



THE UNIVERSITY OF BRITISH COLUMBIA
Institute for the Oceans and Fisheries

WORKING PAPER SERIES

Working Paper #2020 - 01

Evolution of China's policies on bottom trawl fisheries over seven decades (1949 - 2018)

Xiong Zhang, Amanda C. J. Vincent

Year: 2020

Email: x.zhang@oceans.ubc.ca

This working paper is made available by the Institute for the Oceans and Fisheries, University of British Columbia, 2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada

Evolution of China's policies on bottom trawl fisheries over seven decades (1949 – 2018)

Running Title: China's bottom-trawl fishery policies

Authors: Xiong Zhang, Amanda C. J. Vincent

Institution: Project Seahorse, Institute for the Oceans and Fisheries, The University of British Columbia.

Address: 2202 Main Mall, Vancouver, BC V6M 1Z4, Canada.

Abstract

To pursue sustainable fisheries, the world needs to constrain bottom trawling (BT) through effective management. Such change is particularly urgent for China, which operates the largest bottom-trawl fisheries (BTF) both in and beyond its waters. We provide the first comprehensive review of China's approach to BTF over seven decades (1949 – 2018) based on bibliometric approaches (diversity index, network and word-cloud analyses). We collated an inventory of 103 Chinese national policies and classified them into seven categories (e.g., input/output control) over five eras: (i) E1: 1949 – 1977 (planned fishing with limited management); (ii) E2: 1978 – 1992 (regime shift with input control); (iii) E3: 1993 – 2002 (EEZ management with multiple regulations); (iv) E4: 2003 – 2012 (resource conservation with fuel subsidy); and (v) E5: 2013 – 2018 (fisheries transformation with bans ahead). We found that China has increased its concerns on BTF, with more frequent and diverse policies over time. Such changes included more limits (e.g., input and output controls) and more law enforcement. However, many well-intentioned ones (including bans) failed in implementation. We indicate that China's BTF policies have been influenced by both domestic (e.g., political will, consumption demand) and international drivers (e.g., international laws, globalization). We highlight the problems in managing China's BTF, and challenges and suggestions in policy implementation. This review may help policy making and implementation for BTF management in China and facilitate the dialogue between China and the world in fishery policies for sustainable development.

Keywords: bibliometric, biomass trawling, Chinese fisheries, marine conservation, sustainable development, policy reform.

Table of Contents

1.	INTRODUCTION	
2.	METHODS	
2.1.	Data collection	
2.2.	Data analyses	
2.2.1.	Policy classification and coding	
2.2.2.	Policy narrative	
2.2.3.	Bibliometric analyses	
3.	RESULTS	
3.1.	Five eras of policy evolution	
3.1.1.	E1 (1949 – 1977): Planned Fishing with Limited Management	
3.1.2.	E2 (1978 – 1992): Regime shift with Input Control	
3.1.3.	E3 (1993 – 2002): EEZ Management with Multiple Regulations	
3.1.4.	E4 (2003 – 2012): Resource Conservation with fuel subsidy	
3.1.5.	E5 (2013 – 2018): Fisheries Transformation towards Sustainability with Bans Ahead	
3.2.	Generalization of the policy evolution	
4.	DISCUSSION	
4.1.	Factors influencing the evolution of China’s BTF policies	
4.1.1.	Key domestic factors	
4.1.2.	Key international factors	
4.2.	Problems in managing BTF in China	
4.3.	Challenges and suggestions in implementing China’s BTF policies	
4.4.	Comparison of BTF policies between China and other countries	
5.	CONCLUSION	
	ACKNOWLEDGEMENTS	
	DATA AVAILABILITY STATEMENT	
	REFERENCES	

1. INTRODUCTION

Bottom trawling (BT) has long been a focal concern in fisheries management and marine conservation (Dureuil et al., 2018; Pauly et al., 2003). Facilitated by modern technologies (e.g., automation, new materials, fish finders, GPS), BT has been the most efficient fishing practice for catching benthic fishery resources (e.g., shrimps, benthic and benthopelagic fishes) and has been deployed globally (Gillett, 2008). Currently, BT accounts for ~ 23% of the landed marine catches and notably ~ 60% of marine fisheries discards worldwide (Cashion et al., 2018). Its footprints are largely concentrated on coastal waters, imposing high pressures especially on coastal marine ecosystems with a mean trawling intensity up to 8.5 times per year (Eigaard et al., 2017; Kroodsma et al., 2018; Zhang et al., 2016). Such a massive fishing pressure has threatened the livelihood of many coastal communities depending on small-scale fisheries, especially in developing countries (Belhabib et al., 2019). Many studies have demonstrated that BT depletes benthic fish populations, harms benthic habitats and communities, threatens non-targeted and rare species, triggers sediment resuspensions and unleashes pollutants from the seabed (Buhl-Mortensen & Buhl-Mortensen, 2018; Hiddink et al., 2019; Hiddink, Rijnsdorp, & Piet, 2008; Oberle, Storlazzi, & Hanebuth, 2016).

To address the problems of BT, many countries have taken countermeasures including trawl bans, seasonal closures, and gear modifications (Broadhurst et al., 1997; Gillett, 2008; Tao et al., 2018). The earliest ban on the use of bottom trawls was perhaps executed by France in the Mediterranean (De Groot, 1984). Three maritime countries (i.e., Belize, Palau, and Venezuela) have spearheaded bans on BT in their exclusive economic zones (EEZs), and BT has also been prohibited in large regions of the US (e.g., Florida, Georgia, North Carolina), Indonesia, the Philippines, Australia, New Zealand, Atlantic islands (e.g., Azores, Madeira, and Canary Islands), and the Mediterranean Sea (EU and North Africa) in recent decades (Chong et al., 1987; Chuenpagdee et al., 2003; Mazor et al., 2017; Pipitone et al., 2000; Stiles et al., 2010). Some countries (e.g., Australia, Portugal) have mandated gear modifications, such as using square-shaped mesh and bycatch-reduction devices, to mitigate the impacts of BT (Broadhurst, 2000; He

& Balzano, 2011). Some of these changes have had positive effects on fisheries (e.g., biomass or body size increase) and marine ecosystems (Pipitone et al., 2000; Tao et al., 2018). Meanwhile, as global fishing industries are increasingly extending their exploitation to international waters (a.k.a., high seas), there are corresponding calls for ban or restrictions on BT in these regions, especially where deep-sea corals and other fragile habitat-forming creatures are dwelling (Oanta, 2018; Watling, 2013).

As one of the world largest BTF nation, China plays a vital role in curtailing BT and reducing its impact globally (Cao et al., 2017; Pauly et al., 2014). According to its national government's report, China's domestic trawlers landed 4.9 million tons of catches in 2018, nearly half of reported marine domestic catches of the country (BFMOA, 2019). In that year, 28,364 trawlers were registered in China, with a total horsepower of 6.1 million kW; these two values accounted for 18 and 44% respectively of the figure for all Chinese marine fishing vessels (BFMOA, 2019). Meanwhile, China is also operating 2654 vessels in distant waters worldwide (BFMOA, 2019), especially Africa, Asia, and Oceania, and many of them are bottom trawlers (BTs) (Mallory, 2013; Pauly et al., 2014; Xue, 2006). BTs usually contributed ~90% of China's catch from distant waters (Xue, 2006). Currently, the reported total catch by China's distant-water fisheries (DWF) amounts to 2.3 million tons, representing 22% of the nation's total marine catches (BFMOA, 2019). Based on the latest reconstructed data in 2014, the catch by China's BTF (domestic and distant-water) accounted for 29% of the total catch by BTs worldwide (Pauly & Zeller, 2015). China, therefore, ranks as one of the world most influential fishing nations in terms of the capacity and output of its BTF.

Studies have long indicated that China needs to enhance the management of its BT in both domestic and distant waters. Over past few decades, Chinese consumption demand for food fish has increased dramatically along with its rapid urbanization and economic growth (Dong & Zhong, 2006; Zhai et al., 2014). However, China has overexploited its marine fisheries as early as in late 1970s, and was forced to shift its focus to aquaculture (primarily freshwater farms) in ~ 1980s (Cao et al., 2017; Su et al., 2020; Zhong & Power, 1997). Since then, China has consumed large volumes of 'trash fish' (low-valued, small

or undersized fishes and invertebrates; particularly from BT) to make fishmeal and fish feed for its aquaculture development. This has triggered global concerns and hot debates in literature (Cao et al., 2015; Han et al., 2018; Zhang et al., 2020), making China's BTF a focus in addressing sustainability of fisheries and aquaculture worldwide. Currently, half of China's domestic trawling catch are now trash fish, which are mainly used as aquaculture feed (Zhang et al., 2020). The mean depletion rate of its 21 major BTF stocks is 84%, making stock rebuilding extremely challenging and mitigation of fishing pressure an urgent demand (Zhai & Pauly, 2019). On the other hand, since China started its DWF in 1985, bottom trawlers have been the major vessels deployed (perhaps given their overcapacity in domestic waters); these vessels are largely trawling in African waters, threatening small-scale fisheries on which many coastal communities depend (in terms of livelihood and food security) (Belhabib et al., 2019; Mallory, 2013; Pauly et al., 2014; G. J. Xue, 2006). It is also worth noting that Chinese trawlers have been frequently covered and criticized on social media for conducting illegal fishing in distant waters, especially in marine protected areas (Alava et al., 2017). All these issues await China to tackle with enhanced management plans and enforcement.

Currently we lack a comprehensive understanding about China's policies for managing its BTF, impeding the effort to understand the problems and probe solutions. China's fishery management is generally a top-down system with a command-and-control approach: the central and provincial fishery governments are responsible for enacting management policies, and the municipal and county-level governments implement these policies (Shen & Heino, 2014). To address overfishing, the central government (i.e., State Council) and its agencies (e.g., Ministry of Agriculture) has enacted a variety of fishery-related policies, including summer moratoria, input and output control measures, which have been reviewed multiple times in literature (Cao et al., 2017; Shen & Heino, 2014; Su et al., 2020; Wang & Zhan, 1992; Yu, 1991; Zhong & Power, 1997). China has also issued some subsidy policies (e.g., fuel subsidy) to support its fisheries development and may counteract the effects of the limitative policies (He, 2015; Mallory, 2013). Currently, China is attempting to upgrade its marine fisheries, especially DWF

(Zhang & Wu, 2017). Nevertheless, previous reviews on China's fishery policies are largely qualitative narratives (without few quantitative analyses), and no studies have focused on China's policies particularly relevant to BTF. Given China has recently started a new wave of policy reforms in marine fisheries with an ambition to seek sustainable fisheries (Cao et al., 2017; Su et al., 2020), it is timely to review its previous policies on BTF to inform decision making (e.g., avoiding repeating previous mistakes).

Here we review China's national policies on BTF (in both domestic and distant waters) over past seven decades, using both qualitative and quantitative approaches. We aim to draw useful insights and lessons from the history to inform problem solving in managing China's BTF. Our review spans from the founding of the People's Republic of China (PRC, in 1949) throughout 2018. We collect policy information from a wide range of sources, especially Chinese publications and central-government websites. We summarize these policies across different categories and policy eras and assess policy change and its impacts on fisheries. Unlike previous review studies (e.g., Su et al., 2020), we use bibliometric approaches (i.e., diversity indices, network and word-cloud analyses) to quantify, track, and display the seven decades of policy evolution bibliometrics (Guler, Waaijer, & Palmblad, 2016; Rafols & Meyer, 2010; Stirling, 2007). These approaches are also rarely used in fishery-policy reviews. Finally, we discuss four issues of broad interest: 1) factors influencing the evolution of China's national policies on BTF, 2) problems in managing BTF in China, 3) challenges and suggestions in implementing BTF policies in China, and 4) the comparison of BTF policies between China and other countries. This review will support China and the world to enhance policy making and enforcement in curtailing BT, for fisheries sustainability and ocean conservation.

2. METHODS

2.1. Data collection

We collated China's central-government policies related to BTF from 1949 throughout 2018 from multiple sources. Here, the central government refers to national level government bodies, including the National People's Congress (i.e., the highest legislative body) and its standing committee, the president, the State Council (i.e., the highest administration body) and its affiliated ministries / bureaus, and the National Supreme Court (i.e., the highest jurisdiction body). Among them, fishery management authority was normally conducted by the Ministry of Agriculture (MOA) or its counterparts as the government organizations changed the structures and names many times through the history (see Figure S1.1 and a detailed description on Appendix S1). The policies contain both legislative and regulatory documents, which were published with a variety of specific terms used by Chinese governments (e.g., law, five-year plan, outline, agenda, circular, opinions, regulations, provisions, measures; see Table S1.1 & 1.2 on Appendix S1). We first applied the keyword '拖网' (pinyin: Tuo Wang, i.e., trawl)¹ to track down relevant policy documents from the official websites of (1) the State Council (<http://www.gov.cn/>) – China's central government, (2) the national Ministry of Agriculture (MOA, <http://jiuban.moa.gov.cn/>) which covered fisheries, (3) the national Ministry of Agriculture and Rural Affairs (the successor of MOA since March 2018, <http://www.moa.gov.cn/>), (4) other archive websites about Chinese laws (e.g., <http://www.law-lib.com>, <http://www.pkulaw.cn/>, and <http://www.110.com/>), and (5) peer-reviewed literature in Chinese (China Knowledge Resource Integrated Database, a.k.a., CNKI, <http://cnki.net/>; available years from 1983 throughout 2018). We also searched peer-reviewed papers from English sources in the Web of Science (year range: 1950 – 2018) with the Topic words 'China', 'policy', and 'trawl', and other specific policy glossaries (e.g., summer moratorium) identified during the searching process.

