China Sustainable Seafood Assessment (CSSA)

Fishery

Largehead hairtail (*Trichiurus japonicus*)
Offshore Fisheries

CSSA Team

December 2023

Statement

In the assessment of all species, the China Sustainable Seafood Assessment (CSSA) team will strictly follow the assessment criteria and refer to the latest, impartial and objective scientific data. Common sources of reference for evaluation data include literature review, official materials, objective and unbiased media reports, data obtained from field research, and expert interviews. Inevitably, many fisheries face the problem of lacking robust data, and some data are not publicly available, which may affect the assessment results to some extent. The CSSA team is committed to carrying out the assessment and evaluation of the species objectively and impartially, basing on respecting objective facts, making maximum use of open data, and relying on rigorous scrutiny of experts. The results of the species assessment do not represent the opinion of any particular expert, scholar, etc.. The CSSA team has the right to the final interpretation of the assessment results.

Content

Introduction

China is the world's largest fishing country, and also has a large consumer market for aquatic products. The food choices we make determine the present and future of our marine and freshwater ecosystems. In order to cultivate a new generation of responsible seafood foodies, Qingdao Marine Conservation Society (QMCS) has launched the China Sustainable Seafood Assessment (CSSA) project to customize scientific and interesting sustainable seafood consumption guides for domestic consumers. We hope that by raising public awareness and promoting changes in consumer behavior, we can use the power of the market to force industrial transformation and make a lasting contribution to the continuous improvement of the health of China's marine and freshwater ecosystem.

Executive Summary

Largehead hairtail (*Trichiurus japonicus*) is currently the most economically important fish species in China's domestic fishery, with an annual production of about 1 million tons, and the East China Sea is the region with the highest production of hairtail in China.

Due to overfishing and other reasons, the resource status of the hairtail in the East China Sea has declined significantly since the 1960s, as evidenced by the increasingly irrational population structure of the hairtail, the prevalence of younger and smaller fish, the decrease in the number of senior fish and the increasing proportion of juvenile fish. The imbalance in age composition indicates that growth overfishing is occurring. At the same time, the age of sexual maturity of the hairtail has gradually decreased, the minimum anal length at first sexual maturity has tended to be smaller, and there has been extensions of the spawning period, dispersal of spawning grounds, and outward expansion of spawning grounds.

In China, hairtails are mainly caught by trawling, purse seine fishing, longline fishing, gillnets, canvas stow nets, and other fishing operations. The operation of trawl fisheries is prone to have significant negative impacts on the bottom of the operating sea area and is less selective. Canvas stow nets rely on water currents to push the target species to enter the net, having problems such as high fishing intensity and depletion of juvenile fish resources. Currently, in the main production areas for hairtail such as Zhoushan in Zhejiang province, canvas stow nets have been gradually phased out. Hairtail is in the same fishing ground as many other species sue to its feeding ground changes according to the movement of the bait species, such as opossum shrimp, krill, stomatopod, fish, etc. Therefore, some species can be bycaught in the hairtail fisheries, including economic valuable species (e.g., large yellow croaker *Larimichthys crocea*, Japanese Spanish mackerel *Scomberomorus niphonius*, *Octopus variabilis*, silver pomfret *Pampus argenteus*, grey pomfret *Pampus cinereus*, etc.). The hairtail fisheries also pose a certain degree of threat to the ETP (Endangered, Threatened, Protected) species.

The management of the hairtail fishery follows the provisions of the Fisheries Law of the People's Republic of China and other laws and regulations. China has set up a national aquatic germplasm reserve for hairtail in the East China Sea, while the decision to completely ban trawling operations in the Bohai Sea, *the Provisions on the Conservation of Bohai Sea Biological Resources*, and the summer fishing moratorium are all of great significance to the protection of the fishery resources of hairtail.

Given the issues of excessive fishing intensity in China's trawl and canvas stow nets hairtail fisheries, CSSA has rated the hairtail caught in offshore fisheries as yellow - overall sustainability is good, but there remains significant room for improvement.

Largehead Hairtail *Trichiurus japonicus*	Think Twice

Species Profile

Hairtail (*Trichiurus japonicus*) belongs to the subclass Actinopterygii, order Perciformes, family Trichiuridae, genus *Trichiurus*. The hairtail is mainly found in the western Pacific and Indian Oceans and can be found in all coastal provinces of China. The spawning period of hairtail is very long, generally from April to June, followed by September to November, and the amount of eggs spawned at one time is between 25,000 and 35,000, and the suitable water temperature for spawning is 17℃ to 23℃. According to the geographic distribution and morphological characteristics, the hairtail distributed in China is generally divided into the Yellow- Bohai Sea stock, the East China Sea stock, and the South China Sea stock, but there is still disagreement among academics. The South China Sea stock has insufficient research data; the Yellow- Bohai Sea stock has been in serious decline since the 1960s; the East China Sea stock is the main stock of hairtail in China, and many researchers found that the East China Sea hairtail resources have suffered serious depletion, which is mainly reflected in the increasingly irrational composition of the hairtail population, the prevalence of younger and smaller fish, indicating the growth overfishing. The shortening of age composition structure from the age group of 1-7 in the 1960s to the age group of 1-4 at the beginning of the 1990s.

