fisheries Law of the People's Republic of China on January 20, 1986, and revised it for the fourth time on December 28, 2013. This national law stipulates the implementation in all sea areas including “closed season/areas", "the minimum mesh size", and other measures to protect juvenile and spawning stocks. On March 8, 2013, the State Council of China promulgated "Several Opinions on Promoting the Sustainable and Healthy Development of Marine Fisheries," which stipulates a series of effective measures for the protection of fishery resources.

Table 4. Current regulations on promoting the sustainable and healthy development of fishery resources in China

No.	Classification	Laws and regulations	Issued time
1	Basic Fisheries Law	Fisheries Law of the People's Republic of China	Issued in 1986, amended in 2013
		Detailed Rules for the Implementation of the Fisheries Law of the People's Republic of China	Issued in 1987
2	Regulations on the conservation and rational use of fishery resources	Order of the State Council of the people's Republic of China on the forbidding fishing areas for motor trawler in the Bohai Sea, the Yellow Sea and the East China Sea	Issued in 1955, supplemented in 1957
		Regulations on the protection of reproduction of aquatic resources	Issued in 1979
		Decision of the State Council on the establishment of juvenile fish protection areas	Issued in 1981
		Measures for the collection of fees for the protection of reproduction of fishery resources	Issued in 1998, amended in 2011
		Closed season/areas 2 or 3 months closed fishing were issued from	Since 1950’s in limited areas; Trawling was

		1995 in BS, YS and ECS; and from 1998 in SCS; 4-4.5 months since 2017	banned from 1988 in Bohai Sea; Summer ban fishing,1995
		Control fishing capacity	Issued in 1987
		Limits of catchable size and the proportion of juveniles in the catch	Issued in 2000
		Environmental fee for stock protection and enhancement activities	Issued in 2000
		The fishing vessel scrapping program	Issued in 2003
		Reduce fuel subsidies	Issued in 2015, reduce by 60% of 2014 during 2015-2019
3	Regulations on fishery output	Interim Regulations on fishery administration	Issued in 1979
		The fishing license	Issued in 1979
		Provisional Regulations on the avoidance of fishing vessel operations	Issued in 1984, amended in 2007
		Administrative measures for aquatic products wholesale market	Issued in 1998
		Regulations on the administration of fishing license	Issued in 2002, amended in 2018
		Regulations on the administration of Pelagic Fisheries	Issued in 2003, amended in 2004
		The “zero-growth” policy	Issued in 1999
		TAC, Quota management pilot	Issued in 2017

(2) Closed season/areas

Summer ban fishing (closed season/areas) is an effective measure to protect the spawning stock and recruitment stock of major marine fishery species. China has been experimenting this fishery system in the Yellow Sea and East China Sea since 1995. Since then, the summer ban fishing system has been adjusted several times, the closed fishing time has gradually extended, the types of fishing gears prohibited operations have gradually increased. In 2017, the closed fishing time was extended for 4-4.5 months. The specific regulations in the Yellow Sea: the fishing prohibited time in the

Yellow Sea area north of 35 °N is four months (12:00 on May 1 to 12:00 on September 1), and the fishing prohibited in the Yellow Sea area between 35 ° ~26°30′N is four and half months (12:00 on May 1 to 12:00 on September 16), all types of fishing gears prohibited except fishing tackle are required to carry out fishing breaks. Since the implementation of this measure, under the organization and deployment at different levels and in accordance with the Fisheries Law and other relevant laws, the fishery administrative directors at all levels along the Yellow Sea and their subordinate fishery administration management institutions have ensured that the organization, publicity, measures, services and funds for the summer ban fishing management. So as to achieve the summer ban fishing management objectives of "fishing vessels in the port, fishermen on the shore, fishing gears in store house ".

Summer ban fishing is a compulsory measure to reduce the fishing intensity, protect marine fishery resources, and maintain ecosystem balance. The prohibited fishing time is the spawning and breeding period of major marine fishery species, which effectively protects the spawning populations and larvae of marine organisms, increases the size of recruitment populations.

(3) Control fishing intensity

The goal of “double-controlling fishing” in China is to adapt the number of fishing vessels and fishing intensity to the renewable capacity of fishery resources by 2020. The mainly measures are as follows: implementation of fishing license system which limited the fishing place, time, number of fishing gears; control the number and the horse power of fishing vessels; restrict the trawls, movable stow net, large lighting purse seine and other fishing gears, specifies the catchable size of trawls, gillnets and winged nets (such as minimum mesh size of the trawl code-end in Yellow Sea: 54 mm) and the catchable size for important commercial fish (such as in Yellow Sea: the catchable size of small yellow croaker ≥150 mm, mackerel ≥220 mm, and Spanish mackerel ≥380 mm), according to the “Regulations on the administration of fishing license”, “Circular on the implementation of the minimum mesh size system for fishing gears and transitional fishing gears for marine fishing” and “Circular on the implementation of the minimum catchable size for 15 important commercial fish and the allowable proportion of juveniles in the catch” by the Ministry of Agriculture and Rural Affairs of China.

(4) Designation of forbidding fishing areas

Forbidding fishing areas are specific waters that protect the breeding of aquatic animals. The forbidding fishing areas, especially the shallow waters within 40 meters along the coast, are the important nursery grounds for fishery species. Prohibiting the operation of a certain type of gear or prohibiting catching a depleted species in these areas is of great significance for protecting and improving the reproduction capacity of fishery resources, maintaining the fishery ecological balance.

Since July 1957, China has delineated the connecting line which consists of 19 basis points, as boundary of motor trawler fisheries closed fishing areas, in the Bohai Sea, the Yellow Sea, and the East China Sea. The inshore waters not beyond this line are regarded as closed areas that all motor trawlers are not allowed. According to the regulations of "Order of the State Council of the People's Republic of China on the no fishing areas for motor trawler in the Bohai Sea, the Yellow Sea and the East China Sea", 1955 and "The supplementary regulations of the order of the State Council of the people's Republic of China on the no fishing areas for motor trawler in the Bohai Sea, the Yellow Sea and the East China Sea", 1957(Fig.4).