¹ Note that in Chinese this word is like a wildcard that would cover 'trawl fisheries', 'bottom trawlers', and all other words related to trawl.

To understand political drivers in the policy evolution, we collected information about the major political wills and influences on fisheries development of the five leaders (Mao Zedong, Deng Xiaoping, Jiang Zemin, Hu Jintao, Xi Jinping) of the PRC. To this end, we first derived relevant information from the collected policy documents and peer-reviewed literature, and then searched more data about this aspect from CNKI and Web of Science like a snowball searching.

We also collected available input and output data from various sources to construct the context of China's capture fisheries (and BTF if available) and aquaculture (e.g., fishmeal production; see details on Appendix S1). We are interested in exploring the potential interactions between the collected BTF policies and relevant input and output variables. However, given our focus was understanding the policies, we did not address data gaps in these fishery and aquaculture variables, which were of concern (see Appendix S1). Therefore, while linking policies with these variables, one should interpret our results with caution.

2.2. Data analyses

2.2.1. Policy classification and coding

We split the history of China's BTF policies to five eras within the time frame from 1949 throughout 2018. China has been ruled by one party, i.e., the Communist Party of China (CPC) since 1949. Given its 'top-down' government regime, central government leaders have strong influences upon policies of each sector of the economy including marine fisheries (Cao et al., 2017). Therefore, we adopted a five-era framework matching the political imprints of the five Chinese leaders over past seven decades: Mao Zedong (E1: 1949 – 1977), Deng Xiaoping (E2: 1978 – 1992), Jiang Zemin (E3: 1993 – 2002), Hu Jintao (E4: 2003 – 2012), and Xi Jinping (E5: 2013 – 2018). We were interested in comparing the policy profiles among these five eras with the following analyses.

In each era, we classified policies into seven categories and coded them for the ease of tracking. The seven categories were international laws and agreements (hereafter, IA), (domestic) overarching policy (OP), ban & protection (BP), input control (IC, i.e., constraining / reducing fishing capacity & effort), output control (OC, i.e., constraining / reducing catch), law enforcement (LE), and (fuel) subsidy² (SS; Table 1; adapted from Cao et al., 2017; FAO, 1996). We then coded each policy with three elements (linked with a dash between each element): the era (E1 - E5), the category (IA, OP, BP, IC, OC, SS, and LE), and the chronological order³ (started with 1). For instance, E1-IA-1 means the first policy of international laws and agreements (IA) in the first era (E1).

2.2.2. Policy narrative

In each era, we summarized the political and fisheries context based on the collected data, and then narrated the policies in the context, primarily in chronological order. Wherever information was available, we explained 1) the reasons for making each policy, 2) the major policy elements and their importance in respect to BTF, 3) whether it was successfully implemented, 4) whether it met the expected target, and 5) why it succeeded or failed. We put this detailed narrative of each policy on Appendix S2 and generalized the major findings in the Results.

We compared each era's policy profile based on five characteristics and the six categories of policies. The five characteristics were 1) general features (serving as a short title for the era), 2) pressures & drivers (for making/changing the policies), 3) policy priority (i.e., major focus in marine fishery management), 4) landmark (i.e., a flagship policy document that represented the change of the era), 5) management strategy (i.e., general approaches for dealing with BTF).

² Here we focused on fuel subsidy as it was the most important and controversial fishery subsidies (especially for bottom trawlers) provided by the central government in China (Mallory, 2016; Zhu & Huang, 2014); but see a comprehensive review on China's fishery subsidies by Mallory (2016).

³ Order in terms of the time when the policy became in effect.

2.2.3. Bibliometric analyses

We compared five indices of the policies among the five eras. The first index was the mean number of policies issued per year in each era, measuring the general level of China's concern on BTF. The other four indices were two sets of diversity and evenness measures: (i) Shannon's diversity index and equitability, and (ii) Inverse Simpson's diversity index and equitability (Laakso & Taagepera, 1979; Magurran, 1988; Simpson, 1949). These indices have been widely used in measuring diversity and evenness in ecological, social, and bibliometric studies (Coulter, 2019; Guler, Waaijer, & Palmblad, 2016; Morris et al., 2014). We here applied them to measure policy diversity and evenness (i.e., treating each 'policy category' as a 'subject/species' in the equations). Here the 'abundance' of each policy category in each era was measured by the number of policy documents belonged to that category. The diversity index measures the richness of policy categories, while the equitability estimates the evenness of the abundance of different categories in each era. We employed these indices to examine whether China has gradually augmented and diversified its policies and in what ways.

We used network analyses to track the policies and to identify 'keystone' policies throughout the history (r packages 'igraph'; Csardi & Nepusz, 2006). For the network analysis, we identified three types of relations between each pair of related policies: 1) extension, 2) reference, and 3) revision. Here, 'extension' refers to the situation when a new policy describes more detailed regulations or extends the spatial or temporal coverage of a former one and they are not exclusive to each other; 'reference' stands for the case when a new policy used the other (usually broader policy or an overarching policy) as its legislative base; 'revision' means that a new policy revised some of the regulations related to BTF⁴ and replaced the other. We identified the 'keystone' policies that were referenced the most frequently throughout the history.

⁴ Note that we only considered this when specific regulations related to BTF were changed. For instance, when a new appendment to a law was initiated for other purposes and did not change the clauses about BTF, we did not count this as a revision or policy change in this context, given our focus was BTF.

We applied the word-cloud technique to identify the policy focus of each era and the whole history based on the detailed narrative (r packages ‘wordcloud’, ‘tm’, and ‘Snowballc’; (Bouchet-Valat & Bouchet-Valat, 2015; Feinerer, Hornik, & Feinerer, 2019; Fellows et al., 2018). To this end, we removed some uninteresting common words that were used in our policy narrative (on Appendix S2). These included ‘fishing’, ‘fishery’, ‘fisheries’, ‘China’, ‘Chinese’, ‘government’, ‘sea’, ‘marine’, ‘bottom trawler’, ‘trawler’, ‘trawling’, ‘issued’, ‘enacted’, ‘approved’, ‘forwarded’, ‘policy’, and ‘policies’. We also made other common edits (e.g., removing stop words, numbers, and punctuations, converting text to lower case, combining singular and plural forms of words) before constructing the word cloud for each era based on the narrative of that era. In the end, we used the whole narrative to build a word cloud that demonstrated the whole profile of all policies.

3. RESULTS

We found a total of 103 national policies that touched on BTF management in China (year range: 1955 – 2018, see Table S2.1 on Appendix S2). We summarized the profile of the five eras in Table 2 and narrated the policies in each era respectively as follows in 3.1 (see the detailed narrative of each policy on Appendix S2). A generalization based on bibliometric analyses was provided in 3.2.

3.1. Five eras of policy evolution

3.1.1. E1 (1949 – 1977): Planned Fishing with Limited Management

Summary: In the era of Mao Zedong (1893 – 1976), China managed its BTF under a planned-economy regime with only a few policies (n = 6). These policies were classified into two categories: international laws and agreements (IA, n = 1), and ban & protection (BP, n = 5; Figure 1). Little is known about their effectiveness, although they were likely implemented (Table S2.1). In E1, China focused on expanding exploitation (including pushing BTs moving towards offshore waters) to provide more seafood

for domestic consumption (He, 2015; Li & Huang, 2005), while starting to protect its BTF stocks (e.g., shrimps) from overfishing in its northern inshore waters (Figure 2).

Political context: After the founding of the PRC (Oct. 1949), the central government adopted a planned-economy regime for all its economic sectors including fisheries. Under this regime, the government controlled the market (i.e., no free market or competition); production materials and profits in fisheries were owned and allocated by the state-owned companies and community-owned cooperatives and communes (Su et al., 2020). During Mao's era, the Five-Year Plan for the National Economy was a dominant mode for China's economy development – a legacy that is still used but has been transformed to focus on public-affair governance in later eras (Heilmann & Melton, 2013). Notably, there were serious conflicts between Japanese trawlers and Chinese fishing boats in the Yellow Sea and East China Sea (Xiao & Li, 2007). Such conflicts then drove China to issue some policies (as narrated below) to resolve the fishery disputes and protect China's fishery interests.

Fisheries context: China's fishing capacity and output gradually increased at relatively low rates in E1 (Figure 3a&b), constrained by the planned-economy regime. China's BTF were mainly active in the 'traditional fishing grounds'⁶ in China's four seas especially the East China Sea and Yellow Sea in the north (Tang, 2012; Figure 3). The contribution of BTF to China's marine fisheries output increased almost linearly from 4.8% (in 1950) to 32.7% (in 1977; Figure S2.1), suggesting a steady expansion of BTF. Meanwhile, an increasing proportion (from 12.2% in 1950 to 53.9% in 1977) of China's BTF catch was from waters beyond its later claimed EEZs (in 1996 of E3, see Section 3.1.3; Figure S2.1). This suggests that Chinese bottom trawlers had been gradually moving offshore. Consequentially, major demersal fish stocks (e.g., bighead hairtail, large yellow croaker, small yellow croaker) in the East China Sea gradually declined because of the overfishing by BTs, both from China and Japan (Lin, 1987; Muscolino, 2009; Zou, 2003).

⁵ The first one started in 1953, and this continued afterwards except between 1963 and 1965 during which the nation was recovering from the Great Leap Forward movement and no plans were conducted.

⁶ Fishing areas that have long been used (long before the UNCLOS) by Chinese fishers (see Tang, 2012).

Major pressures & drivers: 1) food scarcity and low fishing capacity (He, 2015), 2) conflicts for fishing areas in China's northern seas between motorized trawlers (including Japanese ones) and artisanal fishers (Xiao & Li, 2007), and 3) declines of BTF stocks in the northern waters (Lin, 1987).

Ban & protection (BP, n = 5): *no-trawl zone 1955* (E1-BP-1), *no-trawl zone extension 1957* (E1-BP-2), *shrimp protection regulations in Bohai 1962* (E1-BP-3), *no-trawl zone extension 1963* (E1-BP-4), and *fish & shrimp protection regulations in Bohai 1975* (E1-BP-5; Figure 1). The no-trawl-zone policies (E1-BP-1, 2, 4) were issued to resolve the conflicts between motorized trawlers (including Japanese ones) and artisanal fishers in the China's northern seas (i.e., Bohai Sea, Yellow Sea, and East China Sea; Figure S2.2). These are the first national policies for BTF in China and might be well implemented in E1, given that all the relatively few Chinese trawlers were controlled by the government and the catch share from inshore waters gradually declined (Figure S2.1). The stock-protection regulations for shrimp and fish stocks (E1-BP-3, 5) were the first legal documents for BTF stock protection in China, although it only applied to the Bohai Sea. Minimum mesh size, restricted operation time and restricted fishing water for trawlers were detailed in these legal documents to protect spawning stocks of shrimps (in 1962) and commercial fish (in 1975) migrating into the Bohai Sea to spawn (Figure S2.2). However, little is known about their implementation.

International laws & agreements (IA, n = 1): *Sino-Japanese Fishery Agreement 1975* (E1-IA-1). The agreement was the first bilateral fishery agreement signed by the Chinese government as an interim approach to resolve fishery disputes in the Yellow Sea and East China Sea between China and Japan. It stipulated seasonal-closure zones for motorized trawlers and juvenile-fish conservation areas (Figure S2.2). Although little is known about the implementation, these were the earliest initiatives of summer moratoria and fishery-conservation areas, which became national regimes in China in E2.

3.1.2. E2 (1978 – 1992): Regime shift with Input Control

Summary: In the era of Deng Xiaoping (1904 – 1997), China started to apply more policies (especially input control) to manage the explosively growing BTF stimulated by the regime shift from planned economy to market-oriented economy. These policies (n = 26) consisted of four categories: overarching policy (OP, n = 7), ban & protection (BP, n = 13), input control (IC, n = 5), and output control (OC, n = 1; Figure 4). However, all limiting policies (BP, IC, and OC, n = 19) and two overarching policies (Fisheries Law & its implementation rules) were likely failed (Table S2.1). Economy development was the dominant concern in the government and fishing capacity of BTs became out of control. China gradually shifted to focus on developing aquaculture, offshore and distant-water fisheries to meet the increasing consumption demand for fishery food, while attempting to protect its inshore fishery resources as they were depleting.