The wintering grounds of the East Sea hairtail population are mainly located in the outer part of the non-trawling zone for motorized fishing vessel in south-central Zhejiang Province, followed by the southwestern part of Jeju Island. From March to April every year, the wintering hairtail population in the south moves northeastward; the spawning population arrive at Zhoushan fishing ground and Yangtze River estuary fishing ground to spawn in May to July; the feeding population move northward to Dasha fishing ground in the southern Yellow Sea to feed in July and August, then move to the outside of the non-trawling zone of 35°00'N in September. After October, with the cold air moving southward, the southern population would migrate southward for wintering and return to the Yangtze River estuary in October. A small portion of the population would migrate to the offshore wintering grounds, while the majority of the population continued to migrate southward to the wintering grounds in the south-central part of the East China Sea. The changes in the Taiwan Warm Current and the Yellow Sea Warm Current are the main environmental factors affecting the spatial and temporal variations in the migratory routes of hairtail.

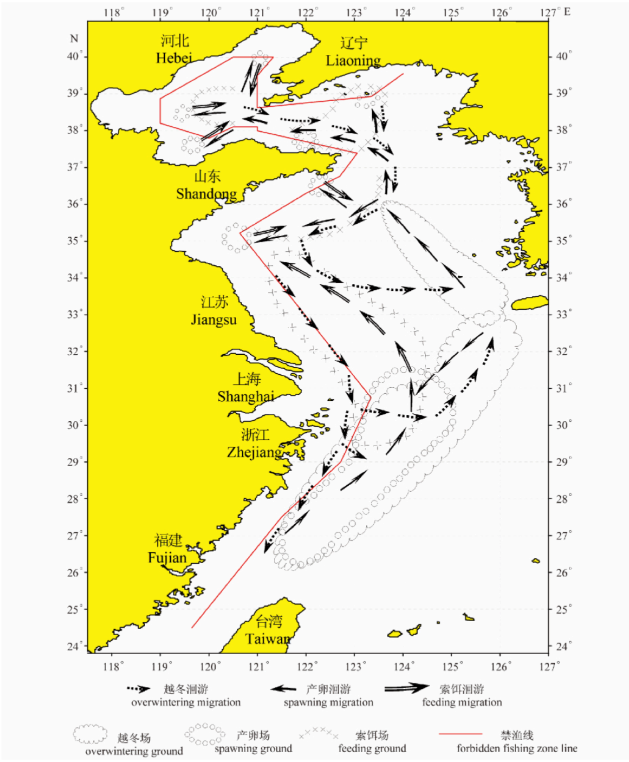

Fig. 1. Migratory routes of T. lepturus in the East China Sea, Yellow Sea and Bohai Sea[13].

FULL ASSESSMENT

Criterion 1: Impact on Target Species

Status of resources

At the beginning of the development of the East China Sea hairtail resources, the fishing grounds were mainly concentrated in offshore waters. In the late 1970s, the rapid development of motorized sailboat trawling and fishing vessel trawling operations damaged a large number of breeding hairtail populations, leading to a decline in the density of hairtail resources. By the late 1980s, the catch of hairtail in the East China Sea has dropped to its lowest level, with only $29.37*10^4$ tons in 1988. [18]. Although protection by management tools such as the establishment of protected areas and summer fishing moratoriums was obtained successively, the fishery resources of the East China Sea hairtail have never been able to recover to their historical level. Xu Hanxiang et al. analyzed the status of its resource stock using data on hairtail from 1986 to 2000, and conducted a study on the fecundity and recruitment population of the East China Sea hairtail, the results of which showed that the parental population of the East China Sea hairtail was still insufficient with the increase in fishing pressure[12] . Yuan Fan (2022) summarized the catch per unit effort (CPUE) of hairtail caught by paired trawlers, canvas stow nets, and light lift net operations from 2010-2019, and concluded that this indicator reflected an improvement in the status of hairtail resources in recent years. However, at the same time, its sampling survey of hairtail resources in the East China Sea from 2016 to 2020 found that the age structure of hairtail in the sampling area was dominated by age-1 fish, with age-3 fish accounting for a relatively low percentage, while age-6 hairtail existed in the 1980s, which indicated that the age composition of the East China Sea hairtail population is gradually shortened. Its study also estimated that the growth rate K value of hairtail has remained around 0.4 in recent years, and found a trend of miniaturization in the hairtail population[15] .Xie Yu et al. (2023) conducted a study on the individual fecundity of hairtail in the East China Sea and found that the anal length of the spawning population showed a declining trend. [11]

Zhang Kui (2022) assessed the fishery resources of the East China Sea hairtail population based on CPUE data, and the results showed that the resource level of the East China Sea hairtail was below the maximum sustainable yield level (B/BMSY<1) and the level of fishing mortality was high (F/FMSY>1) for most of the period from the 1990's to the 2000's. This indicates that the hairtail resources are under high fishing pressure, and the population is in a state of overfishing[17]. Yuan Fan (2023) et al. analyzed the East China Sea hairtail population using the Beverton-Holt model, which estimated the reference point of tc = 0.38a, F = 2.11, indicating that the fishery resources of the East China Sea hairtail are overfished[14].

