China Sustainable Seafood Assessment (CSSA)

Fishery

Japanese anchovy (*Engraulis japonicus*)
Paired Trawl Fishery

CSSA Team

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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

Japanese anchovy (*Engraulis japonicus*) represents one of the single most commercially and ecologically important fish resources in the Bohai Sea, Yellow and northern East China Sea area in China, mainly harvested by pelagic paired trawlers. Japanese anchovy are widely used for feed in Chinese aquaculture.

As reported in many studies, Japanese anchovy populations are exposed to extremely high levels of exploitation, while decreasing anchovy egg size and associated increases in natural egg mortality as adaptive reproductive responses to intense fishing pressure. Besides the high fishing intensity, the population abundance of the short-lived pelagic prey species as anchovy are also influenced by environmental conditions, which may also cause significant fluctuations. In recent years, the national annual catch of the Japanese anchovy fluctuates around 600 kt. The most recent estimated value (2021) of F/Fmsy is less than 1, while B/Bmsy is less than 1, indicating that the fishing intensity of this fishery is moderate, but the resources have not yet been fully recovered.

The other economic species frequently caught in the paired trawler fisheries in the Yellow Sea and Bohai Sea include common hairfin anchovy (*Setipinna tenuifilis*), Japanese Sardinella (*Sardinella zunasi*), sand lance (*Ammodytes personatus*), Japanese Spanish mackerel (*Scomberomorus niphonius*), Japanese jack mackerel (*Trachurus japonicus*), chub mackerel (*Scomber japonicus*), silver pomfret (*Pampus argenteus*), largehead hairtail (*Trichiurus japonicus*) , etc. The statistics found that most of the catch did not reach the allowable catch size stipulated by the Ministry of Agriculture and Rural Affairs, which may pose potential impacts on the resources sustainable utilization of these species. For endangered, threatened and protected (ETP) species, the narrow ridged finless porpoise (*Neophocaena asiaeorientalis*) in the Yellow Sea and Bohai Sea are threatened by paired trawlers. The pelagic paired trawlers mainly operate in the middle to top of the water, which should have minimal long-term effects to the sea floor.

Due to the sensitivity of the short-lived pelagic species to the environmental changes, the

consideration of the environmental issues are necessary in the management of anchovies fisheries. At the same time, as a keystone species in the Bohai - Yellow - East China Sea marine ecosystem, Japanese anchovies has more than 50 species documented in their diet, such as north Pacific krill (*Euphausia pacifica*), while it's also serving as a key prey species of nearly 40 species, including Japanese Spanish mackerel, small yellow croaker (*Larimichthys polyactis*), sea bass (*Lateolabrax maculatus*), chub mackerel, olive flounder (*Paralichthys olivaceus*), largehead hairtail, etc. Therefore, taking into account full consideration of Japanese anchovy's ecological role as both a predatory species and a dominant prey species is needed in developing the fishery management plans.

At present, apart from the closed fishing line for the trawling fishery and the nationwide summer fishing moratorium, there are no specific management measures for pelagic paired trawler Japanese anchovy fishery. While there is a need to enhance the enforcement of existing measures, there are also needs to establish a regular catch monitoring and stock assessment system, apply science based harvest strategy management methods while taking consideration of the ecosystem impacts in the current management system.

To conclude, the CSSA team recognized that Japanese anchovy pelagic paired trawling fishery has unsustainable fishing pressure to the recovering Japanese anchovy population, narrow ridged finless porpoise bycatch issues, and limited application of the ecosystem-based approach in the fishery management. Therefore, this fishery is rated YELLOW, which means it has significant room for improvement in its relevant environmental and management performance.

Japanese Anchovy

Engraulis japonicus

Think Twice

Species Profile

Japanese anchovy (*Engraulis japonicus*) is a short-lived, small pelagic species and important prey resource living in temperate marine waters. The primary distribution of the species in Chinese waters is in the northern East China, Yellow and Bohai Seas (Fig. 1), but also importantly is distributed northerly into Japanese waters and easterly into the Pacific.[1] Though the species have a maximum age of 4 years in Chinese waters, biological data analyzed from Zhao et al. (2003) indicates that a very small percentage reach this age, often comprising 1% or less in any given year with an average of 3% for the period 1987-1996.[8] Age 1 and 2 fish comprised an average 78% of the annual population during this same period. Weight data analyzed from that research report indicated the following average size by age for 1-4 year olds, respectively: 5.9 g, 10.8 g, 13.4 g and 15.6 g. Japanese anchovies

begin maturing during their first year, with fecundity increasing with age and size. The average fecundity is 5,500. Anchovies in the northern Yellow Sea begin to lay eggs in mid to late May. Spawning season decreases after a peak in June and usually ends in September. In the south-central Yellow Sea the spawning period is from early May to mid- October, with the peak during mid-May to late June.