Political context: As Deng became China's paramount leader, he soon abandoned the 'planned economy' regime and launched the 'reform and opening up' policy (a.k.a., economic reform) in Dec.1978 to boost economy growth. The fishery sector was chosen by the central government as a test ground for the reform, since it only contributed a small portion to China's economy (< 2% of agriculture, Figure S2.3) and played a minor role in China's food security system (Li & Huang, 2005). These reforms included free fishery market, price liberalization, vessel privatization, and commune dismantling from the early 1980s (He, 2015). Such reforms derived a more effective market that directly responded to consumption demand, which rocketed with the swift growth of people's income (Dong & Zhong, 2006). As a result, marine fisheries (primarily BTF) became a very profitable business (Li & Huang, 2005). However, since the late 1970s, major BTF fish stocks in China's seas (e.g., great yellow croakers, small yellow croakers) had been declining (Jin, 2004; Liu & De Mitcheson, 2008). Facing this challenge and the increasing demand for food fish, Deng instructed that 'aquaculture should be the focus' in 1980 (Yang, Liu, & Li, 2018). The government then issued a series of fishery policies to shift its focus to aquaculture. Meanwhile, China also started to build its multilayer governance system to manage the growing fishery industry (Appendix S1).

However, since the fishery communes were dismantled during the reform, fishery management and policy implementation became more difficult given the loss of an intermediary between the government and fishers (Chen, 2009; Su et al., 2020).

Fisheries context: After the economic reform, China's fishing inputs and outputs increased rapidly in E2 (much faster than E1; Figure 3a&b), with even more rapid growth in aquaculture and distant-water fisheries (Figure S2.4). Attracted by the relatively high profits from marine fisheries, many small BTs were built and largely operated in the shallow inshore waters (Yu, 1991). While fishing capacity increased rapidly, catch per unit horsepower declined from 3.75 t·kW⁻¹ in 1960 to 0.76 t·kW⁻¹ in 1983 (Luo et al., 1993). Landings gradually contained an increasing proportion of bycatch (or trash fish, i.e., juvenile fish and low-value fish/invertebrates) nationwide; by 1990, bycatch already accounted for 70% of China's BTF catch (Wang & Zhan, 1992; Davies et al., 2009). As a response, China shifted its focus from domestic fisheries to aquaculture and distant-water fisheries in mid-1980s. In 1988, total aquaculture production (primarily in freshwater) surpassed capture fishing output for the first time, and since then, aquaculture has been the major supply for aquatic products in China (Figure S2.4a). However, the prosperous aquaculture industry encouraged 'biomass trawling' in China, since its aquaculture (and animal farms) depended on 'trash fish' as raw feed, ingredients of farm-made feed, and fishmeal (Cao et al., 2015; Weimin & Mengqing, 2007). The government's report showed that its fishmeal production increased from 21,164 tons in 1978 to 100,797 tons in 1992 (general increase speed⁷ = 5688 tons per year; Figure S2.4b). The catch shared by BTs from distant waters⁸ fell off a cliff at the beginning of E2, and then returned to ascend in 1985 (Figure S2.1). The fall in early years might result from an explosive growth of small trawlers (i.e., more catches were from the EEZ); the rise after 1985 might be driven by some fishery policies that facilitate the expansion of China's distant-water fishing (see details below).

⁷ This is measured by the increased tonnage (here, 100,797 – 21,164 = 79,633 tons) within the era (here, 1978 to 1992) divided by the time frame of the era (here, 14 years).

⁸ Note that 'distant water' means waters beyond China claimed EEZs in 1996 (see E3) and the data were from Sea Around Us. That said, this included parts of the Yellow Sea, East China Sea and South China Sea (see Figure 1). China's own statistics had a different definition of 'distant water', which excluded waters from the above seas given EEZ regime was not established until 1996.

Major pressures & drivers: 1) economic development and reforms; 2) BTF depletion in inshore waters (Wang & Zhan, 1992), and 3) the growing consumption demand for fishery food (Dong & Zhong, 2006).

Overarching policy (OP, n = 7): *economic reform 1978* (E2-OP-1), *inshore-fisheries protection 1981* (E2-OP-2), *marine fishery policy 1983* (E2-OP-3), *accelerating fisheries development 1985* (E2-OP-4), *Fisheries Law 1986* (E2-OP-5), *Fisheries Law implementation rules 1987* (E2-OP-6), and *increasing reform speed 1992* (E2-OP-7). The three instructional documents (E2-OP-2, 3, 4), especially E2-OP-4 (a.k.a., No. 5 Central Document), were the landmark policies of this era. They stipulated that China's fishery development should focus on aquaculture, distant-water fisheries, and fishing processing industry, while protecting inshore fishery resources. The E2-OP-5 is the first overarching legislation for fisheries management in China and were frequently referenced by following policies (Figure 4). It established a regime with previous policy initiatives (e.g., no-trawl zone, minimum mesh size) and stipulated the penalty clauses, which were detailed by the law's implementation rules 1987 (E2-OP-6). The E2-OP-7 was a collection of Deng's remarks (during his Southern China Tour in 1992) to strengthen the confidence of Chinese society to develop a market economy. Consequentially, widespread fishery business started in ~ 1993 across China (Gao & Ping, 2002). Meanwhile, large numbers of peasants from inland less-developed provinces (e.g., Sichuan, Henan, Anhui, Guizhou, Jiangxi) flooded to the coast and became fishing labors (a.k.a., non-traditional fishers; Gao & Ping, 2002). The growth rates of total value of fisheries production and its contribution to agriculture was increased after 1992 (Figure S2.3); the fishing capacity of China's distant-water catchers also hiked after that year (Figure 3c).

Ban & protection (BP, n = 13): *stock protection regulations 1979* (E2-BP-1), *trawl ban in Bohai 1979* (E2-BP-2), *summer moratorium 1980* (E2-BP-3), *no-trawl zone extension 1980* (E2-BP-4), *stock protection provisions in Bohai 1981* (E2-BP-5), *summer moratorium 1981* (E2-BP-6), *fishery-conservation areas 1981* (E2-BP-7), *trawl ban in Bohai 1987* (E2-BP-8), *summer moratorium 1987* (E2-BP-9), *fishery-conservation areas 1989* (E2-BP-10), *protecting spawning shrimps 1990* (E2-BP-11),

stock protection provisions in Bohai 1991 (E2-BP-12), summer moratorium 1992 (E2-BP-13). The E2-BP-1 represented the first nationwide fishery policy specifically focused on stock protection in China. It embraced some management measures that were further developed in the later policies, such as fishing permit, allowable catch quota, and seasonal closure. However, they were likely failed given the depletion trend of China's fisheries was not reversed. The E2-BP-2 and -8 were the first attempts of bottom-trawl bans in China, although they were limited to Bohai Sea (Figures 2 & S2.5). The Bohai Sea was an important spawning grounds for many shrimps and benthic fishes, but overexploitation and industrial pollutions caused serious stock declines over the 1950s – 1970s (Zhong & Power, 1997). However these twice trails of trawl bans were not enforced by local governments (Sun et al., 2011), perhaps because of social stability concerns and local protectionism (Yu and Yu 2008). The moratorium policies (E2-BP-3, 6, 9, 13) were the earliest regional trials of seasonal-closure zones for BTs (excluding the South China Sea) with different time and spatial arrangements. They were often compromised with socioeconomic concerns (e.g., exempting beam trawls) and likely not effective (Tang et al., 2012). The E2-BP-4 filled the gap of no-trawl zone in the South China Sea (Figures S2.5 & S2.6). However, the implementation of no-trawl zone was challenged by the growing numbers of small private trawlers after the economic reform. The E2-BP-7 and -10 represented the earliest establishment of conservation areas (in fact, only seasonally closed for BTs) to protect spawning of China BTF stocks (e.g., greater yellow croakers and largehead hairtails) in the East China Sea and Yellow Sea (Figures S2.5 & S2.6). These areas were likely not protected as their management regulations and law enforcement only emerged in E4 (see E4-BP-7).

Input control (IC, n = 5): *vessel-management interim measures 1983 (E2-IC-1), Single Control 1987 (E2-IC-2), resource fee 1989 (E2-IC-3), permit-management measures 1989 (E2-IC-4), and minimum-mesh-size standards 1990 (E2-IC-5).* To facilitate fishing vessel and permit management, China issued two policies in 1983 and 1989 (E2-IC-1 and -4). The former provided the first interim guidelines for implementing fishing permit and vessel inspection regimes and forbade fishing vessels transforming to trawlers fishing in inshore waters. The latter provided the first detailed rules for implementing the fishing

permit regime. However, their implementation was likely poor especially for the fishing permit, since it should be issued based on the estimates of total allowable catches that have not been determined yet (Huang & He, 2019). In 1987, China started to control the horsepower of its inshore fishing vessels (including BTs) with the E2-IC-2. However, this policy was probably failed as some researchers suggested (Yu & Yu, 2008). The reported data also showed a continuous increase in total horsepower of marine fishery vessels (Figure 3a), especially beam trawls in inshore waters (Xue et al., 2011). In 1988, China approved the E2-IC-3 to raise money for stock enhancement and fisheries management, and to encourage non-destructive fishing in inshore waters and offshore fishing by exempt or collect lower resource fees. Researchers have claimed that this resource-fee policy did support fishery stock enhancement and law enforcement in China (Huang & He, 2019). However, it was criticized as the fee was too low to control fishing input (Yue et al., 2017). In 1989, China published its first national standards on minimum mesh size (3.9 cm in the South China Sea, and 5.4 cm in the northern waters) for the cod-end of trawls (effective in Jul. 1990; E2-IC-5). Unfortunately, these standards were not implemented given the pervasive use of much smaller mesh sizes (< 1 cm) in BTF across the coast (Liang & Pauly, 2017).

Output control (OC, $n = 1$): *juvenile catch ratio 1980* (E2-OC-1). It demanded that the proportion of juveniles in the catch by weight not overpass a certain threshold. However, we find little information on its implementation. The only report was from the Bureau of Fisheries of East China Sea that claimed only 3.68% of the inspected vessels in that region violated the regulation during July 1 and October 17, 1981 (Chen, 1982).

3.1.3. E3 (1993 – 2002): EEZ Management with Multiple Regulations

Summary: In the era of Jiang Zemin, China started to build its EEZ management system with more diverse policies to constrain the growth of BTF. These policies ($n = 22$) covered five categories: international laws and agreements (IA, $n = 3$), overarching policy (OP, $n = 5$), ban & protection (BP, $n =$

5), input control (IC, $n = 7$), and output control (OC, $n = 2$; Figure 5). However, five IC policies were failed repeatedly and all BP policies (summer moratoria) were likely not as effective as expected. Only five policies (all IA and two OP policies) were likely effective, and little is known about the remaining six policies (two OP, two OC, and two IC policies; Table S2.1). Economy development was still the priority of local governments and the rapidly growing aquaculture encouraged biomass trawling to provide more fish feeds/fishmeal. China's fishery management focused on accelerating the development of aquaculture and distant-water fisheries, while constraining fishing capacity and output in its EEZ.

Political context: The third era continued along Deng's growth-centric path (Yu & Yu, 2008). Increasing production (e.g., GDP) remained the primary measure of local officials' achievements and a key factor in determining promotion (Yu & Yu, 2008). Such an evaluation system encouraged local governments to support fishing exploitation more than resource conservation, and to probably over-report their marine catch (Watson & Pauly, 2001; Yu & Yu, 2008). On the other hand, to seek more developing space and participate in global competitions, Jiang launched the 'going global' (or 'going out') strategy – expanding economic activities (including fisheries) beyond China's borders in the late 1990s (Cao et al., 2017). China facilitated its negotiation for accession to WTO, which started in 1986 and accomplished in 2001. In this context, China's fisheries policies were also shaped by international laws and standards.

Fisheries context: China's fishing capacity and aquaculture production continued to hike; distant waters became the major source of the catch of China's BTF, while its total output of capture fisheries gradually reversed from increase to decline (Figures 3 & S2.1 & S2.4). China's access to 'traditional fishing grounds' was largely constrained because of the newly adopted EEZ regime and bilateral fishery agreements (see details below). Fishing pressure in China's EEZ was then intensified as the fishing grounds shrank while the number of vessels continued to increase (Liu et al., 2007). The catch contribution of distant waters to China's BTF had a wave-like uplift, and importantly the values were all above 50% throughout the era (and later eras; Figure S2.1), suggesting that distant waters played the major role in China's BTF. The 'biomass trawling' was worsened in this era, given the reversal to decline

on the total catch by trawls (Figure 3b) and a more rapid rise on fishmeal production (general increase speed = 66,564 tons per year in E3 vs. 5688 tones per year in E2; Figure S2.4b). The imported fishmeal also remained on a rising trajectory (Figure S2.4b). Correspondingly, the aquaculture output grew faster than the previous era (Figure S2.4a), and its share (by value) in China's agriculture increased from 8% in 1993 to 11% in 2002 (Figure S2.3).