Table 1 Change in Catch CPUE for the Main Hairtail Fishing Operating Mode, 2010-2019[15]

年份 Year	双拖网(kg/h) double-trawler	帆张网(kg/net) canvas spreader stow net	灯光敷网(kg/net) light falling net
2010	98.05	31.79	55.9
2011	66.79	16.96	32.0
2012	55.53	24.90	82.2
2013	70.83	32.60	167.7
2014	65.23	40.8	84.8
2015	73.63	48.8	121.9
2016	51.91	69.3	153.6
2017	62.90	31.8	159.0
2018	-	35.9	119.4
2019	135.81	22.8	135.9

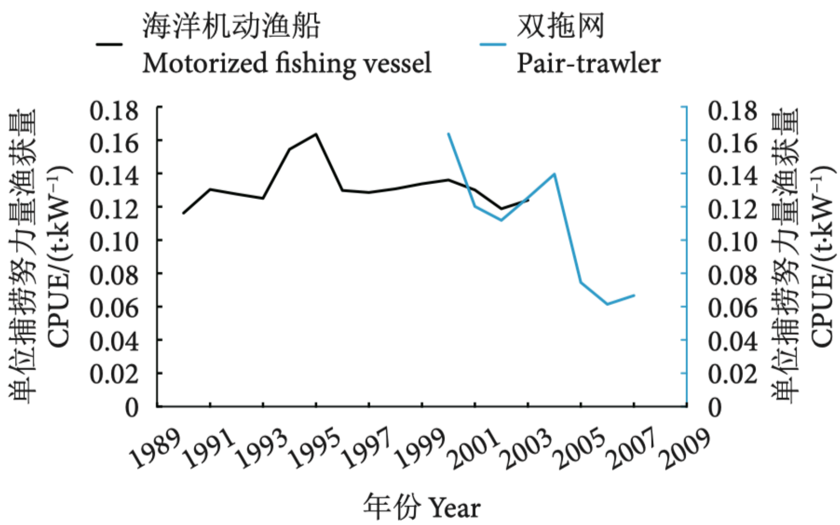

Fig. 2. Catch per unit of fishing effort in the East China Sea hairtail fishery[17]

In summary, although the current hairtail population can sustain fishery production, after decades of intensive fishing, the population are now in growth overfishing, and the stock is showing declining trend, including miniaturization, lower-ageing, accelerated growth, and early sexual maturity.

Fishing level

Currently, hairtail is the species with highest production volume in China's domestic marine fisheries, maintaining a production of around 1 million tons annually in the last decade (the statistics include several species such as *Trichiurus lepturus*, *Trichiurus savala*, etc.), as shown in the figure below. The production in 2016 reached a maximum of 1.1 million tons. It has fallen back slightly in the last three years, with production in 2021 at 900,000 tons. Hairtail can be caught along China's coastal areas, with the East China Sea being the most productive. The production of hairtail in the East China Sea has been on an upward trend from the early 1950s to 1974, reaching a maximum in 1974, when the three provinces and one city in the East China Sea caught a total of 52.8* 10^4 tons, of which 34.1* 10^4 tons were caught by Zhejiang Province[6]. This was due to the rapid development of motor sailboat trawling in the early 1970s, with a high level of fishing for recruitment populations in the April-July period. It then fluctuated and declined to only 29* 10^4 tons in 1988; thereafter, with the rapid growth of fishing capacity, the capture production of hairtail increased dramatically, reaching 91* 10^4 tons in 2000; it began to fluctuate and decline again after 2000, but it has been able to maintain the fishery production, and in 2018 the total capture production of the three provinces of Shanghai, Zhejiang, and Fujian was about 53* 10^4 tons. In 2021, Zhejiang produced 36.5* 10^4 tons of hairtail, accounting for more than one-third of the country’s total production, followed by Hainan, Fujian, and Guangdong. Overall the northern hairtail production is much lower than several southern provinces and cities, which shows that the main distribution of China's offshore hairtail and its fishing grounds is distributed in the East China Sea and the South China Sea, especially the Zhoushan fishing ground.

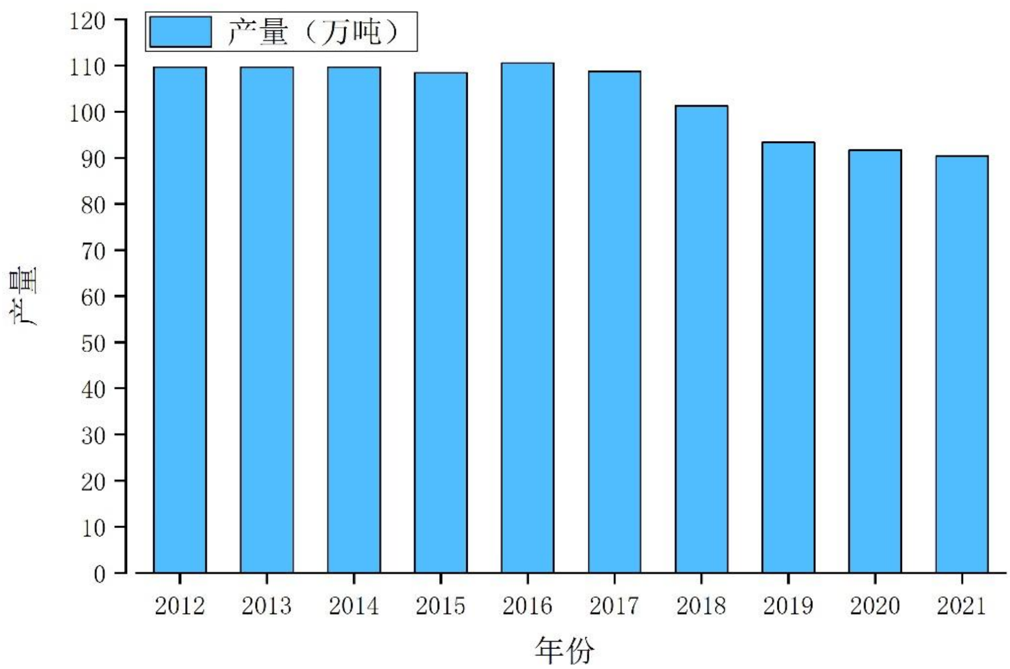

Fig. 3. Inter-annual variation in catches of China offshore hairtail[10]