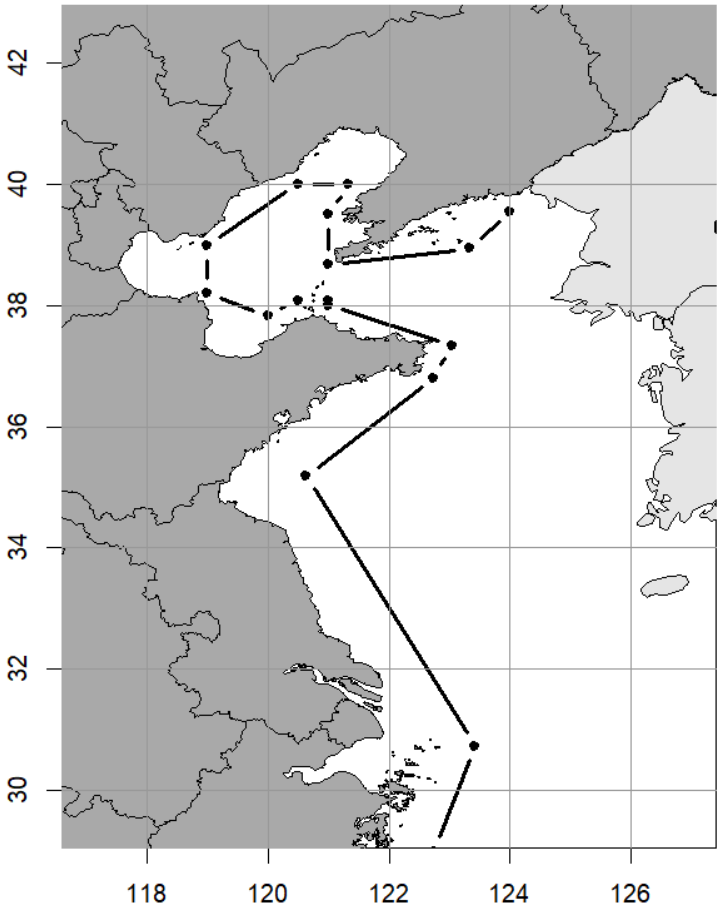

Fig.4 The forbidding fishing areas in the Yellow Sea and Bohai Sea

3.2.2. Marine protected areas

Marine protected area is a representative natural zone which is specially protected marine environment and marine living resources. It is one of the measures to protect marine biodiversity and prevent the deterioration of marine ecological environment. The marine protected areas in China are mainly divided into Special marine protection area (Interim Measures for the administration of Marine Special Protected Areas, 2006) and Marine nature protection area (Measures for the administration of marine nature protection area, 1995), the latter are classified as follows according to different protecting objects: nature reserve for marine ecosystem, marine nature reserve for living

resources, marine natural heritage and non-living resources nature reserve. According to chinagov.cn, the data from the Ministry of Ecology and Environment shows: China has established more than 270 marine reserves at different levels, with a total area of more than 12 million hectares, accounting for about 4.1% of the total sea area to the end of 2017.

3.2.3 Aquatic germplasm resources conservation zones

The aquatic germplasm resources conservation zones mainly protect the important fishery germplasm resources, it belongs to category of marine living resources nature reserves, and it's a certain area of waters, tidal flats and necessary land for special protection and management in the nursery and breeding areas, such as spawning grounds, feeding grounds, migration corridors, etc. The protected objects cover the aquatic germplasm resources and their environment. For example, the small yellow croaker and silver mullet national aquatic germplasm resource conservation zone, located in Lusi fishing ground with a total area of about 1.35 million hectares, mainly protects small yellow croaker and large head hairtail. At present, there are a total of 25 national aquatic germplasm resources conservation zones in the Yellow Sea.

According to the "Specifications for the Delineation of Aquatic Germplasm Resources Protected Areas (Trial)" formulated by China in 2007, the delineation of national aquatic germplasm resources protected areas is carried out under the unified leadership of the Ministry of Agriculture (now called Ministry of Agriculture and Rural Affairs). Besides, the Ministry of Agriculture and the provincial fisheries administrative department establish national and provincial aquatic germplasm resources protected areas review committees to review the declared aquatic germplasm resources protected areas. The regulations provide that the waters and tidal flats that meet one of the following conditions can be designated as aquatic germplasm resources protected areas: (1) spawning, feeding, wintering grounds and migration corridors and other major growth and breeding areas of key fishery resources with higher economic value. (2) it has high genetic and breeding value, and is the leading species of aquaculture in China; (3) natural concentrated distribution area of aquatic organism endemic. (4) Representative or typical areas of concentrated aquatic biodiversity; (5) the area of aquatic ecosystem with special ecological protection or scientific research value and significant impact on fishery development or other human activities. (6) Other areas that need to be protected.

For the establishment of aquatic germplasm resources conservation zone, the management of resource protected areas shall be carried out in accordance with the Interim Measures for the Administration of Aquatic Germplasm Resources Protected Areas issued by the Ministry of Agriculture in 2011, as follows:
(1) The approved establishment of the aquatic germplasm resources conservation zones shall be managed by the fishery administrative department of the people's government at or above the county level in the place where it is located, and the corresponding

administrative organization shall be defined, with necessary management, law enforcement and technical personnel and corresponding equipment and facilities, and be responsible for the management of the aquatic germplasm resources conservation zones.

(2) The Ministry of Agriculture and Rural Affairs and the Department of fishery administration at the provincial level shall set special protection periods for the key stages of growth and breeding, such as the breeding period and the growth period of larvae, of the main protected objects in the national and provincial aquatic germplasm resources protection areas. And, during the period of special protection, fishing, blasting and other activities that may cause damage to living resources and environment in the conservation zone are not allowed. Besides, the fishing activities beyond the special protection period shall comply with the provisions of the Fisheries Law and relevant laws.

(3) For those engaged in the construction of water conservancy projects, dredging channels, building gates and dams, exploration and exploitation of mineral resources, port construction and other projects in the aquatic germplasm resources conservation zone, or those engaged in engineering construction activities outside the aquatic germplasm resources protection areas that may damage the function of the protection areas, a special demonstration report shall be made on the impact of the aquatic germplasm resources protection areas and it shall be included in the environmental impact response evaluation report.

(4) The competent fishery administrative department at or above the provincial level shall participate in the environmental impact assessment of the construction projects involving the aquatic germplasm resources reserve, organize experts to examine the special demonstration report on the impact of the construction projects on the aquatic germ plasm resources reserve, and issue opinions to the construction unit and the competent environmental impact assessment department according to the review conclusions. The construction unit shall incorporate the opinions of the fishery administrative department into the environmental impact assessment report and take relevant protection measures in accordance with the opinions of the fishery administrative department.