Major pressures & drivers: 1) constrained accession to traditional fishing grounds in China's seas, 2) intensified biomass trawling and overcapacity in the EEZ (Liu et al., 2007), 2) growing demand for fishery products (including food fish and fishmeal) (Dong & Zhong, 2006), and 3) going global to compete for more resources & markets (Mallory, 2016).

International laws & agreements (IA, n = 3): *United Nations Convention on the Law of the Sea (UNCLOS) ratification 1996* (E3-IA-1), *Sino-Japanese Fishery Agreement 2000* (E3-IA-2), and *Sino-South Korean Fishery Agreement 2001* (E3-IA-3). The E3-IA-1 marked the beginning of the EEZ management regime. Soon after that, China signed fishery agreements with Japan in 1997 (effective in Jun. 2000) and South Korea in 2000 (effective in Jun. 2001). The agreements were considered as interim measures to co-manage fishing activities in the Yellow Sea and East China Sea before they could resolve their EEZ disputes (Pan, Cheng, & Li, 2015; Zhang, Li, & Tang, 2015). Both agreements defined the co-management zones (Figures 2 & S2.7) in which the quotas for vessels (primarily trawlers) and catch of each nation were negotiated every year. As a result, China's BTs were pushed inshore and escalated their fierce competition in China's EEZ through 'biomass trawling' and illegal fishing, such as using nets with small mesh sizes (< 1 cm), multiple layers, and even electrical pulses; or fishing during the summer moratorium and the no-trawl zones (Lou & Chen, 2004).

Overarching policy (OP, n = 5): *China 21st Century Agenda 1994* (E3-OP-1), *China 21st Century Ocean Agenda 1996* (E3-OP-2), *EEZ Law 1998* (E3-OP-3), *Fisheries Law 2000* (E3-OP-4), and *Distant-Water Fisheries Plan (2001 – 2010)* (E3-OP-5). The E3-OP-1 (issued in 1994) was the first national-level

counterpart of UN Agenda 21 (passed in 1992) and the first time that sustainable development emerged in China's national policies (Guo, 2012). It determined China's national challenges, basic targets, strategies, and general measures of sustainable development of marine fisheries in the 21st century. The E3-OP-2 (issued in 1996) provided more detailed guidelines for marine fishery development and demanded local governments to curtail inshore fishing capacity (particularly BTs). The E3-OP-3 (issued in 1998) was to safeguard China's sovereign rights and jurisdiction over the EEZ and continental shelf. The E3-OP-4 endorsed a catch quota regime and incorporated EEZ related clauses to the Fisheries Law. However, the catch quota system (often used to manage specific species/stocks) was not implemented and challenging to do so given the non-selective nature and diverse fish stocks of its BTF (Fang, Su, & Yang, 2002; Yang & Shen, 2005). The E3-OP-5 was the first national overall plan for distant-water fisheries which was driven by the 'going global' strategy. The plan allocated more investments to high-sea fisheries (e.g., building larger vessels), which did boost the catch from high seas according to a government leader's remark (Xiao & Li, 2015).

Ban & protection (BP, n = 5): *summer moratorium 1995, 1998, 1999, 2000, and 2001* (E3-BP-1, 2, 3, 4, and 5). In 1995, China finally established the summer moratorium for BTs (and stow nets) as a national regime (E3-BP-1). The moratorium in 1995 lasted only two months and excluded the South China Sea (Figure S2.7). The government gradually adjusted and upgraded the moratorium level in later years as it did before. In 1998, MOA extended the moratorium to three month and expanded the coverage in the Yellow Sea and East China Sea (E3-BP-2). The moratorium was finally extended to the South China Sea in 1999 (E3-BP-3; Figures S2.7 & S2.8). These early moratoria started and ended at midnight, which made it inconvenient for local law enforcement. Therefore, in 2000, China adjusted the timeframe (in all seas except the South China Sea) by starting and ending it at noon (E3-BP-4). This adjustment applied to the South China Sea in 2001, though beam trawlers (i.e., shrimp trawlers) were exempted in part of the water (E3-BP-5). Coastal fishery authorities claimed that at least 95% of fishing vessels comply with the moratoria every year through their implementation efforts (Huang & He, 2019; Zhang, 2008). Some

studies have shown that these moratoria did, as hoped, increase the annual catch and catch per unit effort post-moratoria (Cheng et al., 1999; Yan et al., 2007). However, the moratoria did not cover breeding seasons of all commercially important species, and the boosted fishing efforts after moratoria often counteracted the effect of stock rebuilding during the moratoria (Yu & Yu, 2008).

Input Control (IC, n = 7): *vessel registration measures 1996* (E3-IC-1), *Double Control 1997* (E3-IC-2), *vessel registration measures 1997* (E3-IC-3), *permit management measures 1997* (E3-IC-4), *vessel-scraping interim provisions 2002* (E3-IC-5), *fisher-transfer interim measures 2002* (E3-IC-6), and *permit management provisions 2002* (E3-IC-7). Four IC policies (E3-IC-1, 3, 4, 7) showed that China attempted to enhance its management on fishing vessels and permits, especially for trawlers, although they were likely failed repeatedly. For instance, the E3-IC-4 proposed stricter regulations on illegal vessels and fishing. This legislation was upgraded to E3-IC-7, which forbade the transition from other vessels to trawlers and endowed MOA with the authority to control fishing-gear quota and licensing large trawlers (horsepower ≥ 441 kw). The E3-IC-2 was launched in 1997 as a response to the failure of the *Single Control 1987* (in E2). It mandated local governments to exercise stricter control over both the total number of fishing vessels and total horsepower based on the quotas allocated by the central government. Little is known about the effectiveness of this policy and some studies claimed that it failed (Yu & Yu, 2008). In 2002, China enacted the E3-IC-5 and E3-IC-6 to facilitate capacity reduction in its EEZ. The former stipulated that all fishing vessels (including BTs) must be scrapped after the service. The latter provided interim guidelines for the use of a special fund (from the Ministry of Finance) to support vessel scrapping and fishers' job transfer programs. It highlighted that the fund should preferentially target vessels using non-selective and destructive fishing gears (e.g., BTs). This policy might contribute to a consecutive reduction in trawlers (Figure 4b), but little is known about the previous trajectory given China only reported such data after 2003.

Output control (OC, n = 2): *Zero Growth 1999* (E3-OC-1), and *Negative Growth 2000* (E3-OC-2). In 1999, MOA initiated a 'Zero Growth' policy which explicitly stipulated that the nation's marine catch in

1999 should not exceed the amount in 1998 (E3-OC-1). According to its own reports, MOA considered this policy generally successful as the reported marine catch in 1999 only increased 0.06% compared with reported catch in 1998; notably the reported catch by trawlers decreased 7.3% (Figure 3b). In 2000, MOA further adopted a plan for negative growth for that year compared to 1999 (E3-OC-2). As a result, the reported catch in 2000 decreased 1.4% compared with that in 1999; the reported catch by trawlers declined 6.8% (Figure 3b). The Zero Growth policy was retained and the reported total marine catch, as well as the reported catch by trawlers leveled off and never exceeded the ones in 1998 (except for total marine catches in 2015 & 2016; Figures 4b). Some suspected this might be a literally ‘under-report’ response from the local government to this central government policy (Yu & Yu, 2008).

3.1.4. E4 (2003 – 2012): Resource Conservation with fuel subsidy

Summary: In the era of Hu Jintao, China built a more conservation-oriented management system while starting to provide fuel subsidy to sustain its BTF. We found 27 policy documents (2.7 per year) of six category groups in this era (Figure 6): international laws and agreements (IA, n = 1), overarching policy (OP, n = 4), ban & protection (BP, n = 7), input control (IC, n = 8), law enforcement (LE, n = 5), and fuel subsidy (SS, n = 2). Among them, four IC policies were failed; 16 policies (all OP, BP, and LE policies) were unknown about their implementation or effectiveness; only seven policies were likely implemented including four encouraged the growth of BTF (Table S2.1). In this era, China’s fishery management focused on balancing fishery conservation in its EEZ and fishers’ livelihood improvement, while continuously advancing the development of its distant-water fisheries, aquaculture, and fish processing.

Political context: In E4, Hu’s political agenda focused on ‘building a harmonious society’, since income gaps between the rich and the poor were widening and environmental issues became prominent social concerns in China (Fewsmith, 2004; Mohanty, 2012). He called for a balanced development between economy and environment, in contrast to the previous path that merely focused on economic

development. Such a vision was expressed in his ideology of the ‘*Scientific Outlook on Development*’ (Fewsmith, 2004). To build a harmonious society, he launched many social security initiatives, such as offering subsistence allowance to people in poverty and unemployed citizens (Mohanty, 2012). On the other hand, after China joined the WTO in Dec. 2001, China’s cheap and abundant labor and fishery products gave it an advantage in the competition of the global fishery markets (Li & Huang, 2005; Lindkvist, Trondsen, & Xie, 2008). Since 2002, China has been the largest exporter of fish and fishery products (FAO, 2006), making global consumption demand an external driver to the increase on China’s aquaculture production.

Fisheries context: China’s fishing capacity (especially horsepower) and aquaculture production continued to augment; total catch of its marine capture fisheries returned to rise; catch share of BTF fluctuated around the same level, while the share of distant waters in China’s BTF catch slightly shrank (Figures 3 & S2.1 & S2.4). Although the total number of trawlers declined quickly (except in 2012), the total horsepower and mean horsepower per trawler increased in this era (i.e., Figure 3c&d). The contribution of BTF to China’s marine capture fisheries (in terms of catch) leveled off (~ 40%) in this era (Figure S2.1). Along with the nearly continuous rise of its aquaculture output, the fishmeal production ascended at much higher speeds (general increase speed = 151,950 tons per year vs. 66,564 tons per year in E3) and peaked at ~ 2.0 million tons in 2012 (Figure S2.4b), suggesting an intensified ‘biomass trawling’ in China’s EEZ. Illegal fishing & vessels became pervasive in China’s marine fisheries (Lou & Chen, 2004). In the first nationwide census of marine fishing vessels in 2008, MOA found nearly half of all these vessels could be categorized as illegal (Zhu & Pei, 2015). On the other hand, the distant-water fishing capacity also boosted as China continued to develop its distant-water fisheries (DWF; Figure 3c). Though the total number of DWF vessels declined by a small amount (from 1997 in 2003 to 1793 in 2012), its total horsepower and mean horsepower generally increased (Figure 3c&d). Although the catch share in China’s BTF generally declined (from 62.7% to 54.8%), distant waters maintained the major source of the BTF catch of China (Figure S2.1).

Major pressures & drivers: 1) pervasive illegal fishing gears & practices (Lou & Chen, 2004), 2) fishers' livelihood security, 3) growing (domestic & global) consumption demand for fishery products after joining WTO.

International laws & agreements (IA, n = 1): *Sino-Vietnamese Fishery Agreement 2004* (E4-IA-1, effective in 2004) (Figure 6). This agreement was signed in 2000 as an interim approach to resolve the fisheries disputes in the Beibu Gulf (a.k.a., Gulf of Tonkin) between China and Viet Nam, and a co-management zone (Figure 2) was established with limited entry quota of BTs for both nations. Given that the Beibu Gulf contains some major fishing grounds for BTs of Guangxi, Hainan, and Guangdong provinces, the agreement constrained their access to these areas and drove thousands of BTs backward to China's EEZ. By 2009, over 5000 fishing vessels in the region were claimed to be scrapped, and about 28,000 fishers transferred their jobs, with ~ 67 million USD spent by the central government (Pan, Luo, & Hu, 2016). The reported number of trawlers of the three provinces in total did shrink by 32% (4500 trawlers) from 2004 to 2009; however, this was only done by Guangdong and Guangxi, and the reported number in Hainan increased by 15% (BFMOA, 2005, 2010).

Overarching policy (OP, n = 4): *Outline of China's Actions for Conserving Aquatic Biological Resources* (hereafter, *Outline 2006*, E4-OP-1), *MOA's Opinions on Implementing the Outline 2006* (E4-OP-2), *11th Five-Year Plan for Fisheries* (2006 – 2010; E4-OP-3), and *12th Five-Year Plan for Fisheries* (2011 – 2015; E4-OP-4). The E4-OP-1 integrated biodiversity conservation into the core vision of the central government for the first time in China. The long-term goal was to ensure that China would have abundant aquatic biological resources and clean waters by the middle of the 21st century. To this end, it adopted the Double Control target by 2010 (determined in 2003, see E4-IC-3 below) and added a new target for vessel scrapping by 2020. Following this, the E4-OP-2 highlighted the priority of scrapping trawlers in these Double Control targets. Meanwhile, China started to apply its five-year development

plans specifically for fisheries (E4-OP-3 & 4), in line with the counterpart for national economy⁹. These fishery plans aimed to 1) enhance fishery-resource conservation through protecting juvenile fish, using selective gears, and reducing BTs; and 2) encourage the development of distant-water fisheries. However, there were no quantitative targets for these goals, except for the Double Control. Moreover, the real targets and achievements on Double Control were unclear given they were inconsistent among the government's reports and peer-reviewed literature (Li, 2011; MOA, 2006, 2011) (see details on Appendix S2).