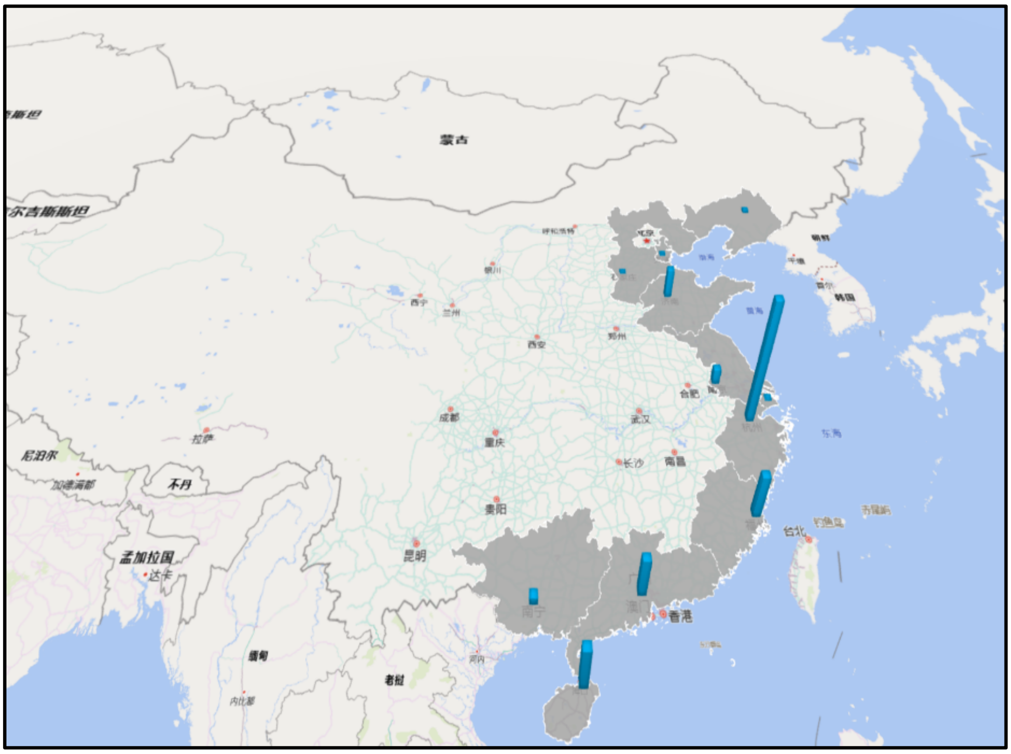

Fig. 4. Production Distribution of hairtail of China coastal Provinces and Cities in 2021[10]

Zhang Kui (2015) et al. conducted a resource assessment of largehead hairtail in the East China Sea and concluded that the East China Sea hairtail was in an overfished state during 1995-2010, with fishing mortality coefficients $F>F_{MSY}$ from 2000-2006, and a relatively good condition in 2012 [17]. Yuan Fan (2022) conducted a comparison of the fishing mortality rate F of hairtail in studies over the years and found that in the 1960s the East China Sea hairtail was fished by traditional small-scale fishing gears, so the fishing mortality rate was low and the resource exploitation rate was only 70%. Since the 1970s, large-scale trawlers were put into the production of the East China Sea hairtail and the fishing mortality rate increased, while the resource exploitation rate reached more than 80%. The current fishing mortality rate and the resource utilization rate maintains at a high level, and the hairtail resources have been overexploited[16]. Li Lihua (2022) et al. estimated an MSY of $77.83*10^4$ tons for Zhejiang offshore hairtail by analyzing historical catch production data. In 2018, the MST valued estimated by Zhang Kui et al. was $69.75\text{-}86.25*10^4$ tons[6]. The current capture volume of hairtail has far exceeded the MSY level.

Criterion 2: Impact on Non-target Species

Bycatch of other concurrently harvested species and Threatened, Endangered, Protected (ETP) species

There are seasonal differences in the diet composition of hairtail, with Indian perch *Jaydia lineata*, krill, and hairtail as the main diet in the spring; hairtail, krill, opossum shrimp, and Pacific rudderfish *Psenopsis anomala* in the summer; stomatopod larvae, Skinnycheek lanternfish *Benthosema pterotum*, and jack mackerel *Trachurus japonicus* in the fall; and hairtail, Skinnycheek lanternfish, small hairtail, and opossum shrimp as the main diet in the winter. Seasonal variation in feeding intensity was not significant, being highest in the fall and lowest in the summer. Comparison with historical data revealed that the food composition of the East China Sea hairtail has undergone a major change from krill-based to fish-based, while showing an obvious phenomenon of cannibalism. At the same time, the feeding grounds of hairtail largely coincide with the aggregation sites of their predators (Spadenose shark *Scoliodon laticaudus*, Bombay duck *Harpadon nehereus*, etc.). When hairtail are fished by canvas stow nets, purse seines, and gillnets, some species can be harvested as well, as shown in the table below.