(5) Units and individuals engaged in aquatic resources investigation, scientific research, teaching practice, tour, film and television shooting and other activities in the aquatic germplasm resources conservation zone shall abide by relevant laws and regulations and the management system, and shall not damage the aquatic germplasm resources and their environment.

(6) It is prohibited to engage in lake farming, land construction or reclamation in the aquatic germplasm resource conservation zone.

(7) It is forbidden to build new sewage outlets in the aquatic germplasm resources conservation zone. The construction, reconstruction and expansion of sewage outlets near the aquatic germplasm resources conservation zone shall ensure that the water body in the conservation zone is not polluted.

(8) The cancellation and adjustment of aquatic germplasm resources conservation zones shall be handled in accordance with the establishment procedures.

(9) If there are some damages to the aquatic germ plasm resources and their environment in the aquatic germplasm resources conservation zone, the fisheries administrations at or above the county level or its subordinate fishery administration supervision and administration organizations shall deal with it according to law.

3.2.4 Environmental protection of fishing areas

The protection of habitat of marine organisms is the basis for the restoration of fishery resources. It is about 80% of marine pollutants from land, and most of them all concentrated in inshore waters. Therefore, controlling the discharge of land-based pollutants is the key to improve the water quality and environment. China has set up ecological monitoring areas in important water areas and implemented online monitoring to grasp the dynamics of water quality. At present, Shuangtaizi Estuary ecological monitoring area, North Jiangsu shoal ecological monitoring area and Yangtze River estuary ecological monitoring area have been established along the Yellow Sea to regularly monitor marine pollution and evaluate the marine environment quality. For example, the "China sea surveillance 11" is a law enforcement ship that monitors and enforces the marine environment of the Bohai Sea and the Yellow Sea.

3.3 Analysis of spawning and nursery grounds of major commercial species

Anchovy, small yellow croaker, mackerel and Spanish mackerel are important economic fishes in the Yellow Sea. Anchovy is a small-size pelagic fish in the coastal waters, as well as the important fishing target of trawling fishery, the development of anchovy fisheries promotes the development of aquatic processing industry (fish meal and fish oil) in the coastal area. Small yellow croaker is one of the important marine fishery species in China, it’s the target species of bottom trawl, drift net, and it's also the target of fixed fisheries. Mackerel is one of the important economic fishes in the Yellow Sea. At present, the production of mackerel is from light-purse seine, followed by trawl and drift net, the rapid growth of the number of purse seine fishing vessels in China and the excessively high catches are the main reasons for the decline of mackerel resources in recent years. Spanish mackerel is a warm-temperate and long-distance migratory fish species, as the most important large pelagic fish with high economic value in the Yellow Sea. According to the “Investigation and division of fishery resources in the Yellow Sea and Bohai Sea”, the location of spawning and nursery grounds of four commerical fish can be determined.

3.3.1 Anchovy

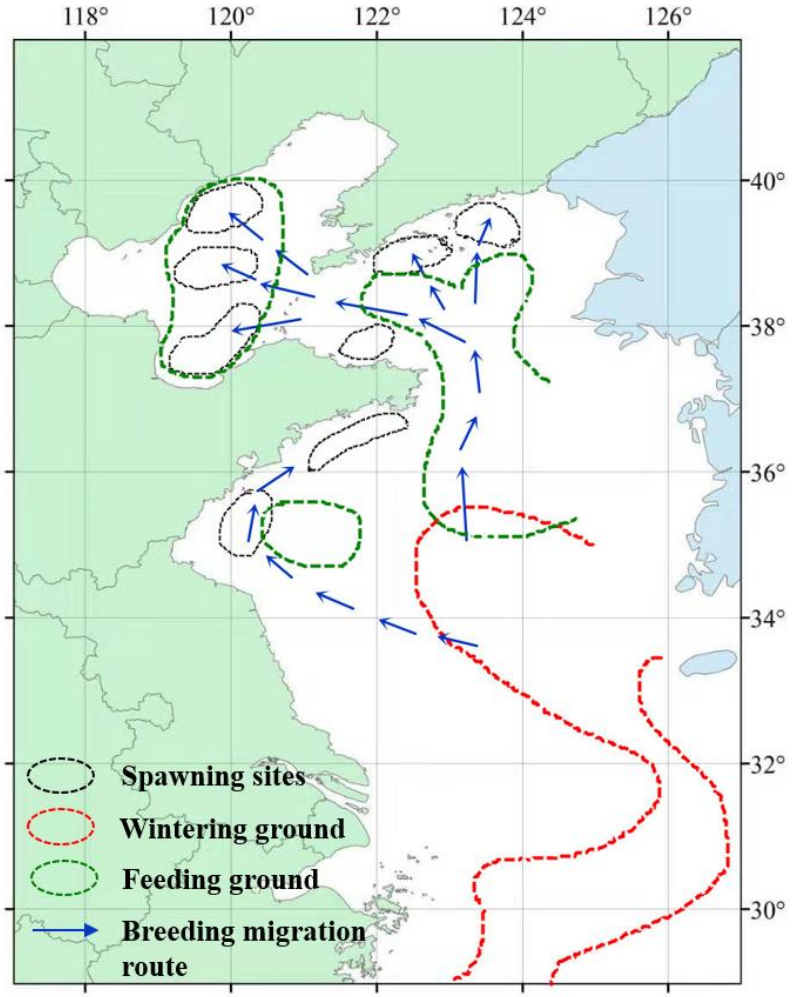

Fig.5 The breeding migration route of anchovy

Anchovy has early sexual maturity, even matures at the age of one. Its spawning season extends from May to August. Anchovy stocks divided in two major branches migrate from the wintering ground to the northwest in March every year: a group of anchovy migrate westward to offshore of Haizhou Bay, Qingdao and Rushankou for spawning, reaching the spawning peak around May 20, and the spawning period lasts until early to mid-July; another group migrate northward from the wintering ground to the vicinity of 123 °00′ E, then migrate northward, and from the end of April to the sea outside the Chengshantou, and in the beginning of May reach the Yanwei fishing ground, southeast of the Haiyangdao, Dayang river estuary spawn. After spawning, the parent fish gradually moved from the coast to the deep water for feeding, and the hatchlings feed in the coastal waters (Fig.5).