Anchovy distribution is closely related to water temperature. The optimum temperature range for anchovy overwintering is about 7 ~ 15 ℃, with the most optimum temperature range of 11 - 13 ℃. The optimal water temperature for spawning in the northern Yellow Sea is 14-18 ℃. The formation of concentration zones of anchovies is closely related to the horizontal gradients of flow and temperature related to optimum temperature conditions.

Japanese anchovies are widely used for feed in Chinese aquaculture.

Figure 1. Distribution of Japanese anchovy in Chinese waters[3]

FULL ASSESSMENT

Criterion 1: Impact on Target Species

Status of resources

Japanese anchovy represents one of the single most commercially and ecologically important small

pelagic fish resources in the Yellow- East China Sea area. Zhao et al. (2003) documented an almost two-decade history of active stock assessments and harvest analyses, when anchovy biomass ranged from 2 to over 4 million tons during a 12-yr period from 1984-85 through 1995-96.[8] Their extensive acoustic surveys and biological sampling produced a stock recruitment analysis for this period with a resulting estimate of maximum sustainable yield (MSY) of 550 kt and an optimum yield of 520 kt, which equated to wintering and spawning stock biomasses of 2.6 and 2.3 million tons, respectively.

As reported in Wan and Bian (2012), scientists believe that Japanese anchovies are being exposed to extremely high levels of exploitation, which caused the decline of anchovy abundance in the Yellow Sea.[7] Wan and Bian (2012) noted decreasing anchovy egg size and associated increases in natural egg mortality as adaptive reproductive responses to intense fishing pressure. As supporting evidence, they cited the observation by Li et al. (2006) of a trend in decreasing age and size of anchovies as well as increases of individual fecundity at a given size as evidence of this population level adaptation.[9][12]

A more recent study estimates the resource status of Japanese anchovies in the Yellow Sea and Bohai Sea by applying the Schaefer production model and data-limited methods.[20]The data used in this research are the capture and fishing effort data provided by China's annual fishery statistical yearbooks. The results concluded that the Japanese anchovy stock in the Yellow Sea and Bohai Sea is under stable fluctuations after being overfished, with the estimated maximum sustainable yield MSY of this stock about 0.8 million tons. The estimated value of F/Fmsy is less than 1, while B/Bmsy is less than 1, which indicates that the fishing intensity of this fishery is moderate, but the resources have not yet been fully recovered.

While fishing intensity undoubtedly had a significant impact on anchovy population status in China following the mid-1990s, it's also important to note that short-lived pelagic prey species are also subject to significant fluctuations in population abundance due to environmental conditions, with factors such as air and sea surface temperature (SST) being important determinants in recruitment success. Huang et al. (2016) opine, based on reconstructed anchovy abundance over the past 150 years, that recent patterns of abundance are similar to long-term 50-yr cycles observed in their analysis, including the post mid-1990s collapse (Fig. 2).