Ban & protection (BP, n = 5): *summer moratorium 2003 (E4-BP-1), conservation regulations in Bohai 2004 (E4-BP-2), prohibiting gear switch in moratoria 2005 (E4-BP-3), enhancing moratorium management 2005 (E4-BP-4), summer moratorium 2006 (E4-BP-5), summer moratorium 2009 (E4-BP-6), and conservation-area measures 2011 (E4-BP-7).* Before 2003, beam trawlers in some waters of the Yellow Sea and East China Sea were exempted from the summer moratoria. In 2003, MOA started a one-month closure (16 Jun. to 16 Jul.) for beam trawlers (E4-BP-1). In 2005, MOA issued two urgent circulars to prohibit trawlers using unregulated fishing gears (mainly purse seine) and other illegal fishing practices in the summer moratorium (E4-BP-3, 4). In 2006, MOA extended summer moratorium on beam trawlers to two months (E4-BP-5). In 2009, MOA extended the moratorium on all BTs (except beam trawls) by starting it half month earlier (E4-BP-6). However, we know little about their implementation or effectiveness. The E4-BP-2 restated the trawl ban policy in the Bohai Sea but exempted smaller trawls (here, perimeter of the net opening < 30 m). Such an exemption might be a compromise between socioeconomic concerns and conservation, reflecting the political will of building a 'harmonious society' in this era. In 2011, MOA enacted the E4-BP-7 (an interim policy), providing the first guideline for managing fishery conservation areas, which were frequently appropriated by sea-use projects (as mentioned in the policy document). However, these measures have likely not been well implemented yet for many local governments did not have the required manpower or budget.

⁹ the 1st Five-Year Plan for National Economy started much earlier in 1953. The 11th and 12th Five Years here referred to 2006 – 2010 and 2011 – 2015 respectively.

Input control (IC, n = 8): *Vessel-inspection regulations 2003* (E4-IC-1), *fisher-transfer provisions 2003* (E4-IC-2), *Double Control 2003* (E4-IC-3), *minimum-mesh-size standards 2004* (E4-IC-4), *permit provisions 2004* (E4-IC-5), *permit-approval decentralization 2004* (E4-IC-6), *minimum-mesh-size standards 2005* (E4-IC-7), and *Double Control 2011* (E4-IC-8). The E4-IC-1 was an upgraded policy on fishing vessel inspections, conferring more power on law-enforcement officers to combat illegal vessels and fishing activities (e.g., gear/vessel confiscation;). The E4-IC-2 lowered the qualified engine horsepower to 10 kW (compared to 20 kW in the interim provisions issued in 2002) and gave priorities to BTs for receiving allowance in vessel scrapping and fishers' job-transfer programs. Meanwhile, the E4-IC-3 started an eight-year program to scrap 30,000 fishing vessels (preferentially trawlers) with a total of 1.269 million kW (10% of the level in 2002) by 2010. Although the target was likely well achieved in terms of reducing total capacity of all fishing vessels (MOA, 2011), total horsepower of trawlers had only shrunk by 1% (Figure 3d). A further Double Control program was launched from 2011 to 2015 (E4-IC-8), but again it did not reduce fishing capacity of trawlers as the reported total horsepower increased by 4% (Figure 3d), which might be driven by the fuel subsidy. Four other IC policies (E4-IC-4, 5, 6, 7) focused on mesh size and fishing permit management and reflected the government's will of developing larger trawlers for distant-water fisheries. For instance, the E4-IC-5 and -6 shortened the process of examining and approving fishing permits of large trawlers and large purse seiners ($hp \geq 441$ kW) and decentralized that power to regional fishery authorities of the three marine zones (i.e., Fisheries Bureaus of the Bohai & Yellow Sea, East China Sea, and South China Sea). This likely boosted the growth of mean horsepower of trawlers and perhaps primarily those distant-water ones (Figure 3d).

Law enforcement (LE, n = 5): *Protecting Fisheries 2006, 2007, 2009, 2010, and 2011* (E4-LE-1, 2, 3, 4, and 5). These new LE policies suggest that China finally take actions to address the 'implementation gaps' in its fisheries management. In 2006, China launched the *Protecting Fisheries 2006* (E4-LE-1) during the summer moratorium primarily to combat illegal fishing vessels and practices. It imbued law enforcement officials with the power to confiscate the illegal vessels with median-to-high horsepower (>

44.1 kW) and to detain other illegal vessels. China continued the special actions during the moratorium in the following years of this era, although new policy documents were not issued in 2008 and 2012. The priorities of these campaigns were changed slightly every year. For instance, the E4-LE-4 prioritized the effort on examining and correcting identifiers¹⁰ of fishing vessels with a horsepower higher than 44.1 kW and established a ‘blacklist’ system for tracking those lawbreakers. However, the effectiveness of these special actions might be limited given they were only operated in summer moratoria.

Subsidy (SS, n = 2): *fuel subsidy opinions 2006* (E4-SS-1), and *interim measures of fuel-subsidy funds 2010* (E4-SS-2). Facing the crude oil price rise in 2005, China started to subsidize fuel consumption in its fisheries in 2006. The E4-SS-1 stipulated that the amount of fuel subsidy received by a vessel owner per year equals to the horsepower of the vessel’s major engine multiplied by a constant (e.g., 1000 RMB per kW) and the operation time. The E4-SS-2 stipulated that aquaculture vessels and motorized fishery auxiliary vessels were also covered by the fuel subsidy; it also authorized local fisheries agencies to reduce/suspend the allocation of fuel subsidies to fishing vessels that violated the Fisheries Law and other policies. It mandated that fishing vessels (except distant-water catchers) should operated a minimum of three months per year to qualify for the fuel subsidy. From 2006 - 2012, fuel subsidy for fisheries increased tenfold (from 3.2 billion to 35.1 billion RMB), and the expenditure continued to rise except during the economic crisis of 2009 (Mallory, 2016). Trawlers suffered the most from the crude oil price rise as oil consumption accounted for over 55% of their operation cost (Pan & Li, 2016), and therefore they were the greatest beneficiaries. The fuel-subsidy policies might have then encouraged trawlers to stay longer in fisheries and even use (or illegally change to) higher horsepower (see Figure 3d), and thus were not in concert with other IC policies (e.g., Double Control).

¹⁰ A code that was painted or pinned with an iron plate on the boat, similar to traffic licence plate and used as the unique identifier of each vessel. Some fishing vessels faked/alterd/copied an identifier to conduct illegal fishing.

3.1.5. E5 (2013 – 2018)¹¹: Fisheries Transformation with Bans Ahead

Summary: In the era of Xi Jinping, China attempted to transform its marine fisheries towards sustainable development with more restrictive policies including new bans on pair trawlers. These policies (n = 22) were composed of six categories: overarching policy (OP, n = 4), ban & protection (BP, n = 3), input control (IC, n = 7), output control (OC, n = 2), law enforcement (LE, n = 5), and subsidy (SS, n = 1; Figure 7). Among them, 12 policies were unknown about their implementation or effectiveness; one IC policy had encouraged the growth of larger trawlers; and the other nine policies were likely implemented with some positive effects (Table S2.1). In this era, China's marine fisheries started to shift from the extensive-growth mode to a quality-oriented mode. That said, China continued to reduce total fishing capacity in its EEZ, while increasing mean capacity of individual boat, especially distant-water vessels.

Political context: In E5, Xi launched a campaign for eliminating poverty and enhancing the construction of the rule of law, with a vision to rejuvenate the Chinese nation – realizing the ‘Chinese Dream’ (Wang, 2014). To this end, he not only followed his predecessor (Hu Jintao) to allocate more resources to improve social equality, but called for building a ‘Beautiful China’ through the ecological-civilization (a.k.a., eco-civilization) construction which seeks the balance between human development and nature sustainability (Sun et al., 2018). Since 2013, eco-civilization construction has been a priority strategy in China's policy making. In 2015, China enacted a few of national policies (e.g., *Overall Plan of Eco-Civilization System Reform*) to promote the development of eco-civilization. These policies have driven institutional reforms and reconstruction in natural resource management sectors (Su et al., 2020). For marine sectors, Xi aimed to build China into a marine superpower and embraced marine fisheries into the national development strategy. Such political will has been reflected in the nation's fisheries policies, which have emphasized the principle of ‘sustainable and healthy development’ through multiple

¹¹ Here the time frame was bounded by the end of 2018 simply because this was the latest time we set up for this review. The fifth era, however, may match with the whole presidency of Xi Jinping, who is in his 2nd term from 2018 - 2022.

approaches, such as speeding up industry transformation (from extensive growth to quality improvement) and enhancing law enforcement.

Fisheries context: China's fishing input and output (especially trawl fisheries) in its domestic waters reversed to decline, while the counterparts of its distant-water fisheries grew rapidly in E5 (Figure 3). The number of Chinese BTs continued to reduce and the total horsepower began to decline in 2015, although the mean horsepower per trawler remained on a growth trajectory (Figure 3c&d). Aquaculture maintained a high growing speed (Figure S2.4a), since the consumption demand, especially for seafood, remained rising rapidly (Zhang & Wu, 2017). The reported fishmeal production was on a dramatic decline (from ~2 million tons to ~ 650,000 tons) (Figure S2.4). The imported fishmeal also experienced a decline in 2013 (~ 0.8 million tons) but then returned to ascend especially in 2017 (~1.6 million tons; Figure S2.4b). Meanwhile, the development of distant-water fisheries was accelerated in E5. Although the reported number of distant-water fishery vessels leveled off, the reported total horsepower increased rapidly, resulting less but more powerful vessels (Figure 2c&d). Given the reported catch from distant waters increased while the reported total marine catch decreased, the contribution of distant waters to the output of China's marine fisheries was gradually improved (Figures 3b & S2.1). As Chinese trawlers were expanding to EEZs of 35 countries and the high seas (Mallory, 2013), their illegal fishing also emerged in distant waters (Alava et al., 2017; Cocks & Ba, 2017).

Major pressures and drivers: 1) eco-civilization construction, 2) illegal fishing in domestic and distant waters, 3) increasing seafood consumption in China.

Overarching policy (OP, n = 4): *Opinions on Advancing Sustainable and Healthy Development of Marine Fisheries* (hereafter, *Opinions 2013*, E5-OP-1), *MOA's Opinions on Implementing Opinions 2013* (E5-OP-2), the *13th Five-Year Plan for Fisheries* (2016 – 2020; E5-OP-3), and the *13th Five-Year Plan for Distant-Water Fisheries* (2016 – 2020; E5-OP-4). The E5-OP-1 was issued by the State Council and it signalled that marine fisheries became one of China's strategic industries (MOA, 2017). It set up fishery

development goals for two phases (2013 – 2015, and 2016 – 2020). It mandated that fishery governments should firmly restrict the construction of new BTs and enhance law enforcement in combating illegal fishing; while, on the other hand, encouraging improvements of fishing vessels – building steel and more energy-saving vessels, using selective gears, and modernizing distant-water fishing fleets. Shortly after this, in the E5-OP-2, MOA announced pilot projects of total allowable catch (TAC) which were then implemented in five maritime provinces for several stocks (e.g., Chinese prawns, swimming crabs; see more in Su et al., 2020). The E5-OP-3 mandated a negative growth in domestic marine catch and set up new targets in vessel scrapping with a priority given to pair trawlers. The E5-OP-4 conveyed a new vision shifted from extensive develop to quality improvement in China’s distant-water fisheries (DWF). It set up two targets: 1) fewer than 3000 DWF vessels by 2020, and 2) zero growth in the number of DWF companies from 2016. Meanwhile, it stipulated that more resources should be allocated to modernize its DWF vessels and curtail illegal fishing in distant waters. The implementation and effectiveness of these OP documents remain to be examined.