3.3.2 Small yellow croaker

The spawning grounds of small yellow croaker are distributed in the estuarine waters and the coastal waters, and the bottom material is muddy, sandy muddy or soft muddy. The spawning ground locates waters with high temperature area where low and high

salt water are mixed. The largest spawning ground of small yellow croaker is Lusi fishing ground in the Yellow Sea. There are also several small size spawning grounds in Haizhou Bay, Rushan, Haiyang Island and the west coast of Korea. The spawning period of small yellow croaker in Yellow Sea is generally from April to May (Fig.6).

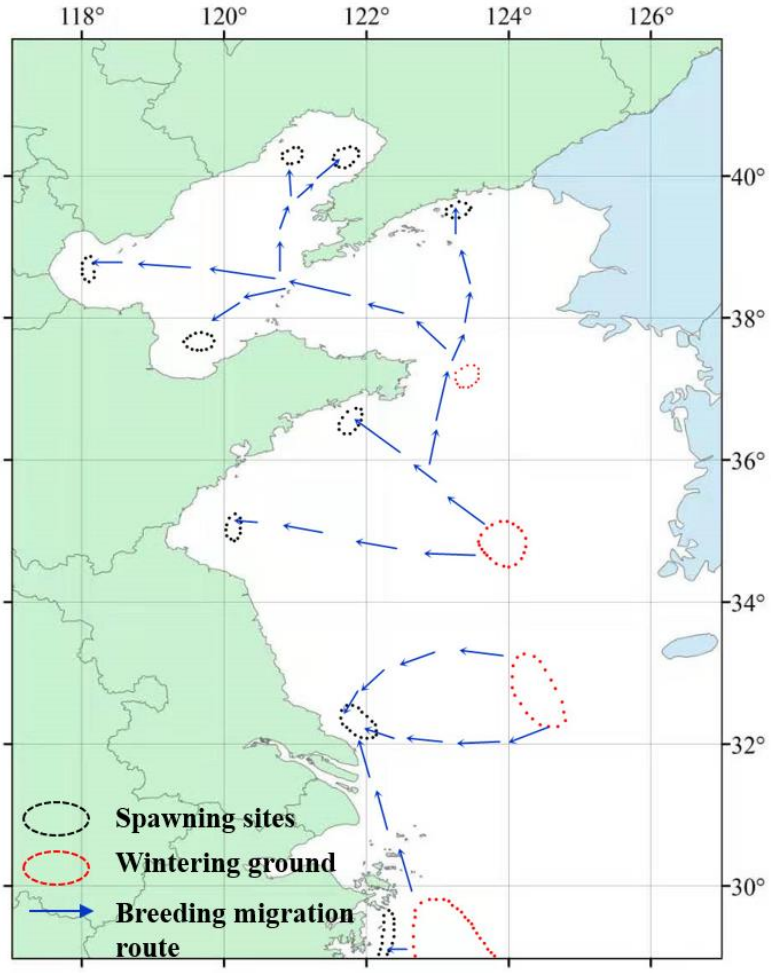

Fig.6 The migration route of small yellow croaker

Since the 1950s, the resources of small yellow croaker in the Yellow Sea and Bohai Sea have experienced a process from prosperity to decline to slow recovery. Prior to 1963, the total catch of small yellow croaker in the Yellow and Bohai Sea accounted for 9.3% to 20.2% of their total catch, after which the output declined year by year. In 1972, the proportion of small yellow croaker in marine catches fell to 0.3%. After the 1990s, under the protection of relevant national policies, the resources of small yellow croaker began to gradually recover. However, small yellow croaker in the catch is characterized with simple population structure, rapid growth, and early sexual maturity, which mainly are attributed to overfishing. Therefore, the effective measures should be taken to strengthen the protection of spawning grounds and juvenile distribution areas of important commercial species in the Yellow Sea and Bohai Sea, such as small yellow croaker.

3.3.3 Mackerel

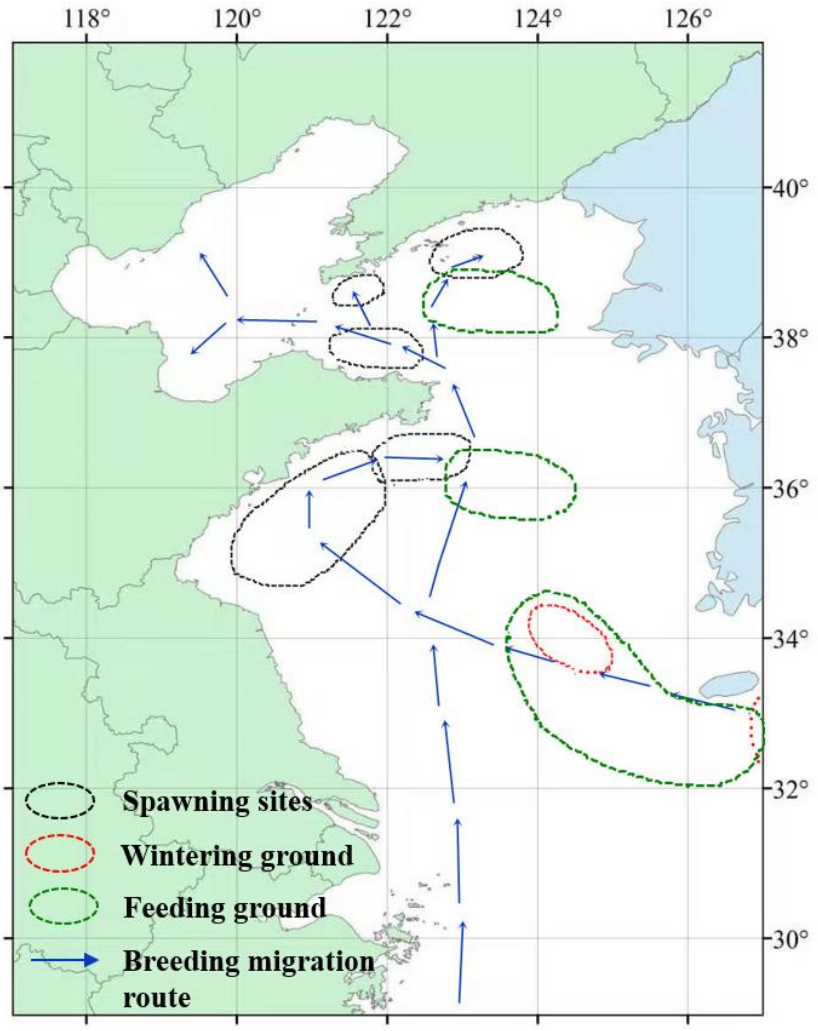

Fig.7 The migration route of mackerel

There are three main mackerel spawning grounds in the Yellow Sea, namely the Haiyang Island spawning ground in the northern Yellow Sea, the Yanwei spawning ground, and the central Yellow Sea spawning ground. In the East China Sea, the overwintering cohorts of mackerel moves northward at the end of March and early April each year, and roughly enters the Yellow Sea along the 123 ° 30′E, 30-40 m isobaths. And then, reaches the Qingdao-Shidao inshore waters in the middle of the Yellow Sea, the Haiyang Island and the Yanwei waters in the northern Yellow Sea to spawn, from May to June. The mackerel spawning period in the central Yellow Sea is generally from late May to late July; and the spawning period in the Haiyang Island and Yanwei offshore is generally in the middle of May to mid-July (Fig.7).