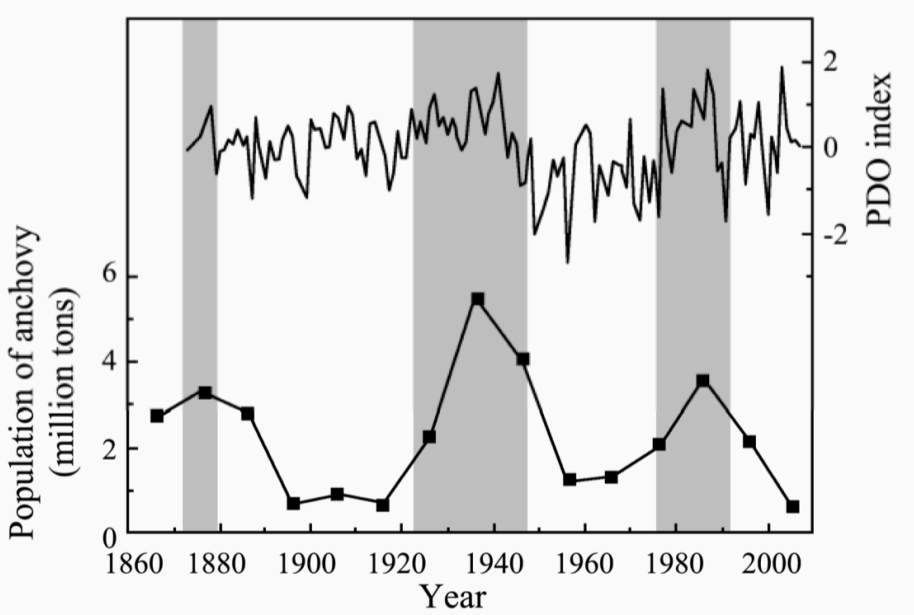

Figure 2. Long-term, reconstructed abundance trends of Japanese anchovy in the Yellow Sea, showing hypothesized relationship to the Pacific Decadal Oscillation Index. [2]

Fishing level

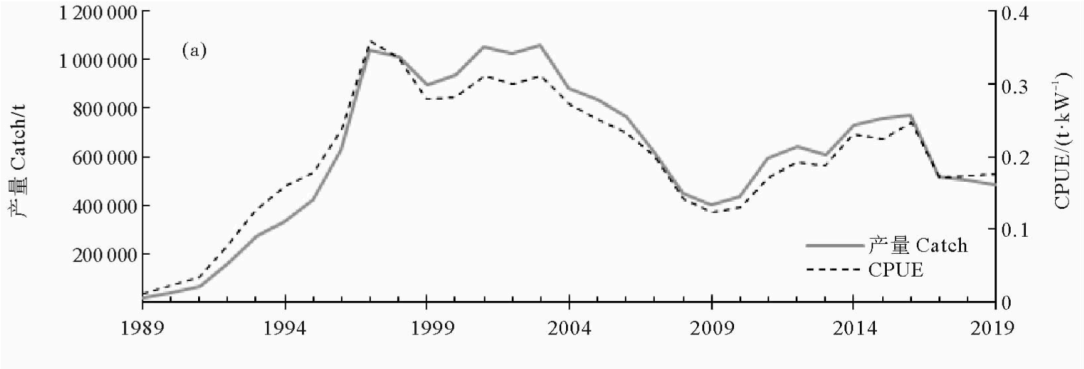

Figure 3. Statistics of catch and CPUE for the anchovy stocks in the Yellow Sea[20]

The development of Chinese fisheries 'targeting' anchovies began in the 1960s, driven by declines in higher trophic level species, a resulting increase in economic value and growing use in aquaculture as a direct feed and fish meal.

Harvest rose sharply from 113 kt tons in 1991 to 600 kt in 1996, then reaching high in 1997 and 1998 of approximately 1 million tons annually. That was achieved through an increase of fishery effort, even though the anchovy resource abundance appeared to be declining as evidenced by younger age composition and smaller size in the catch, reduced population density as evidenced by lower catch per haul, and inconsistent availability on traditional fishing grounds. The declining anchovy fishery harvest after this peak occurred even as fishery effort was still increasing.[17] In recent years, the national annual catch of the Japanese anchovy has fluctuated at 600 kt. The estimated value of

F/Fmsy in Zhang and Lin's (2021) research is less than 1, indicating that the fishing intensity of this fishery is moderate.

Criterion 2: Impact on Non-target Species

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

The Japanese anchovies in the Yellow Sea and Bohai Sea are mainly caught by paired pelagic trawlers. In addition to Japanese anchovies, the main target of the paired trawlers in the Yellow Sea and Bohai Sea include common hairfin anchovy (*Setipinna tenuifilis*), Japanese Sardinella (*Sardinella zunasi*), sand lance (*Ammodytes personatus*) and other small pelagic species, as well as the Japanese Spanish mackerel (*Scomberomorus niphonius*), silver pomfret (*Pampus argenteus*) [1], largehead hairtail (*Trichiurus japonicus*) and other larger pelagic fish. Study conducted on the selectivity of the paired trawler in the Yellow Sea in the fall, and the statistics of the catches found that the dominant species were Japanese Spanish mackerel, largehead hairtail, silver pomfret, Japanese jack mackerel (*Trachurus japonicus*), chub mackerel (*Scomber japonicus*), and common hairfin anchovy. The statistics also found that most of the catch did not reach the allowable catch size stipulated in "Circular of the Ministry of Agriculture and Rural Affairs (MARA) 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".[14] Therefore, the selectivity of the paired trawlers should be improved to mitigate the bycatch of the juveniles of the economically valuable species, to avoid hindering the recovery of the fisheries resources in the Bohai Sea and Yellow Sea.