Ban & protection (BP, n =3): *forbidden gears 2014 (E5-BP-1), advancing fisheries transformation 2016 (E5-BP-2), optimized summer moratorium 2017 (E5-BP-3).* The E5-BP-1 was issued to ban a total of 13 types¹² of destructive fishing gears, including pair trawls with multiple codends and a single piece of webbing. It categorized BTs, for the first time, as one of the interim gears and prohibited using inner nets in BTs (as a manner to reduce bycatch). This policy also allowed local law-enforcement officials to inspect and confiscate these banned gears and deduct the fuel subsidy for fishing vessels using these gears. The E5-BP-2 called for improving the fishing-permit regime and fishers’ organization level, conducting total-allowable-catch (TAC) pilot projects, and phasing out pair trawlers. The E5-BP-3 was enacted to fix some loopholes in previous moratoria, such as the inconsistency of starting date among different seas or gears and the exemption of single-layer gill nets. These issues had triggered trawlers to cross boundaries or conducting illegal trawling while disguising themselves with unregulated gears (e.g., single-layer gill

¹² Other types of forbidden gears include a variety of drag-and-rake nets and traps.

nets). The optimized moratorium then embraced all gill nets into the moratorium leaving only hooks and lines being exempted. The moratorium period for BTs across the coast was extended to three to four months (dependent on the locations) starting from the same date (May 1st). The effect of this reform remains to be examined.

Input control (IC, n = 7): *permit provisions 2013* (E5-IC-1), *minimum mesh size standards 2014* (E5-IC-2), *resource fee exemption 2015* (E5-IC-3), *detailed rules for resource-fee exemption 2015* (E5-IC-4), *vessel scrapping and standardization 2015* (E5-IC-5), *Double Control 2017* (E5-IC-6), *permit provisions 2018* (E5-IC-7). The E5-IC-1 decentralized the power of fishing-permit approval for large trawlers and large purse-seiners ($hp \geq 441$ kW) from regional administrations (see E4-IC-6) to provincial fishery governments, facilitating the growth of larger fishing vessels embarking on distant-water fisheries (Figure 3d). In addition to these regulations, the E5-IC-7 prohibited the construction of pair trawlers and stipulated that moderate ($12\text{ m} \leq \text{length} < 24\text{ m}$) and large ($\text{length} \geq 24\text{ m}$) trawlers are banned within the no-trawl zone. It also stated that if these moderate and large trawlers needed to fish within the no-trawl zone because of traditional fishing habits, local governments could allow this but should report it to MOA. In contrast, small vessels ($\text{length} < 12\text{ m}$) should only be confined within the no-trawl zone and not cross the provincial/municipal administrative boundaries. The E5-IC-2 was issued specifically for the allowable and interim fishing gears and stipulated that all trawls that using additional inner nets in the cod-ends were banned with detailed penalty measures. The E5-IC-3 and its detailed rules (E5-IC-4) exempted resource fee for small fishery cooperatives and commercial fishery households, as a measure to improve fishers' income. The E5-IC-5 emphasized that vessel-scrapping funds should be allocated preferentially to pair trawlers and upgrading pair trawlers would not be subsidized. The E5-IC-6 stipulated new Double Control targets by 2020. It highlighted that local governments should prominently reduce old wooden fishing boats, especially pair trawlers, and prohibiting the import or construction of new fishing vessels in China's waters, except upgrading the old ones. The effect of this new Double Control remains to be reviewed in future.

Output control (OC, n = 2): *total allowable catch 2017 (E5-OC-1); catchable size & juvenile ratio 2018 (E5-OC-2).* The E5-OC-1 stipulated an output control target by 2020 for its national marine capture fisheries (reduced to < 10 million tons) and that in each maritime province (decreased at least by 23.6% with an annual reduction rate > 5%). However, based on the government's reports, the annual marine catches of all coastal provinces / municipalities increased in 2016 (failed to meet the annual reduction target), and five of the 11 administrative regions failed the reduction target in 2017 (Table S2.2). Such failures were also found in terms of catch by trawlers (Table S2.3). The E5-OC-2 was enacted for 15 commercial fish stocks and it mandated that catch ratio of juveniles per fishing trip should be $\leq 50\%$ (by weight) in 2018, 30% in 2019, and 20% in 2020 and afterwards. The policy also indicated that juvenile-fish protection should be integrated into the missions of the law enforcement special actions.

Law enforcement (LE, n = 5): *implementing minimum-mesh-size standards & forbidden gears 2014 (E5-LE-1), combating illegal fishing gears 2016 (E5-LE-2), Provisions on hearing illegal-fishing cases 2016 (E5-LE-3), combating illegal fishing gears 2017 and 2018 (E5-LE-4, and 5).* In 2014, MOA issued a circular to promote the implementation of the minimum mesh size standards for allowable and interim gears and the eradication of forbidden gears (E5-LE-1). In 2016, MOA published a circular to demand continuously combating 'annihilation nets (in pinyin, Jué Hù Wǎng)¹³' and other illegal fishing gears including illegal trawls (E5-LE-2). Shortly after this, the Supreme Court of Justice enacted the first judicial guidelines in dealing with illegal fishing cases in China (E5-LE-3), which did encourage lawsuits on illegal fishing in some provinces such as Guangdong (Liao, 2017). In 2017, MOA delivered the E5-LE-4 which emphasized law enforcement in the summer moratorium should focus on illegal fishing gears that violated the 'minimum mesh size' regime and those used additional inner nets. Meanwhile, MOA determined to conduct a one-year special action (Oct. 2018 – Nov. 2019) to combat illegal fishing gears that using electrical pulse devices (E5-LE-5). These law-enforcement measures are likely implemented and might gradually become routine in China's fisheries management (Liao, 2017).

¹³ This category refers to the so-called 'maze traps' – a group of stationary inshore fishing traps with multiple net tunnels stretched by standing poles and using very small mesh sizes (normally < 1 cm).

Subsidy (SS, n = 1): *subsidy reduction 2015* (E5-SS-1). This policy was a product of years' debates and calls for reducing fuel subsidies in fisheries, especially in the WTO (He, 2015; Zhu & Huang, 2014). It only emerged in 2015 partly because the crude oil price was in a downward slide in that year, which provided a policy window for MOA to reach an agreement with the Ministry of Finance (MOF), who allocated the subsidies (R. Guo, personal communication, Dec. 13, 2017). It stipulated that fuel subsidy should be reduced by 40% from 2014 to 2019, and MOF would allocate 20% of the subsidy fund to support vessel-scrapping and -updating projects. The effect of this new policy on BTF remains to be examined when data become available.

3.2. Generalization of the policy evolution

We found some evident trends and patterns in the evolution of China's BTF policies. First, the mean number of relevant policy documents (became in effect) per decade grew from 2 in E1 (1949 – 1977) to 37 in E5 (2013 – 2018, Figure 8). Second, China issued gradually less proportion of ban & protection measures (from 83% in E1 to 14% in E4) while increased the uses of input controls (from 0 to 33%) and law enforcement actions (from 0 to 23%; Figure 8a). Third, except the first era, overarching policies consistently accounted for a prominent portion (15 – 27%) of policies in each era (Figure 8). Fourth, the diversity indices of China's policies increased across the eras, although the increase rate gradually slowed down (Figure 8b). The Shannon diversity index increased from 0.45 in E1 to 1.64 in E5 (Figure 8b). The inversed Simpson's diversity index increased from 1.38 in E1 to 4.65 in E5 (Figure 8b). The evenness indices of the policy categories also generally increased but peaked in E3 (Shannon's equitability = 0.65 – 0.95; Simpson's equitability = 0.69 – 0.86; Figure 8b).

Over the 103 policies we identified, 26 were through the central government bodies (primarily the State Council). The other 77 policies were from the ministries or agencies of the central government (primarily the MOA). We found that the *Fisheries Law* (version 1986 & version 2000) was the most

referenced (31 times, directly) ‘keystone’ policy throughout the history, followed by the *Outline of China’s Actions for Conserving Aquatic Biological Resources 2006* (eight times, directly).

We found that the focus of China’s BTF policies shifted over the five eras, with a general emphasis on fishing-vessel management and fishery-stock protections throughout the history (Figure 9). In E1, China’s policies mainly focused on the Bohai Sea and inshore waters (Figure 9a), including the no-trawl zone, the fishery agreement (with Japan), and shrimp stock protection (Figure 9a). In E2, fishery stocks became the major concern, with vessel (management), (fisheries) law, (fishing) permit, (summer) moratorium, (resource) fee started to emerge in policy documents (Figure 9b). In E3, China’s policies started to focus on fishing vessels (management) in its EEZ, with more regulations, measures, and controls on catch, (fishing) permit, (summer) moratorium, while also emphasized development (Figure 9c). In E4, although vessel related regulations remained as the focus, there were a variety of new policy terms appeared, including (vessel) scrapping, gear (regulations), illegal trawl, conservation (areas), minimum-mesh-size standard, fuel subsidy, law enforcement special actions, and the Five-Year Plans (Figure 9d). In E5, fishing gears became the focus, followed by vessel and stock (Figure 9e). In this ear, law-enforcement actions to combat illegal fishing gear and fishing practices became more outstanding; fuel subsidy was reduced; summer moratorium were reformed, and (fisheries) development returned to be frequently mentioned in the policy document (Figure 9e). The word cloud of all five eras indicated that China’s policies on BTF have mainly focused on vessel & stock management with diverse policies. Generally, the Fisheries Law, fishing permit & gear regulations, and summer moratorium were the most frequent policies (Figure 9f).

4. DISCUSSION

Our study suggests that the concerns on restricting BTF (especially in China’s domestic waters) have been gradually increased in China’s national policies over past seven decades, although its management quality is still at a low level (Su et al., 2020). Notably, most policies in its present management system

for domestic BTF were ‘ban and protection’ measures and input controls. For most of the restrictive policies, the levels of enforcement and compliance are low or unknown (Su et al., 2020; Zhang et al., 2020). Although there are some output-control measures and law enforcement programs, their effectiveness is likely limited. Additionally, China’s fishery-data collection and statistics (quality and capacity) and the stakeholder involvement are insufficient to inform robust policy making or evaluation, although some improvement programs (e.g., on-board observer) are testing (Cao et al., 2017; Huang & He, 2019; Su et al., 2020). These are the typical features of Level 1 (the lowest) and Level 2 types of management regime in the FAO’s regional guidelines for the management of tropical trawl fisheries in Asia (Table S2.4; Funge-Smith, 2014). For the distant-water BTF, the management quality is even lower, given only recently (2017) has China issued a few input-control regulations. Such poor management status on its BTF is undoubtedly not compatible with China’s leading role in other global sustainability affairs (e.g., climate change, poverty eradication), where China has been widely applauded (Ali et al., 2018). Currently China has invested very little on the SDG 14 – Life Below Water, in contrast to other SDGs (e.g., SDG 15 – Life On Land) (Ali et al., 2018; Bryan et al., 2018). China should then allocate more resources to upgrade its management on BTF timely, if it is to achieve the SDG for marine fisheries in the following decade (Bryan et al., 2018).

There are many issues emerged from our review and require further discussion. Here below we focus on four topics of broad interests: 1) factors influencing the evolution of China’s BTF policies, 2) problems in BTF management in China, 3) challenges & suggestions in implementing China’s BTF policies, and 4) comparison of BTF policies in China and the rest of the world. Although some of these topics have already been discussed in a broader scope of China’s marine fishery management (see a latest example by Su et al., 2020), we here sharpen our focus on BTF and bring some new insights into the discussion.

4.1. Factors influencing the evolution of China's BTF policies

We indicate that the evolution of China's BTF policies has been shaped by both domestic and international factors. Although these factors are intertwined, we discuss and highlight some major drivers as follows respectively. The key domestic factors are political will, consumption demand for fishery products, and the search for socio-economic and political security. Meanwhile, key international influences include UN Agenda 21, UNCLOS, globalization, and external criticism relating to China's distant-water fisheries.

4.1.1. Key domestic factors

Management policies for China's BTF, as for other industries, have been influenced by China's top leaders' political wills (Cao et al., 2017; Zhang & Wu, 2017). Our analyses reveal that such a political will shifted its focus through (i) 'planned development' with national investments in fishery exploitation in Mao's era, (ii) 'economic reforms and market opening up' with rapid growth in fisheries in Deng's era, (iii) further 'going out' and EEZ management in Jiang's eras, (iii) 'scientific development' with vessel scrapping and Double Control in Hu's era, and (iv) 'sustainable & healthy development' with enhanced law enforcement and industry transformation in Xi's era. When Chinese top leaders changed the nation's development strategy, new fisheries policies followed correspondingly to match their political agendas. Such realities mean that policy-change incentives to help China achieve sustainability in marine fisheries and curtail its massive BTF (including distant-water fleets) will need to engage the top leaders.