3.3.4 Spanish mackerel

Every March, the Spanish mackerel began to leave the overwintering ground and migrate northward for breeding. Some of fish foraged here after arriving at the fishing

grounds in central and eastern Fujian. The large group was divided into two sub-stocks to continue northward migration. After entering the Yellow Sea, one group swims northeastward to the west coast of North Korea, arrives at the Haiyang Island fishing ground to lays eggs and foraged here; another fish group goes north along the 20-40 m isobaths, and then from southeastward to northwestward enters the southwest sea area of Lianqingshi fishing ground. Some of them are westward entering the fishing grounds of Haizhou Bay, Lianqingshi, Qinghai and Shidao in late April, while the others are bypassing Chengshantou to the Yanwei fishing grounds in the northern Yellow Sea for spawning and feeding. The spawning season of Spanish mackerel in the southern Yellow Sea is from early May to mid-May, and the spawning period of Spanish mackerel is from early May to late May in the central Yellow Sea, and the spawning period of Spanish mackerel is from mid-May to early June in the northern Yellow Sea (Fig.8).

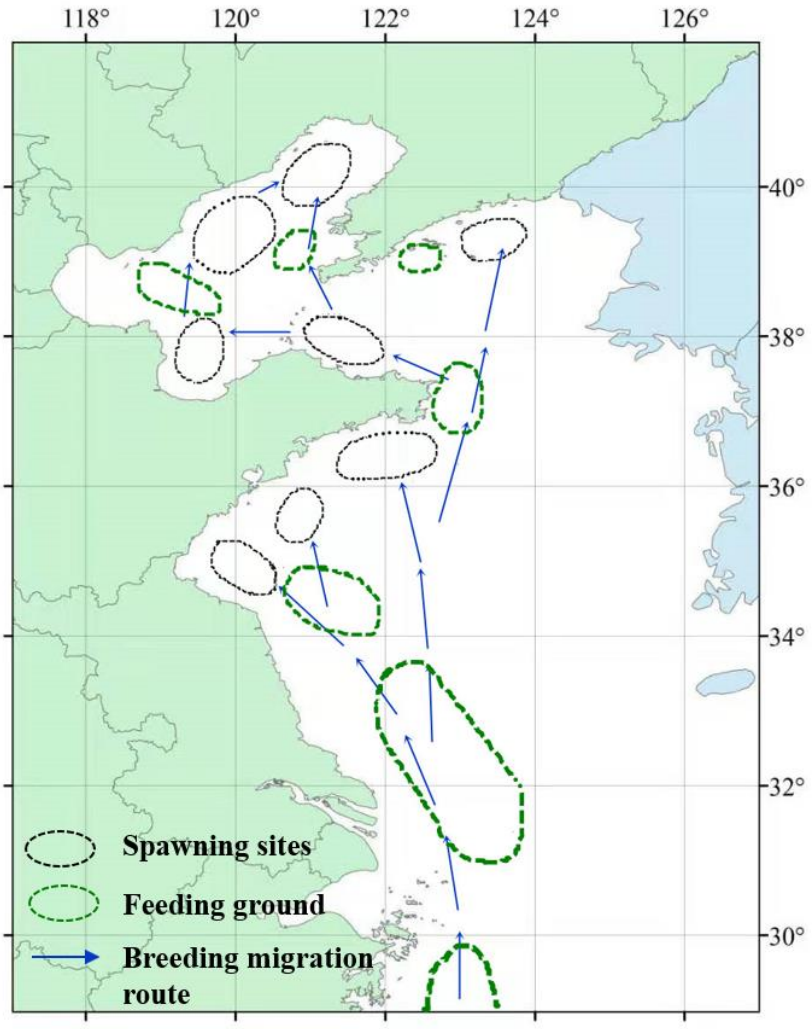

Fig.8 The migration route of Spanish mackerel

The Spanish mackerel is an important target species of trawling, drift net and set stow net in the Yellow Sea. Although the biomass of Spanish mackerel in the Yellow Sea has been relatively stable at present, due to its long-term fishing pressure, the CPUE of

Spanish mackerel has decreased year by year, the age of the first sexual maturity has been advanced, and the reproductive population has tended to be younger and smaller, indicating that the resources of the Spanish mackerel have been fully and over utilized. Therefore, it's of great significance to strengthen the protection of Spanish mackerel.

3.4 Gaps in conservation of spawning, nursery, feeding and migration corridors of the four species

At present, the protections of spawning fish and juvenile fish in China are mainly by restricts fishing gear, fishing boats, and fishing license, implements summer ban fishing, establishes closed season/areas and marine protected areas. Those protections effectively alleviated the decline of fishery resources and increased the biomass of some fishery resources, but there are still longtime way to pursue for the restoration of fishery resources.

First of all, although under the protections of the summer ban fishing system, the biomass of fishery resources increased to some extent, but because of the large base of existing fishing vessels and the rapid development of current fishing technology, the current closed fishing system only plays the role of short-term temporary conservation, and the decline of resources is still difficult to be fundamentally contained (Cheng et al, 2008).

Secondly, under the summer ban fishing system the Yellow Sea from May 1st, it is overlapping with the spawning time of anchovy, mackerel, small yellow croaker and Spanish mackerel. However, with the global climate change, the increase of water temperature will lead to the rapid development of fish gonads, and the spawning time will also be earlier accordingly. If the year of high water temperature is encountered in the fishing ground, the spawning period of some fishes (such as small yellow croaker with earlier spawning period and progressive sexual maturity in the Yellow Sea) will be advanced, and the fishing will directly lead to the decline of spawning stock (Shan et al, 2011; Chen et al, 2010).