For the endangered, threatened and protected (ETP) species, the narrow ridged finless porpoise (*Neophocaena asiaeorientalis*) in the Yellow Sea and Bohai Sea are threatened by paired trawlers. Narrow-ridged finless porpoise is endemic to the East Asia region, and the species was included in the IUCN Red List of Threatened Species as Endangered (EN) in 2017, because of historical and anticipated future population declines. This species is listed as Class II protected species in the List of Wildlife under Special State Protection.[10] No recent study on the fisheries bycatch impacts to the narrow ridged finless porpoise published, while a survey published more than 20 years ago has shown that the proportion of porpoise bycatch cases by trawl fisheries is approximately 5.7%, while stow net poses higher threats (59.5%), followed by gillnet (35.8%).[19] Informed by the fishers, the incidental bycatch of the species has often occurred in the paired trawl fishery.

[1] The species here is controversial. There are related claims that *Pampus argenteus* is not distributed in the further north of Taiwan, and the pomfret in the Yellow Sea and Bohai Sea area is *Pampus echinogaster*.

Criterion 3: Control Impact on Ecosystem

The effect of fishing gear

In paired trawling the net is towed by two boats simultaneously, one towing each side of the trawl and held open by the distance apart of the vessels. There will be some disturbance to the seabed through the contact of the sweeps and the ground gear of the net, but because Japanese anchovy is a pelagic species, the pair trawlers mainly operate in the middle to top of the water, which should have minimal long-term effects to the sea floor.[6] The port-based survey also found very little demersal species in the catch, indicating the limited contact to the substrate of the anchovy fishing grounds.

Ecosystem-based fisheries management

Small pelagic fish populations like Japanese anchovy are subject to extreme fluctuations in recruitment success and population abundance due to their short life expectancy, aggregative behavior, and highly variable natural mortality related to climate and marine environmental conditions. This fact makes assessment and management of such species challenging with successful harvest management paradigms either being very intensive and responsive to real time abundance monitoring or, alternatively, more precautionary consistent with the degree of uncertainty.[5] Modeling by Lindgren et al. (2013) of California sardines suggested that collapse of this stock in the mid-20th century would have occurred regardless of fishing exploitation, simply due to unfavorable environmental conditions but that the collapse was accelerated and recovery slowed by the level of exploitation experienced by the stock.[4] Therefore, the consideration of the environmental issues are necessary in the management of anchovies fisheries.

Japanese anchovies mainly feed on plankton, with more than 50 species documented in their diet in the southern Yellow and northern East China Seas. The population structure of the zooplankton species is likely to undergo large structural changes as the predation pressure from anchovy decreases significantly. According to the research of Meng Tianxiang (2003), north Pacific krill (*Emphamsia pacifica*) is the main prey for Japanese anchovies, especially the large sized individuals.[13] In recent years, monitoring surveys in the Yellow Sea have indicated that north Pacific krill has shown a clear trend of increase and has become a bycatch species, suggesting that the zooplankton community has undergone significant changes.[21]

At the same time, Japanese anchovy is one of the keystone species in the Bohai Sea and Yellow Sea ecosystem. According to Wei and Jiang (1992), Japanese anchovy is the key prey of nearly 40 species, including Japanese Spanish mackerel, small yellow croaker (*Larimichthys polyactis*), sea bass (*Lateolabrax maculatus*), chub mackerel, olive flounder (*Paralichthys olivaceus*), largehead hairtail, etc.[18] According to previous research, Japanese anchovy contributed 81% of the stomach contents of the Japanese Spanish mackerel in the 1980s, 65.7% by weight. Assuming a food conversion efficiency is 15% for Japanese Spanish mackerel, approximately 900 kt of anchovy is needed per year

to support a Japanese Spanish mackerel population of 200 kt. Such a large bait requirement can only be provided if the fishing mortality coefficient of the anchovy stock is below the optimal value of 0.3. If the anchovy stock can't provide this volume, the mackerel population must switch to other prey species. Stomach content samples of mackerel in spring 2000-2002 showed that anchovy accounted for only 6.5%, 3.6% by weight. Sand lance has replaced the anchovy as the main bait species. These observations clearly show that the decline of anchovy resources in the Yellow Sea would have a serious impact on the food supply of other economically important species in the Yellow Sea marine ecosystem.[21] In Weihai area, located in the northern Yellow Sea, the Japanese anchovy has a local name called "Spanish mackerel food", vividly indicating the fishers' understanding of their ecosystem role as a key prey species of predatory Japanese Spanish mackerel.