The increasing interest of China's leaders in fisheries may partly arise from the country's rapid increase in seafood consumption, driven by the increase in the nation's urbanization and wealth (Fabinyi, 2012; Liu & Raven, 2010). Based on the government's report, the annual per capita income of Chinese citizens increased 31-fold from 1978 to 2017 (NBSC, 2019), with most of the wealthier population living in coastal areas (He et al., 2014). As the citizens become richer, they consume more high-quality animal proteins including comparably more seafood (Dong & Zhong, 2006; Popkin, 2014). From 1960 to 2013,

Chinese per capita seafood consumption (in mainland China) increased sevenfold, with a rapid and continuous rise since 1980s (i.e., after economic reforms) (FAOSTAT, 2013). Nowadays, the consumption of luxury seafood in restaurants has become a popular means for wealthy Chinese citizens to build and maintain social relationships (Fabinyi, 2012; Fabinyi & Liu, 2014). Indeed, the rise in consumption demand often appears as a driver in China's policy documents (Zhang & Wu, 2017).

As China's economy continues to prosper, the increasing consumption demand on fishery products (especially seafood) will further drive China's EEZ and distant-water fisheries resources to depletion unless changes are made accordingly in its fishery and aquaculture industries (Cao et al., 2017; Su et al., 2020; Zhang et al., 2020). China is expected to consume 38% of global food fish by 2030 (World Bank, 2013). Notably, throughout the history, most fish products consumed in China are from its marine capture fisheries (including DWF) and aquaculture (including mariculture) rather than import, although the latter is growing (Figure S2.10). However, both China's fisheries and aquaculture, to a large extent, rely on the unsustainable 'biomass trawling' (and sometimes illegal fishing) in its EEZ (and perhaps distant waters) to produce food fish or fish feed/fishmeal (Cao et al., 2015; Zhang et al., 2020).

Studies have shown that the growing environmental awareness among the public and market (e.g., seafood ecolabeling and certification) can drive fisheries toward sustainability (Travaille et al., 2019), although this public/market driver has not motivated sufficient improvement on fishery governance and marine environment especially in developing countries (Roheim et al., 2018). Unlike many other developing nations, China's central government often responds quickly to public interests and has the capability and leadership to make great achievements in public affairs, as shown in areas of poverty elimination, forestation, and air quality improvement (Bryan et al., 2018; Sun et al., 2018). Once Chinese consumers become widely aware of the serious issues of BTF and the unsustainable utilization of its catch for fish feeds in aquaculture (Cao et al., 2015; Zhang et al., 2020), they might drive top leaders to make comparable improvements in BTF management. However, studies have shown that current awareness of sustainable seafood among Chinese citizens is very low (Fabinyi et al., 2016), in line with our own

observations. Given that Chinese seafood consumption demand is expected to increase, cultivating sustainability awareness in China is urgently needed (Cao et al., 2015; Lindkvist, Trondsen, & Xie, 2008).

China's policy making for fisheries has certainly been informed by concerns about social security: safety issues related to fishing as well as employment and livelihood security of fishers in the marine fishery sector. The no-trawl zone policies, for instance, were partly driven by the concerns about collisions and interest conflicts between trawlers and small fishing vessels on the sea. Fishing was and is still a high-risk occupation because of the harsh working conditions on the sea and accidental vessel collisions. In 2000, for instance, 727 people died accidentally in China's marine fisheries, with another 306 fishers heavily wounded (BFMOA, 2001). Such tolls dropped to 51 deaths and 7 heavy wounded in 2017, partly because of government policies that encouraged investments on fishing vessels and safety facilities (BFMOA, 2018). Employment and livelihood security are also notable concerns in managing marine fisheries in China. Based on the government's statistics for 2017, a total of 5.5 million people in China depend on marine fisheries for livelihoods; about 3.8 million people work in marine fisheries and ~1 million fishers work full-time in marine capture fisheries, especially BTF (BFMOA, 2018). Such a large population size seriously limits dramatic reduction in China's BTF, and helps explain the failure of many policies such as the trawl ban in Bohai, the no-trawl zone policy, and minimum-mesh-size standards. This could also explain why China exempted small trawlers (perimeter of trawl opening < 30 m; the major type of trawlers operated in Bohai) from the trawl ban in Bohai in 2004 (Sun et al., 2011), after the failures of trawl bans in 1979 and 1987.

Pursuit of economy and political security at a national level has helped drive China to focus on marine fisheries as a national strategic sector (Zhang & Wu, 2017). China's economy has slowed down (from ~10 to ~6%) during Xi's presidency as he aims to transform China's high energy-consumption industries to advanced manufacturing (a.k.a., supply-side reform) (Fang, 2018). To seek 'new growth points' and maintain a 'steady and robust transformation', in 2016, President Xi launched the *One Belt One Road* initiative (Cai, 2017). Since then, Chinese top leaders have identified marine fisheries as one of the major

fields for international cooperation (Zhang & Ji, 2019; Zhang & Wu, 2017). This has been reflected in the 13th Five-Year Plans (2016 – 2020) for Fisheries and for Distant-Water Fisheries. Meanwhile, Chinese top leaders have also recognized the importance of marine fisheries in the context of the increasing political tensions in the East China Sea and South China Sea (Zhang, 2016). Given these national concerns, it remains to be seen how China's BTF will be shaped in building a maritime superpower and modernizing fisheries, even though bans on pair trawls have already been decided (E5-BP-1 in Section 3.5).

4.1.2. Key international factors

Whereas some studies claimed that international laws and agreements generate little influence on China's marine fishery governance (Zhang & Wu, 2017), we find that China's BTF policies have actually been reshaped by international policies (Brans & Ferraro, 2012; Mallory, 2013). The UN Agenda 21 is the direct external driver for China to publish its own 21st Century Agenda (1994) and the following Ocean Agenda (1996) (Brans & Ferraro, 2012). Both agendas have adapted the goals and framework regarding fisheries sustainability from UN Agenda 21 into China's own context, although this has rarely been recognized in literature (Su et al., 2020; Wang, 2012). The ratification of the UNCLOS (1996) in China and subsequent bilateral fishery agreements (2000, 2001, and 2004) also caused a ripple effect on China's fishery management and policies (Mallory, 2013). The impact is historic considering the massive loss of previously free-access fishing grounds and increasing pressures to manage fishing activities both in China's EEZ and in the shared fishing zones in China's seas with the neighboring countries (Rosenberg, 2005). These international policies above have imposed a strong external pressure in driving China to shift its policy focus from exploitation expansion to EZZ management and conservation (Cao et al., 2017). Such constraints have also stimulated China to accelerate the development of its aquaculture and distant-water fisheries (Mallory, 2013).

Globalization, and the growing participation of China in world trade, is another external driver to the expansion of China's fishery and aquaculture which is rarely addressed in literature. Fishery products are

one of the most traded food commodities in the world with ~ 40% of the production being traded internationally (Bellmann, Tipping, & Sumaila, 2016). Although China has often been a net importer of fishery products over past three decades (Figure S2.10), it has grown to be one of the major suppliers of fish products in the global market with its particular strengths in fish processing (Yang et al., 2016). Given this, foreign consumers and countries may also play a role in shaping China's fish production system, especially its BTF and aquaculture. Indeed, there is a growing awareness on sustainability and illegal fishing in seafood production, and the US, as a major importer of seafood, have spearheaded on addressing this issue on both its domestic and imported seafood (Walsh et al., 2015; Willette & Cheng, 2018). In this context, some US companies (e.g., Sea Farms, Beaver Street Fisheries) and NGOs (e.g., Marine Stewardship Council, Sustainable Fisheries Partnership) have initiated fishery improvement projects for squids stocks (primarily caught by BTs) in China (Fang, Drugan, & Director, 2018; H. Han, personal communication, Dec. 20, 2019). Though such internal projects are still in the infancy and only available for a few local fisheries, they may gradually extend to other BTF stocks, helping Chinese governments and industries to advance BTF management and monitoring towards seafood transparency and sustainability.

In the face of increasing international pressure in recent years (Alava & Paladines, 2017; Mallory, 2013; Pauly et al., 2014), China has issued national policies to regulate the behavior and constrain the growth of its distant-water fishing fleets. Since late mid-1980s, many Chinese trawlers have joined distant-water fisheries (DWF) in response to depletion of fishery stocks (and decreased profitability) in domestic waters and government encouragement (Mallory, 2013; Xue, 2006). Such a movement has caused a global concern as it might intensify fishing competition and resource depletion in other nations' EEZs and the high seas, although other nations (e.g., European fleets) have long been fishing in distant waters (Mallory, 2013; Pauly et al., 2014). Some researchers have pointed out that the DWF catch was likely underreported by the Chinese government (Pauly et al., 2014), probably because of illegal, unreported and unregulated (IUU) fishing. In recent years, Chinese distant-water fishing vessels

(especially BTs) were frequently exposed in international social media for illegal fishing in distant waters, such as in Senegal and the Galapagos Marine Reserve (Alava et al., 2017; Cocks & Ba, 2017). Under the presidency of Xi Jinping, improving Chinese reputation and leadership in international affairs has been central to the nation's foreign policies (Ferdinand, 2016; Pu & Wang, 2018). China has responded to the international criticisms by issuing restrictive policies such as capping the number of DWF vessels at 3000 (currently 2654; BFMOA, 2019), enhancing surveillance to reduce DWF illegal fishing practices, and prohibiting new construction or purchases of trawlers since 2018 (E5-OP-4).

4.2. Problems in managing BTF in China

Among the many issues in managing BTF in China, four essential problems are among the greatest concerns both domestically and globally.

First, China has failed repeatedly in implementing many of its well-intentioned policies to constrain the growth of BTF in its own waters. These policies include fishing permit regulations, minimum-mesh-size standards, and trawl bans in the Bohai Sea; they have been revised multiple times and yet failed in implementation (Huang & He, 2019; Liang & Pauly, 2017). Understanding such failures and policy-making behavior may facilitate problem-solving in China and provide lessons to other fishing nations that also hold large numbers of trawlers.

Second, China has provided fuel subsidies to maintain the operation of its fisheries primarily BTF (both domestic and distant water) since 2006. Although that subsidy has been cut down since 2015 and is supposed to be eradicated in 2020 based on a recent policy issued by MOA in 2019, it counteracted the effect of vessel buyback programs and other input control policies (He, 2015; Zhu & Huang, 2014; Zhang & Vincent, *under review*).

Third, China has exported its fishing capacity (largely BTs) from its EEZ to distant waters since 1985. Although some constraints are set recently under international pressure (as discussed in 4.1.2), such

capacity export might have facilitated overfishing in distant waters over past few decades (e.g., West Africa; Pala, 2013; Pauly et al., 2014). China – as a rising world leader – should take more accountability by reducing the size of its distant-water BTs and their capacity (both in other countries EEZs and the high seas), thus help the world achieve sustainable-fisheries targets.

Last and perhaps most importantly, there is an urgent need in addressing ‘biomass trawling’ (including illegal trawling) that feeds China’s growing aquaculture (Cao et al., 2015). China’s BTs have been executing ‘biomass trawling’ since late 1970s (Wang & Zhan, 1992; Zhang et al., 2020). The situation has been worsened by illegal trawling practices in recent decades (Yu et al., 2007). The growing demands for fish/animal feeds has inject an economic incentive into the BTF and thus maintained such reduction fisheries. Although China contributes more than 60% of the global aquaculture production at a cost of only 20 – 30% of global fishmeal production (Han et al., 2018), it should be noted that researchers have long suggested that the majority of the ‘trash fish’ (mainly caught by BTs) is used as raw fish feed (50%) and farm-made fishmeal (40%) (Cao et al., 2015; Tacon, Hasan, & Metian, 2011; Weimin & Mengqing, 2007), and these usages are not counted and rarely reported. One estimation indicated that, in 2008, China’s aquaculture likely consumed 6 – 8 million tons of low-valued ‘trash fish’ directly as raw fish feeds (FAO, 2012) – much higher than fishmeal production or import in that year (Figure S2.4b). In a recent national conference, a Chinese expert has proposed to prohibit using the iced small trash fish as raw fish feed in aquaculture, which (as he claimed) accounts for one fourth of the nation’s annual domestic catch (Zhang, 2019). However, little is known whether this proposal has been adopted. Existing regulations (e.g., juvenile catch ratio, minimum mesh sizes, bans) have not been successfully implemented (Liang & Pauly, 2017; Su et al., 2020).

4.3. Challenges and suggestions in implementing China’s BTF policies

Fishery-policy implementation can be impeded by various socioeconomic and political factors. These factors include the local government’s management capacity, political concerns, and local development

inequality (Fleisher, Li, & Zhao, 2010). Here our discussion focus on three domains that are notable in China: (i) provincial variability, (ii) lack of public participation, and (iii) bureaucracy.