Thirdly, the sea level rise caused by global warming results in significant changes in the physical structure of the coastal and Inner Bay waters, thus introducing changes in the living environment of spawning and fattening fish species in the coastal waters, which will become an unstable factor affecting the development of offshore fishery resources and bring losses to the sustainability of fishery resources (Huang et al, 1999).

Fourthly, the development of coastal zone is blind and unreasonable, and the reclamation project destroys the coastal ecological environment seriously, which breaks the natural ecological balance and fish migration law of coastal zone, covers and buries the young eggs of various aquatic organisms, and destroys many natural spawning grounds, nursery grounds and feeding grounds (Cao et al, 2015). For example, the coastal reclamation area of the Yellow Sea is the spawning and feeding grounds for the

Spanish mackerel and other aquatic animals, which not only encroaches on the living space on which the germplasm resources of the Spanish mackerel in the Yellow Sea, but also causes serious damages to the ecological environment, which directly threatens the sustainable utilization of the germplasm resources of the Spanish mackerel in the Bohai and Yellow Sea and the continuation of the population (Sun 2009).

Lastly, reduced environmental flow from rivers affected the salinity of the estuarine areas and the consequent spawning behavior of some fish species. The results showed that in summer and autumn, many fish swarms migrated to the estuary and the mixing area of saltwater and fresh water to spawn and breed. If the amount of water entering into the sea was greatly reduced, the salinity of the estuary and adjacent waters increased, which damaged the spawning, hatching and nursery environment of migratory fish, directly affected the migration route of fish and the change of spawning site location, and destroyed the habitat environment of the estuary (Jin, et al. 2005). For example, since the closure of the Three Gorges Dam in 2005, the fresh water runoff in the Yangtze River Estuary has decreased, resulting in the reduction of the area of the low salt sea area in the estuary, while the small yellow croaker is suitable to the narrow salty waters, so the decrease of the Yangtze River runoff brought some impacts on the distribution of the main spawning grounds of small yellow croaker in the southern Yellow Sea (Lin et al, 2008).

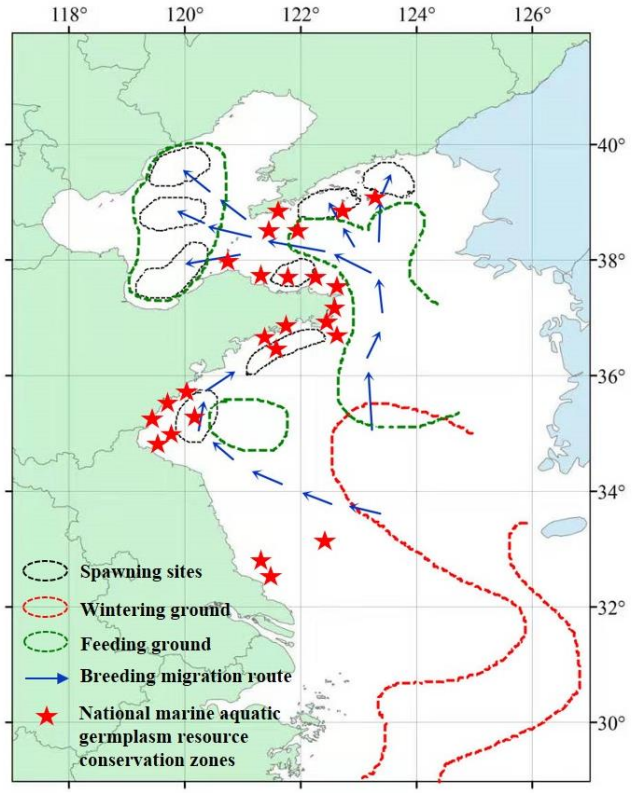

Fig.9 The migration route of anchovy and the marine Aquatic Germplasm Resources Conservation Zones in Yellow Sea

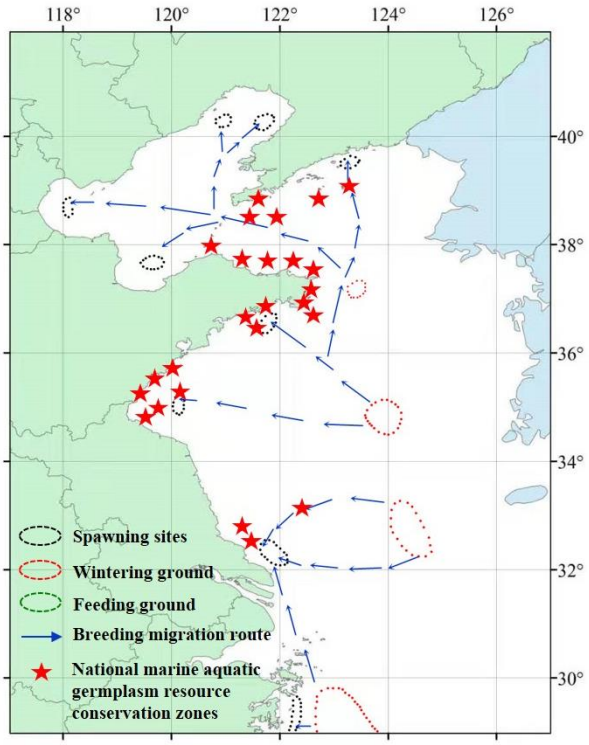

Fig.10 The migration route of small yellow croaker and the marine Aquatic Germplasm Resources Conservation Zones in Yellow Sea

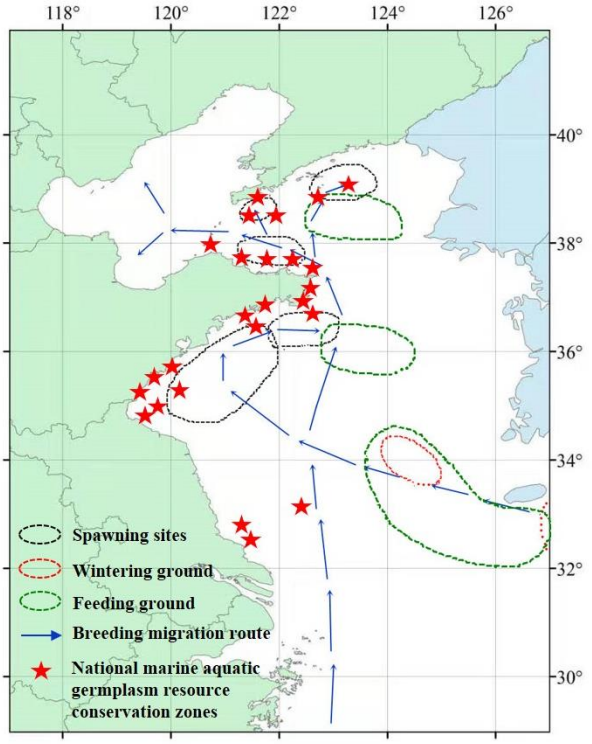

Fig.11 The migration route of mackerel and the marine Aquatic Germplasm Resources Conservation Zones in Yellow Sea