Besides, the migration route and timing of anchovies in the Yellow Sea and Bohai Sea area is similar to the migration habits of Japanese flying squid, and there is some belief that Japanese flying squid may prey on anchovies. Therefore, evaluation and management of fishery impact on ecosystem function is needed, taking into account full consideration of Japanese anchovy's ecological role as a predator to planktons, as well as dominant prey species, e.g., for Spanish mackerel, Japanese flying squid etc. in the Yellow Sea and East China Sea. These actions will form a critical scientific basis for an ecosystem-based fishery management scheme.

Criterion 4: Management and Implementation

Fishery management plans for target species

In 1955, the State Council released the Order on Setting a Closed Fishing Line to the Motorized Trawlers in the Bohai Sea, Yellow Sea and East China Sea, which is connected by 17 base points, stipulating that motorized trawlers were prohibited to fish within the landward side of the closed fishing line.[11] The closed line was further extended to the south in 1957 and 1980, and from 1981 onwards all motorized bottom trawlers were prohibited to enter and operate within the closed area line.

Since 1995, in order to protect the spawning populations in summer, a fishing moratorium from July to August for trawlers and canvas stow nets in the East China Sea has begun to be implemented, which has gradually been expanded to the entire coast of China. At present, the summer fishing moratorium system has become one of the most fundamental fisheries management systems in China, and the time, scope and type of fishing closure are adjusted in accordance with the situation each year. In 2022, the fishing moratorium in the Bohai Sea and the northern Yellow Sea is from May 1 to September 1, while it's from May 1 to September 16 in the southern Yellow Sea and the northern East China Sea, and from May 1 to August 16th in the southern East China Sea and the South China Sea.[16]

In 2017, MARA issued a Circular of the Ministry of Agriculture on Strengthening Domestic Fishing Vessel Control and Implementing Total Amount Control Over Marine Fishery Resources. The Circular

is an important milestone because it set a time-bound agenda for all coastal provinces and municipalities directly under the Central Government to initiate total allowable catch (TAC) management pilots for individual species. Juvenile anchovy fishery by purse seine in Zhejiang province has become one of the first TAC pilots in the coastal provinces, launched in 2018. The pilot aims to test the feasibility of opening and managing a species-specific fishery during the national "one-size-fits-all" summer fishing moratorium. This juvenile anchovy fishery is subject to the catch limit management, complemented by the observer system, electronic logbook and electronic monitoring system, etc.[22] This fishery has provided important experiences on the finfish TAC management, with many key elements of a sophisticated fishery catch monitoring system being tested, and yielded important results for advancing catch monitoring in China. However, this model is still being implemented within Zhejiang province, and has not been applied in wider anchovy fisheries management.

Apart from the closed fishing line and the summer fishing moratorium, there are no specific management measures for pelagic paired trawler Japanese anchovy fishery, i.e., no structured stock assessment- based management and harvest approach, with associated harvest control rules and conservation measures.

Fisheries management system

Currently, China's law enforcement and management system for the oceans and fisheries industry has basically been established and it is sound. However, the Chinese fishery management system is relatively insufficient with respect to essential science based monitoring, assessment, harvest controls and basic compliance. Examples of key deficiencies include:

- Stock abundance is not systematically conducted based on regular catch and biological monitoring/accounting.
- Prevalence of non-selective gears result in potential issues with bycatch and juveniles of economically valuable species and little information is available to assess these impacts.
- Large catches of lower trophic level species could have significant consequences to ecosystem function and there is little evaluation on these impacts.
- No harvest strategy is utilized beyond the general management measures such as summer fishing moratorium.

Therefore, while there is a need to enhance the enforcement of the measures, including strictly limiting the use of destructive fishing gears and fishing methods, combating "three nos" fishing vessels, improving the gear selectivity, and implementing closed seasons and areas, minimum mesh sizes, minimum catch size, etc., there are also needs to incorporate the regular catch monitoring, ecosystem-based approach and harvest strategy management methods into the current management system. At the same time, it's recognized that many challenges are faced in terms of the mechanisms and institutions in the fisheries management department, for example, insufficient manpower affects the efficiency of law enforcement and management work.

Acknowledgement

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