Table 2 Possible Bycatch Species

Broad categories likely to be fished	Examples of representative species-specific names
opossum shrimp	*Acanthomysis longirostris,* etc.
krill	*Euphausia pacifica, Pseudeuphausia lalifrons,* etc.
stomatopod	*Oratosquilla oratoria*
fish	*Pampus argenteus, Scomberomorus niphonius, Branchiostegus japonicus, Setipinna tenuifilis, Scomber japonicus, Larimichthys polyactis*, etc.

Bycatch of endangered and protected species in the hairtail fishery is relatively rare, and occasionally, as in the case of bycatch of some shark species, the amount is small, for example, when Li Lingzhi (2010) et al. carried out a study of mesh size selectivity in silver pomfret gillnets in the East and Yellow Sea, there was an occurrence of the Scalloped hammerhead (*Sphyrna lewini*) in the gillnet catch.[7] The Scalloped hammerhead is rated as Critically Endangered (CR) by the IUCN Red List of Threatened Species, and is distributed in China in the South China Sea, the East China Sea, and the Yellow Sea, and is a common species in longline fishing operations in the Xisha, Nansha and Zhongsha Island sea areas.[2] The bycatch of Scalloped hammerhead in gillnet fisheries is incidental and have a low impact on their population. In addition, the large yellow croaker (*Larimichthys crocea*) (IUCN - Critically Endangered CR) may also appear in gillnet fisheries. Although it is not listed as an endangered protected species in our country, its wild population has never been truly recovered, and the status of the resource is under great threat. Another commonly bycatch species in the East China Sea is Bombay duck (*Harpadon nehereus*) (IUCN-Near Threatened NT), a species rated as NT by IUCN, has large production in China. It is also possible that species such as Spadenose shark (*Scoliodon laticaudus*) (IUCN-Near Threatened NT) may be incidentally caught in offshore fisheries. Measures should be taken to minimize the risk of bycatch of these occasionally caught threatened, endangered, or protected species by recording and reporting the catch and releases of them, and improving gear selectivity in the future fishery practices.

Criterion 3: Control Impact on Ecosystem

The effect of fishing gear

Trawls, purse seines, longlines, gillnets, and canvas stow nets are the most common fishing practices to harvest hairtails. The gears that have the greatest impact on the marine ecosystem are trawls and canvas stow nets.

Trawl is a mobile filtering fishing gear that uses the movement of the vessel to drive the fishing gear forward on the seabed or in the seawater, and uses the water pressure to push the fish, shrimp, and crabs to enter the cod end to fish. Trawling not only causes great damage to the fishery resources, but also to the marine ecosystems, especially bottom trawling. In the last decade, the technical innovation has allowed the development of the bottom trawlers, which improves the strength of the nets and makes it easier to operate in complex substrate with a wider range of impacts on the benthic habitats. Trawl cod end meshes are generally in diamond shape, which are easily closed when moving in the water, making it difficult for juvenile fish to escape.

The hairtail is the dominant species in the catch of canvas stow nets. Canvas stow nets originated from Jiangsu Province in the early 1980s, developed by improving the Korean monkfish net. It's proved to be a highly efficient fishing gear, with high mobility and flexibility, high yield, and low cost. This fishing gear was introduced to Zhejiang in the early 1990s, and by the end of the 20th century, the number of canvas stow net fishing vessels had grown to nearly 3,000 throughout the East China Sea area.[8] However, canvas stow nets usually have small mesh sizes and low selectivity, which adversely affects fishery resources. Liu Yong (2022) et al.'s study of canvas stow net catches in Jiangsu Province showed that the proportion of juveniles of economic species and small and medium-sized fish in catches exceeded 80% in the winter and 30% in fall.[8] After analyzing the catch of canvas stow nets in the East China Sea, Cheng (2000) et al. found that juveniles of small yellow croaker accounted for more than 30% of the catch throughout the year, and that the proportion of juvenile silvery pomfret and hairtail was also high.[3] In order to address this issues, the East China Sea Fisheries Administration formulated *the Implementing Measures for the Management of Canvas Stow Nets* in 1995 to control the total number of fishing vessels, restrict the fishing area and the number of gears, and implement fishing moratorium, with the total number of fishing vessels controlled to be no more than 1,000. China enacted the *Provisional Measures for the Management of Canvas Stow Nets* in 2000, which implements a special license system for canvas stow net fishery, while reducing the number of vessels year by year with the ultimate goal to eliminate the canvas stow nets. Zhoushan City decided to reduce canvas stow nets by more than 90% by the end of 2023, and to eliminate the canvas stow nets by September 16, 2024. [21]

Ecosystem-based fisheries management

Based on the principles of ecosystem-based fisheries management, it is imperative to not only focus on the target species but also consider the broader components and functions of the ecosystem in fisheries management practices. [4] Ecosystem-based fisheries management represents a more comprehensive approach to resource management. However, in China, fisheries management predominantly relies on total catch and input controls, with limited implementation of measures for conserving and managing fisheries resources at the ecosystem level. While Aquatic Germplasm Reserve have been established for hairtail to conserve and replenish fishery resources, the planning and design of these protected areas have yet to fully integrate their ecological roles and impacts on the ecosystem into the fisheries management framework.

Hairtail is in higher trophic level in the marine ecosystem, and a decline in its population may lead to an increase in the proportion of lower trophic level species in the ecosystem, changes in the population structure, and a decrease in the stability of the marine ecosystem, which has already been confirmed in relevant studies. Consequently, CSSA advocates for the comprehensive consideration of various factors, including the management of prey resources, when developing management plans for hairtail fisheries. This approach facilitates the maintenance of marine ecosystem balance and the achievement of management objectives aimed at restoring fishery resources.