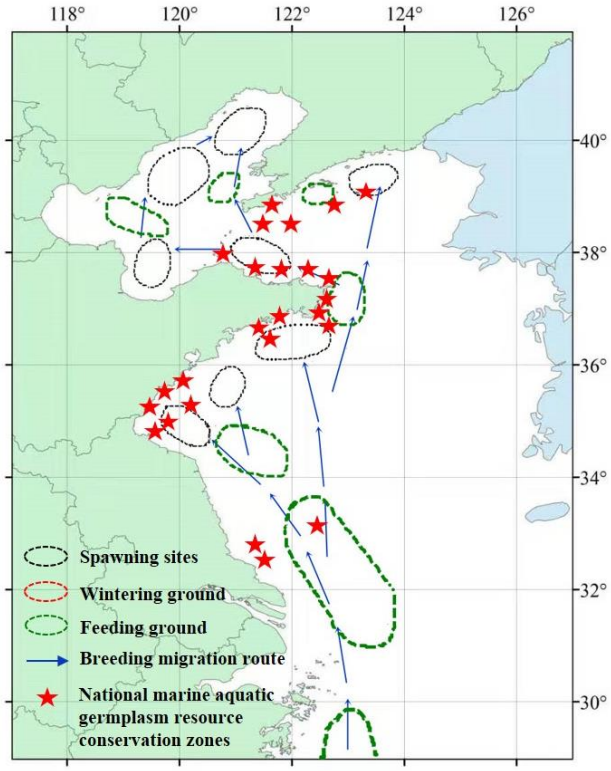

Fig.12 The migration route of Spanish mackerel and the marine Aquatic Germplasm Resources Conservation Zones in Yellow Sea

The establishment of marine protected areas can protect the marine environment and species resources and effectively maintain the balance of marine ecosystems, especially for the migratory public aquatic germplasm resources with important economic value and ecological status, such as small yellow croaker, mackerel, Spanish mackerel, anchovy, etc. There are of great significance to delimit reasonable protection areas in their spawning grounds, feeding grounds and nursery grounds. At present, although there are 25 National Aquatic Germplasm Resources Conservation zones along the coastline of the Yellow Sea (Fig. 9-12), a few conservation zones focus on the protection of small yellow croakers, anchovy, Spanish mackerel, mackerel (such as Small yellow croaker and *Pampus argenteus* National Aquatic Germplasm Resources Conservation Zones in Lusi fishing ground). At the same time, there are no conservation zones in some of the spawning, nursery, feeding and migration corridors of those species (such as the spawning ground of Spanish mackerel and mackerel located north of Haizhou Bay fishing ground and southwest of Qinghai fishing ground), some conservation zones even though located in the spawning, nursery, feeding and migration corridors of the four species, is too small to meet the protection needs. And, other shortcomings such as incomplete coverage and no complete system also exist (Liu et al, 2015). Under the premise that the offshore fishery resources in China are declining and based on the control of the summer closed fishing system and the fishing intensity, accelerating the protection and construction of marine fishery resources is the focus of ensuring the sustainable development of China's inshore fishery resources.

3.5 Suggestions for establishing the aquatic germplasm resources conservation zones

3.5.1 Systematic conservation planning method can be taken in planning of the new conservation zones

The realization of marine protection goals must be based on a scientific and systematic marine protected area planning method. However, in the process of marine protected area construction in China, there is still a lack of scientific and systematic planning standards and procedures, which leads to a certain irrationality in the planning of protected areas. For example, the planning of protected areas is restricted by administrative divisions to form a patchy and isolated spatial distribution pattern, and issues such as the connectivity between different types of marine habitats are ignored (Li et al, 2020). In view of the shortcomings of traditional protection planning methods, Margule proposed the concept of Systematic Conservation Planning (SCP), which has now become the mainstream international protection planning method (Margules et al, 2000).

The system protection planning method uses mathematical algorithms for quantitative analysis to avoid the interference of human subjective factors and realize the evaluation and optimization of planning strategies. The process of SCP mainly includes collecting biodiversity data and biodiversity mapping, determining planning goals, evaluating the existing protection system, find out the protection vacancy and select the supplementary area, implementation managing and monitoring of protection planning (Groves et al, 2002). In the planning process of new protected areas, commonly used system protection planning tools include C-Plan, MARXAN, ZONATION and other decision-supporting software embedded in simulated algorithms. Among them, MARXAN uses simulated annealing algorithm, which is the earliest and most widely used marine protection network, and it has been applied to the theoretical research of marine protected areas in some sea areas in China (Li et al, 2019).

The SCP has quantified protection goals and protection costs, and comprehensively considers the connectivity of the protection system and human interference factors, and calculates with an optimized algorithm to obtain a clear biological diversity protection system. At the same time, the application of the SCP method for the planning of protected areas is transparent, and the public can directly monitor and understand the planning decision-making process. And, the results are easy to interpret and modify, can tolerate multiple data inputs for conservation biology, ecology, and economics, and have the ability to explain ecological processes and human disturbance threats, which has positive significance for the macro-planning of conservation areas and the formulation of conservation policies (Zhang et al, 2013).

3.5.2 Factors to be considered in determining the boundary of the new conservation zones

The size of the protected area, the reasonable core area and buffer structure are important parameters for the planning of marine protected areas (Benjamin et al, 2003). The boundaries and areas of marine protected areas are demarcated， in addition to the topography of the sea area, more consideration is given to biological properties, such as the diffusion distance of species (including adult and larval migration distance) and the protection target (Dahlgren et al, 2000).

Therefore, based on the gaps in conservation of spawning, nursery, feeding and migration corridors of the four species, factors to consider in determining the boundary of the new conservation areas are as follows: for the main protected species with earlier spawning period and obvious early maturing phenomenon in this area (such as small yellow croaker, etc.), scientific and effective protection time shall be set for their main spawning grounds and migration corridors to make up the protection gap under the system of summer ban fishing and forbidding fishing areas. Furthermore, in the estuarine offshore areas, the spawning and nursery areas of protected populations are large and concentrated, and the prohibited areas should be designated for reclamation projects that have significant ecological impacts on marine fishery populations. Besides, due to the decrease of river water runoff, salinity of the estuary and the surrounding sea area also changes accordingly, so that the protected area should be reasonably delimited on the basis of full consideration of the salinity suitable for the survival of each protected population. Finally, on the basis of the existing national marine protection area, the spawning and nursery areas of four fish populations shall be distributed on the premise of the situation, a new marine reserve with special protection function shall be established.

3.5.3 Proposed new conservation zones to enhance connectivity and resilience of existing aquatic germplasm resources conservation zones of four selected species

The successful marine conservation zone planning should be based on local reality, comprehensively consider the interaction of factors such as human use, natural environment, and social pressure, and adopt scientific protected area planning methods to ensure the effectiveness of marine protected area planning (Liu et al, 2007). At the same time, in the selection of protected areas, the long-term scientific survey data should be used to realize the quantitative analysis of the natural environment conditions and species distribution of the protected areas, the analysis of interactions between various components of the ecosystem, the simulation and prediction of future protection effects of marine protected areas and other analysis work (Li et al, 2019). However, based on the background data we have collected, it is not enough to achieve scientific and reasonable marine protected area planning. Therefore, based on the current spawning and nursery area distribution and utilization of relevant habitats of the four economic fish species, based on the current protection deficiencies, a proposal for the protection area planning of the existing network of protection areas is made, and only

use it as a reference basis for the designation of new and effective protected areas:

On the one hand, expand the existing national marine aquatic germplasm resources conservation zones. 1) Expand the area of Zhangzi Island and Haiyang island conservation zones along the coast of Dalian, and focus on protecting spawning, nursery and feeding grounds of anchovy, small yellow croaker, mackerel and Spanish mackerel, the special protection period is from early May to August. 2) Expand the area of Kongtong Island, Xiaoshi Island and Jingzi Bay conservation zones in the southern coastal area of Yanwei fishing ground, and focus on protecting spawning and nursery grounds of anchovy, mackerel and Spanish mackerel, the special protection period is from early May to August. 3) Expand the area of Rushan Bay, Qianliyan and Jinghai Bay conservation zones located in the north of the Qinghai fishing ground, and focus on protecting spawning and nursery grounds of anchovy, mackerel and small yellow croaker, the special protection period is from April to mid-July. 4) Expand the area of Haizhou Bay and inshore waters of Rizhao conservation zones located in the southwest of Haizhou Bay fishing ground, and focus on protecting spawning and nursery grounds of anchovy and Spanish mackerel, the special protection period is from early April to early July.

On the other hand, establishing the new national marine aquatic germplasm resources conservation zones. 1) The new conservation zone should be established north of 36 ° N to the southern coastal area of Yantai and Weihai, the spawning and nursery grounds of mackerel and Spanish mackerel need to be protected, the special protection period is from early April to mid-July. 2) The new conservation zone should be established in the southwest of Qinghai fishing ground and north of Haizhou Bay fishing ground, and focus on protecting spawning and nursery grounds of mackerel and Spanish mackerel, the special protection period is from early April to mid-July.

At the same time, the following rules can be adopted into the management regulations of the new protected area. For the purpose of protecting the spawning sites and nursery grounds of the four economic fish species in the Yellow Sea, specific suggestions are as follows: in the protected area, encirclement and trawling operations are prohibited, and fishing methods that destroy aquatic resources such as fish frying, poisonous fish, electric fishing, and bombing operations are strictly prohibited. It's also forbidden to discharge harmful and toxic sewage, oil, oily mixture and other pollutants and wastes into the MPAs. For the reclamation project in the coastal area of the protected areas and the water conservancy project in the main stream where the estuary is located, the ecological impact assessment results of the fishery population in the protected areas should be taken as the premise.

Based on the recommendations, a more comprehensive collection of the latest data on related species, distribution of protected areas, and socioeconomic development, and continuous improvement of research results, and the use of scientific protected area planning methods to reduce the impact of subjective factors, can build a more effective

protected area network system.

3.5.4 Enabling measures to ensure effectiveness of existing and newly proposed MPAs

Suggestions for ensuring effectiveness of existing and newly proposed MPAs are as follows:

First of all, comprehensively consider the existing marine protected areas and strictly follow the relevant rules and regulations for the construction of marine protected areas in China, and formulate protected area construction specifications in terms of the regional layout, type structure, and protected species of protected areas to avoid the problems of unscientific protected objects, unreasonable scope of the protected areas and repeated construction.

Secondly, for newly established marine protected areas, scientific research work such as follow-up investigation and testing should be carried out regularly for their key protected species and their living environment to provide scientific basis for effective management of protected areas.

At the same time, strengthen the construction and management of protected areas, increase the economic investment in fishery resources proliferation, ecological restoration, scientific research and other aspects of protected areas to ensure the long-term effective operation of protected areas (such as, in the estuarine area which is greatly affected by the reclamation project in the protected areas, the conservation of fishery resources is realized through the proliferation and release of artificial fish reefs).

Finally, by publicizing the status quo of resources of key protected species, deepening the awareness of coastal fishermen on the importance of marine protected areas, improving people's awareness of the conservation of fishery resources, and creating a good social environment for the conservation and multiplication of fishery resources in China.

4. Future work

In order to maintain the population structure and quantity of the main economic fish species in the Yellow Sea, to realize the sustainable development of offshore fishery resources, it is of great significance to strengthen the special protection of the coastal nursery and spawning grounds. The construction of marine protected areas has played a key role in protecting marine species and their ecological environment. Based on the space-time characteristics of the fishery population of nursery and spawning grounds in the Yellow Sea, rationally plan the area of the core area, and adjust the corresponding protection time and protection scale to achieve comprehensive and effective protection of the target protection. At the same time, under the existing system of protection measures for fishery resources in China, we must improve and strictly implement only

by improving and strictly implementing the system of summer close season and the system of fishing forbidden zone, and strengthen the conservation of fishery resources and the restoration of the offshore ecological environment. Only in this way can the protection of spawning populations and juveniles in the offshore areas be realized, thereby achieving the healthy and sustainable development of the Yellow Sea fishery resources.

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