Criterion 4: Management and Implementation

Fishery management plans for target species

In 1955, the State Council issued the "Order on the Prohibition of Trawling in the Bohai Sea, Yellow Sea, and East China Sea by Motorized Trawlers," which established a non-trawling zone line consisting of 17 reference points. It stipulated that motorized trawlers equipped with propellers and fishing gear intended for bottom-dwelling aquatic animals (excluding sailboat fishing vessels) were not allowed to operate within the non-trawling zone line. The zone line was extended in 1957 and 1980, resulting in the national non-trawling zone line for motorized trawling fishing vessels comprising 40 reference points. Starting in 1981, all motorized bottom trawling fishing vessels were prohibited from operating within the aforementioned non-trawling zone line.

Since 1995, to conserve the spawning fisheries resources in summer, the East China Sea region has implemented a comprehensive fishing ban on trawling and canvas stow nets in July and August, gradually extending to the entire Chinese coastline. Currently, the summer fishing ban has become one of the fundamental fisheries management measures in China, covering major fishing operations and adjusting the timing, types, and scope of fishing bans according to the actual situation each year.

The 2003 *Regulations on the Conservation of Bohai Biological Resources* strengthened the protection of important spawning grounds, feeding grounds, wintering grounds and migratory routes for biological resources of the Bohai Sea, and played an important role in the conservation of hairtail resources.

A hairtail spawning ground reserve was established 1989 in the East China Sea to protect hairtail parents and recruitment populations. The Ministry of Agriculture approved the establishment of the "East China Sea National Hairtail Aquatic Germplasm Reserve" in December 2008, which is by far the largest aquatic germplasm reserve in China's jurisdictions and is located in the northeastern part of the coastal waters of Zhejiang Province, where is the most important habitat for the East China Sea Hairtail to inhibit and breed.[5] The total area of the Reserve is about 22,500 km^2. The special protection period of its core area is from April 16 to September 16 every year. The main conservation target species include hairtail, large yellow croaker, small yellow croaker, mackerel, jack mackerel, grey pomfret, silver pomfret, elongate ilisha, and Japanese Spanish mackerel, etc. A fishing ban has been in force in the core area of the Reserve since 2013.

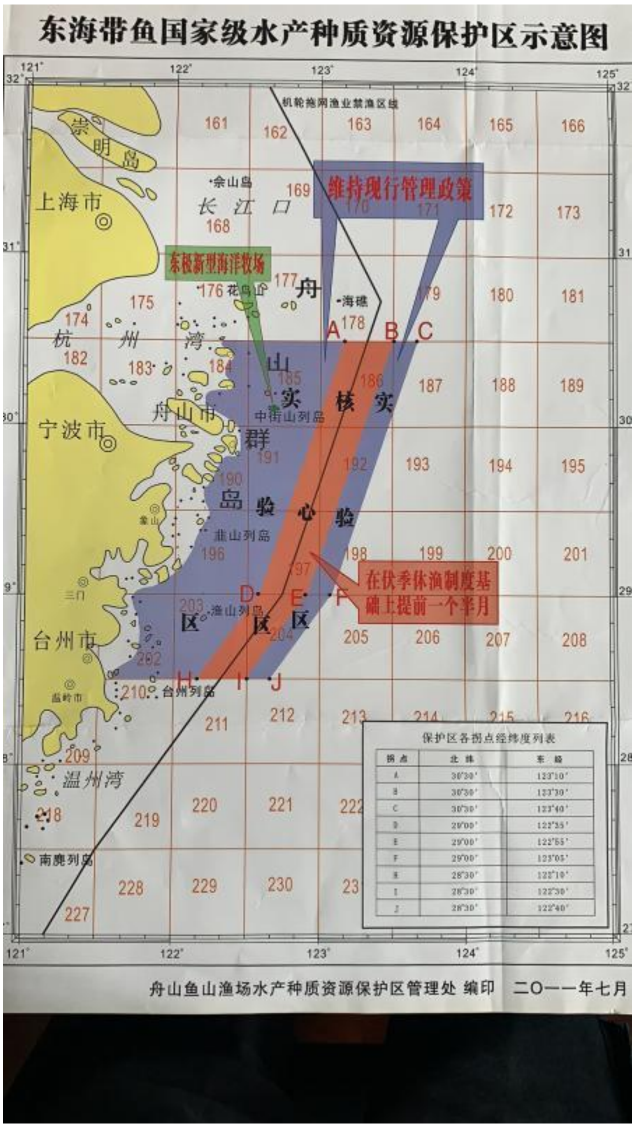

Fig. 5. Schematic diagram of the East Sea hairtail national aquatic germplasm resource reserve (Source: Internet)

Regarding the minimum catch size for hairtail, relevant management regulations already exist. In 2015, Zhejiang Province issued a Notice on the *Implementation of the Minimum Catch Size and Juvenile Proportion Management System for Key Marine Fishery Species*, setting the minimum catch size of hairtail at a weight of 125 grams or a length of 205 mm. [19] In 2016, according to the *Decision of the Standing Committee of the Zhejiang Provincial People's Congress on Strengthening the Protection of Marine Juvenile Resources to Promote the Restoration and Revitalization of Zhejiang Fishing Ground*, Zhejiang Province began implementing a transitional minimum catch size management system for six key marine fishery species, including hairtail, large yellow croaker, small yellow croaker, silver pomfret, chub mackerel, and gazami swimming crab. [20] In February 2017, the Zhejiang Provincial Bureau of Ocean and Fisheries issued a *Notice on the Transitional Minimum Catch Size of Key Marine Fishery Species*, setting the minimum catch size of hairtail at a weight of 60 grams, effective from March 24, 2017. [19]To effectively protect juvenile fish resources and promote the recovery and sustainable utilization of marine fishery resources, starting in 2018, the *Minimum Catch Size Standards and Juvenile Catch Proportion Management Regulations for 15 Important Economic Fish Species* were implemented in accordance with the requirements of the Ministry of Agriculture and Rural Affairs. The minimum catch size for hairtail is set at a length of ≥210 mm for the Bohai Sea, Yellow Sea and East China Sea, while a length of ≥230 for the South China Sea. [9]

Fisheries management system

China's current fisheries management primarily relies on measures such as summer fishing moratorium, non-trawling zone lines, and aquatic germplasm reserves to control fishing intensity and alleviate fishing pressure. While these initiatives have yielded some initial outcomes, they have not effectively addressed the overarching goal of resource recovery. China's fisheries management system faces several key deficiencies:

1. Inadequate data reporting and monitoring of fishery catches, leading to a lack of fishery-dependent species biomass assessment and monitoring.
2. Low gear selectivity resulting in a high proportion of non-target species and economically valuable species' juveniles in the catch, with limited information available to evaluate associated impacts.
3. The substantial catch of low trophic level species may have significant ecosystem impacts, but relevant information for assessing these impacts is lacking.
4. Absence of specific management plans tailored to individual species, beyond general measures like summer fishing moratorium and non-trawling zones.

Moreover, China's nearshore areas typically feature mixed fisheries involving multiple species. Challenges in designing and implementing quota-based fishing management systems arise due to incomplete regulations, lack of vessel and catch volume data, and the absence of an effective fisheries monitoring system.

To address these challenges, it is imperative to not only reinforce enforcement of existing management measures but also to:

- Strictly limit the use of destructive fishing gear and practices.
- Crack down on three-no fishing vessels (fishing vessels without licenses, vessel names or proof of being on a port registry).
- Improve gear selectivity to reduce bycatch.
- Strictly implement minimum mesh sizes and minimum catch sizes to protect juveniles.

Additionally, there is a pressing need to develop comprehensive fish catch monitoring systems, design and implement ecosystem-based management approaches, and integrate species-specific fishing management plannings into the existing management framework. These efforts are crucial for establishing a robust and effective fisheries management system in China.

Acknowledgement

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Reference

[1] ZHANG Kui, ZHANG Jun, XU Youwei, et al. Application of a catch-based method for stock assessment of three important fisheries in the East China Sea[J]. Acta Oceanologica Sinica, 2018, 37(2): 102-109.

[2] 陈丕茂,李永振,袁蔚文.路氏双髻鲨的种群统计分析[J].南方水产科学, 2006, 2(2).DOI:10.3969/j.issn.2095-0780.2006.02.003. Pi-mao, C., Yong-zhen, L., Wei-wen, Y. Demographic analysis of scalloped hammerhead, Sphyrna lewini[J]. South China Fisheries Science, 2006, 2(2): 15-19.

[3] 程家骅，陈雪忠，林龙山，等．东海区帆式张网渔业资源利用结构的动态分 析［J］．中国水产科学，2000，7（2）：64—68．Cheng J H, Chen X Z, Lin L S, et al. Dynamics analysis of available resource structure for stow net fisheries in East China Sea Region[J]. Journal of Fishery Sciences China, 2000, 7(2): 64-68(in Chinese). doi: 10.3321/j.issn:1005-8737.2000.02.014

[4] 褚晓琳.基于生态系统的东海渔业管理研究[J].资源科学, 2010(4):6.DOI:CNKI:SUN:ZRZY.0.2010-04-006. Xiao-lin, C. (2010). Ecosystem-Based Management of Fishery Resources in the East China Sea. Resources Science.

[5] 国务院批准设立东海产卵带鱼保护区[J].中国水产,1988(07):16. State Council. (1988). Establishment of the East China Sea Spawning Hairtail Protection Area approved by the State Council. China Fisheries, (07), 16.

[6] 李立华,严小军,王健鑫,等.浙江近海大黄鱼和带鱼产量的长期变化及资源评估:基于历史统计数据分析[J].浙江海洋大学学报：自然科学版, 2022(001):041. Li-hua, L., Xiao-jun, Y., Jian-xin, W. (2022). Long-Term Change of Yield and Stock Assessment of Larimichthys crocea and Trichiurus lepturus in Zhejiang Coastal Waters Based on Historical Data. Journal of Zhejiang Ocean University (Natural Science).

[7] 李灵智，黄洪亮，王磊，冯春雷，许永久，张禹.东黄海区银鲳流刺网网目尺寸选择性研究[J].海洋渔业, 2010, 032(001):89-94. Ling-zhi, L., Hong-liang, H., Lei, W., Chun-lei, F., Yong-jiu, X., Yu, Z. (2010). The mesh size selectivity research of silvery pomfret gillnet in Yellow and East China Sea.

[8] 刘勇，程家骅，张寒野.2014 年江苏省帆式张网渔业时空分布特征[J].海洋渔业,2022,44(6):790-. LIU Yong, CHENG Jiahua, ZHANG Hanye. (2022). Spatial and temporal distribution characteristics of sail-style stow net fisheries in Jiangsu Province.

[9] 农业部，农业部关于实施带鱼等 15 种重要经济鱼类最小可捕标准及幼鱼比例管理规定的通告,2018 https://www.moa.gov.cn/nybgb/2018/201803/201805/t20180528_6143239.htm Ministry of Agriculture. (2018). Circular of the Ministry of Agriculture and Rural Affairs on the Implementation of the Minimum Allowable Catch Standard for Fifteen Important Economically Important Fish Species and Provisions on Management of the Proportion of Juvenile Fish in the Catch.

[10] 农业农村部渔业渔政管理局, 全国水产技术推广总站, 中国水产学会. 2022 中国渔业统计年鉴 [M]. 中国农业出版社, 2022. China Agriculture Press. (2022). 2022 Chinese Fishery Statistical Yearbook.

[11] 谢玉，朱凯，玄文丹，等.东海海域带鱼的个体繁殖力[J].广东海洋大学学报,2023,43(3):75-81. XIE Yu, ZHU Kai, XUAN Wen-dan, XU Kai-da, ZHOU Yong-dong. 2023. Individual Fecundity of Trichiurus japonicus in the East China Sea. Journal of Guandong Ocean University, 43(3): 75-81. doi: 10.3969/j.issn.1673-9159.2023.03.010

[12] 徐汉祥,刘子藩,周永东.东海带鱼生殖和补充特征的变动[J].水产学报,2003(04):322-327. XU Han-xiang.Variation of Trichiurus haumela productivity and recruitment in the East China Sea[J].Journal of Fisheries of China,2003,27(4):322-327.

[13] 徐兆礼 & 陈佳杰. (2015). 东、黄渤海带鱼的洄游路线. 水产学报 (06), 824-835. XU Zhaoli, CHEN Jiajie. 2015. Migratory routes of Trichiurus lepturus in the East China Sea, Yellow Sea and Bohai Sea. Journal of Fisheries of China, 39(6): 824-835. doi: 10.11964/jfc.20141009534

[14] 袁帆，朱文斌，王忠明，等．东海带鱼的最适可捕规格．应用生态学报，2023，34（1）：242-248 Yuan, F., Zhu, W.-B., Wang, Z.-M., et al. (2023). Optimum capture size of Trichiurus japonicus in the East China Sea. Chinese Journal of Applied Ecology, 34(1), 242-248.

[15] 袁帆. (2022). 东海带鱼生长、死亡参数及管理对策研究 硕士学位论文，浙江海洋大学 doi:10.27747/d.cnki.gzjhy.2022.000331. Fan, Y. (2022). Study on Growth and Death Parameters and Management Countermeasures of hairtail in the East China Sea.

[16] 张魁,陈作志.应用贝叶斯状态空间建模对东海带鱼的资源评估[J].中国水产科学,2015,22(05):1015-1026. Kui, Z. (2015). Using Bayesian state-space modelling to assess Trichiurus japonicus stock in the East China Sea. Journal of fishery sciences of China.

[17] 张魁.基于丰度指数和恢复力的渔业资源评估:以日本海和东海带鱼为例[J].南方水产科学,2022,18(4):9.DOI:10.12131/20210213. ZHANG Kui. Fish stock assessment based on abundance index and resilience: a case study of largehead hairtail in Sea of Japan and East China Sea[J]. South China Fisheries Science, 2022, 18(4): 1-9. DOI: 10.12131/20210213
[18] 张秋华,程家烨,徐汉翔,等.东海区渔业资源及其可持续利用[M].上海:复旦大学出版社,2007. Zhang, Q., Cheng, J., Xu, H., et al. (2007). Fishery Resources and Sustainable Utilization in the East China Sea Region. Shanghai: Fudan University Press.
[19] 浙江省海洋与渔业局，关于实施海洋渔业资源重点保护品种可捕规格及幼鱼比例制度的通告， 2015 https://www.zj.gov.cn/art/2021/8/18/art_1229278041_2322439.html Zhejiang Provincial Bureau of Ocean and Fisheries. (2015). Notice on the Implementation of the Minimum Catch Size and Juvenile Proportion Management System for Key Marine Fishery Species.
[20] 浙江省海洋与渔业局，浙江省海洋与渔业局关于海洋渔业资源重点保护品种最小可捕过渡性规格的通告，2017 https://www.zj.gov.cn/art/2021/8/18/art_1229278041_2322506.html Zhejiang Provincial Bureau of Ocean and Fisheries. (2017). Notice on the Transitional Minimum Catch Size of Key Marine Fishery Species.
[21] 浙江省人大常委会关于加强海洋幼鱼 资源保护促进浙江渔场修复振兴的决定，2016 http://www.daishan.gov.cn/art/2017/1/5/art_1229683988_13240353.html Decision of the Standing Committee of the Zhejiang Provincial People's Congress on Strengthening the Protection of Marine Juvenile Resources to Promote the Restoration and Revitalization of Zhejiang Fishing Ground. (2016).
[22] 舟山市人民政府, 舟山市人民政府关于印发舟山市帆张网渔船整治两年攻坚三年清零行动计划的通知, 2021 http://xxgk.zhoushan.gov.cn/art/2021/12/27/art_1229433793_44434.html Zhoushan Government. (2021). Notice on the issuance of the Zhoushan Municipal People's Government's action plan for the rectification of fishing vessels using canvas stow nets in Zhoushan City for two years of intensive efforts and three years of zero clearance.