The implementation of national-level policies can be compromised by provincial variability (Su et al., 2020). For instance, after the nationwide vessel-scrapping policy, Hainan's reported number of trawlers increased, which might result from its regional distinctiveness (Figure 1). First, Hainan is the furthest oceanic province from Beijing, making it less politically connected to the central government. Second, Hainan's government capacity is lower than many other coastal provinces (e.g., Zhejiang, Guangdong, Fujian) which implemented the vessel-buyback policy (Liu et al., 2017). Third, because Hainan includes fishery counties that have long fished around the internationally disputed Paracel Islands and Spratly Islands, Hainan's fishing fleets are perceived to play a vital political role in maintaining China's interests in the South China Sea (Daksueva & Lin, 2018). Fourth, Hainan's GDP per capita is lower than other southern maritime provinces (e.g., Zhejiang, Fujian, Guangdong) except Guangxi, making economic opportunities very valuable (He et al., 2014). Fifth, 69% marine fishers in Hainan were traditional professional fishers in 2002 (before the vessel-buyback policy), while this proportion was much lower in its neighboring provinces, i.e., Guangdong (37%) and Guangxi (32%) (BFMOA, 2003). Further studies to examine the impacts of these potential local drivers may provide useful insights (e.g., resources allocation) for the central government avoid failures in policy implementation.

A central flaw in the policy making process of China is the lack of public participation (Ahlers & Schubert, 2015), which erodes the implementation of many well-intentioned policies. China's top-down political system motivates the local officials to respond to the opinions of their superiors rather than public demands (O'Brien & Li, 1999). Although the National People's Congress can bring some public concerns into national policy making (Chen, 2016), marine fishery policies haven't gained much attention. Moreover, local fishers' representatives have not been engaged in national policy making for fisheries management since the dismantling of fishery communes in economic reforms. Because of non-transparency, little is known about the policy making process for marine fisheries and more specifically

BTF (but see an example in Su et al., 2020). This may be changing now, as the central government have recognized the non-compliance of so many fishery policies. For instance, a feedback stage has been set up in the policy making process: once a new policy has been drafted, it will be sent to local governments for feedbacks or published on the government's website to gather public opinions (mainly through phones or emails) before it is officially enacted. However, given most fishers are mid-to-old-aged and not well literate (Luo, 2004; Yu et al., 2016), the extent to which this supposedly participatory approach could gather the opinions of most fishers is questionable. Another example is that the central government is attempting to re-organize fishers by reintroducing fishery corporates and non-corporate organizations (E5-BP-2; Su et al., 2020). Although such an attempt may enhance law enforcement, corresponding reforms are also required to establish a more transparent regime that ensures the participation of fishers' representatives and other stakeholders (e.g., marine NGOs) in the policy making process.

China's national fishery agency (i.e., MOA) continued to enact/revise limiting policies (e.g., trawl ban in Bohai, fishing permits, minimum-mesh-size standards) that had repeatedly failed (Cheng et al., 2006). This may be explained by the bureaucracy of the government system, and the challenges it poses for policy implementation. In China, the authority of the national fishery agency (e.g., MOA) is essentially confined to providing regulatory guidelines (rather than mandatory orders) for local fishery governments to execute in managing fisheries (BFMOA, 2014). Local fishery agencies, however, are largely under the administration of their own local governments (e.g., provincial or city councils) and leaders (e.g., majors or provincial governors), who are subject to the actions of central governments (e.g., State Council) and their leaders (Ferraro et al., 2009). These local governments are commonly in conflict of interest with MOA's restrictive policies: some officials wanted to increase fisheries production for personal promotion, and some own fishing companies that seek to maximize catch (Ferraro et al., 2009). Such duelling interests have created a major obstacle to policy implementation along China's coast.

One way to address the bureaucracy would be upgrading the regulatory guidelines for fisheries to national laws through the State Council, its leaders (e.g., President) and legislatives (i.e., National

People's Council). These national authorities could then drive local governments and their leaders to enforce these laws. However, even some regulatory policies (e.g., fishing permit) that were embraced into national laws (e.g., Fisheries Law) have not been well implemented in the past (Shen & Heino, 2014; Yu, 1991). Another option is to place the supervision of local fishery agencies directly within a provincial and national agency (a.k.a., vertical administration). Such a reform has been conducted in China's governance of environmental protection since 2016 (Kostka & Zhang, 2018; Sun, 2016). It establishes a 'supervision & inspection system' for environmental protection, which empowered the national environmental agency to send an inspection team to each province for a certain period (e.g., a month) to investigate environmental issues and receive environmental complaints from the public (Gao & Fu, 2017; Wu & Hu, 2019). It also brings the local government agencies to the direct administration of the provincial agencies (Sun, 2016). This reform has derived some positive effects and is still ongoing (Wu & Hu, 2019). Although such a vertical administration is not a panacea to all obstacles in policy implementation, it might improve the efficacy of China's fishery management.

4.4. Comparison of BTF policies between China and other countries

Many of the fishery policies of China's BTF can find their counterparts in other marine fishing nations. For instance, China's policies encourage trawlers move offshore, which are common in other countries (e.g., Vietnam, Thailand, Malaysia) (Pomeroy et al., 2016). China's 'capacity export' behavior was also seen in European fishing powers (e.g., the United Kingdom, France, Germany) in the first three decades of the 1990s, although the latter are shifting to more responsible conducts in their distant-water fisheries (Gagern & van den Bergh, 2013; Gillett, 2008). China's fuel subsidy policy was also widely used in the Asia-Pacific region, America, and some European countries (Sumaila et al., 2016; Sumaila et al., 2006). Before China embarked on vessel buy-back policies, Canada and USA have used such approaches to reduce fishing capacity in trawl fisheries since 1970s. Australia has also successfully applied license buyback programs in its prawn and lobster fisheries since early 1980s (Holland, Gudmundsson, & Gates, 1999; Pascoe et al., 2012). The summer-moratorium policy is not unique to China, since similar (although

shorter) seasonal closure practices have long been used elsewhere (e.g., US, Australia, Europe) to protect spawning stocks and juveniles of commercially important species and to reduce bycatch (Demestre et al., 2008; Dunn, Boustany, & Halpin, 2011; Little et al., 2015).

As the world largest developing country, China has long been learning experiences in many fields (including fisheries management) from other more developed countries, as well as adapting them into Chinese reality (Fan, 1998). A more recent example of such a learning mode is China's TAC pilot projects for several fishery stocks with an on-board observer system (since 2017), which was learned from Alaska and Northeast fisheries, USA (W. Li, personal communication, Nov. 15, 2018). Such a learning approach is certainly beneficial to help China improve its management quality. However, whether China can successfully achieve sustainable fisheries and contribute to the global fisheries sustainability largely depends on its own will and actions including more rigorous policy implementation to curtail its BTF, both in its EEZ and distant waters.

5. CONCLUSION

The evolution of China's BTF policies has been driven by a wide range of domestic and international factors. We show that China has gradually intensified its attention to BT, with diversified measures and seemingly stricter implementation. Nevertheless, China has a poor track record in management of BTF: 1) it failed repeatedly in implementing many of its policies to curtail BTF, 2) it provided fuel subsidies to maintain the operation of its BTF (although that subsidy is now being reduced), 3) it exported fishing capacity from its EEZ (although some constraints are set recently), and 4) it engendered 'biomass trawling' to largely feed its growing aquaculture. Although these drawbacks are pervasive in global BTF management – and not limited to China – China has an undeniable responsibility to improve its management quality, which is at a low level according to FAO's standards. This is vital because of not only the sheer size or scale of China's BTF and the inherent impacts on global fisheries, but also its

1071 growing aspirations to international leadership and its commitment to the UN's Sustainable Development
1072 Goals 2030.

1073 To move forward, China certainly needs more practical and proactive reforms in its policy making,
1074 law enforcement, and fisheries institutions as discussed above and in literature (Cao et al., 2017; Shen &
1075 Heino, 2014; Su et al., 2020). Eventually, China may move towards sustainable fisheries through more
1076 investments in capacity reduction programs, fishery resource protection, and policy implementation.
1077 However, this change could be facilitated if the problems in BTF are widely recognized in China's
1078 society to a level that generates actions and attracts serious attentions of its top leaders like President Xi
1079 who claims a vision for ecological protection. Such a need for attention and engagement calls for a joint
1080 effort from diverse organizations, including fishery research institutions, marine NGOs, and social media
1081 (both domestic and worldwide).

ACKNOWLEDGEMENTS

This study is a contribution from Project Seahorse. It was motivated by our visit to Dr. GUO Rui, former Director of the Fisheries Resource and Environmental Conservation (Division of Aquatic Wild Fauna and Flora), Bureau of Fisheries and Fisheries Law Enforcement, Ministry of Agriculture, P.R.C. in Dec. 2017. We thank Dr. Sarah Foster and a Chinese colleague (who wishes to be anonymous) for their constructive comments that helped us improve the manuscript. XZ is supported by a postdoctoral fellowship from the NSERC CREATE Training Our Future Ocean Leaders Program and by Project Seahorse at the University of British Columbia. Project Seahorse is supported by Guylian Chocolates (Belgium) in a partnership for marine conservation.

DATA AVAILABILITY STATEMENT

The policy data used in this study are available from the websites and references listed on the Table S2.1 on the Appendix S2.

REFERENCES

- Ahlers, A. L., & Schubert, G. (2015). Effective policy implementation in China's local state. *Modern China*, 41(4), 372–405. <https://doi.org/10.1177/0097700413519563>
- Alava, J J, Barragán-Paladines, M. J., Denking, J., Muñoz-Abril, L., Jiménez, P., Paladines, F., ... Calle, M. (2017). Massive Chinese fleet jeopardizes threatened shark species around the Galápagos marine reserve and waters off Ecuador: Implications for national and international fisheries policy. *International Journal of Fisheries Sci Res*, 1(1), 1001.
- Alava, Juan José, & Paladines, F. (2017). Illegal fishing on the Galápagos high seas. *Science*, 357(6358), 1362. <https://doi.org/DOI: 10.1126/science.aap7832>
- Ali, S., Hussain, T., Zhang, G., Nurunnabi, M., & Li, B. (2018). The Implementation of Sustainable Development Goals in “BRICS” Countries. *Sustainability*, 10(7), 2513. <https://doi.org/10.3390/su10072513>
- World Bank. (2013). Fish to 2030: Prospects for fisheries and aquaculture. *In Agriculture and Environmental Services Discussion Paper*, 3.
- Belhabib, D., Cheung, W. W. L., Kroodsmma, D., Lam, V. W. Y., Underwood, P. J., & Virdin, J. (2019). Catching industrial fishing incursions into inshore waters of Africa from space. *Fish*

- and Fisheries. <https://doi.org/10.1111/faf.12436>
- Bellmann, C., Tipping, A., & Sumaila, U. R. (2016). Global trade in fish and fishery products: An overview. *Marine Policy*, 69, 181–188. <https://doi.org/10.1016/j.marpol.2015.12.019>
- BFMOA. (2001). *China fishery statistical yearbook 2001 (in Chinese)*. Beijing: China Agriculture Press.
- BFMOA. (2003). *China fishery statistical yearbook 2003 (in Chinese)*. Beijing: China Agriculture Press.
- BFMOA. (2005). *China fishery statistical yearbook 2005 (in Chinese)*. Beijing: China Agriculture Press.
- BFMOA. (2010). *China fishery statistical yearbook 2010 (in Chinese)*. Beijing: China Agriculture Press.
- BFMOA. (2014). Major responsibilities and inner organizations of the Bureau of Fisheries, Ministry of Agriculture (BFMOA) (in Chinese). *China Fisheries*, 10, 3–5. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotat-SICA201410003.htm>
- BFMOA. (2018). *China fishery statistical yearbook 2018 (in Chinese)*. Beijing: China Agriculture Press.
- BFMOA. (2019). *China fishery statistical yearbook 2019 (in Chinese)*. Beijing: China Agriculture Press.
- Bouchet-Valat, M., & Bouchet-Valat, M. M. (2015). Package ‘SnowballC.’
- Brans, M., & Ferraro, G. (2012). International agreements and the salience of domestic politics: Locus, focus and gradus. The case of fisheries policy reforms in China and Senegal. *Journal of Comparative Policy Analysis: Research and Practice*, 14(1), 9–25. <https://doi.org/10.1080/13876988.2011.646817>
- Broadhurst, M. K. (2000). Modifications to reduce bycatch in prawn trawls: a review and framework for development. *Reviews in Fish Biology and Fisheries*, 10(1), 27–60. <https://doi.org/10.1023/A:1008936820089>
- Broadhurst, M. K., Kennelly, S. J., Watson, J. W., & Workman, I. K. (1997). Evaluations of the Nordmøre grid and secondary bycatch-reducing devices (BRD’s) in the hunter River prawn-trawl fishery, Australia. *Fishery Bulletin*, 95, 209–218.
- Bryan, B. A., Gao, L., Ye, Y., Sun, X., Connor, J. D., Crossman, N. D., ... Yu, D. (2018). China’s response to a national land-system sustainability emergency. *Nature*, 559(7713), 193–204. <https://doi.org/10.1038/s41586-018-0280-2>
- Cai, P. (2017). *Understanding China’s belt and road initiative*. Lowy Institute For International Policy. Lowy Institute for International Policy. Retrieved from <http://hdl.handle.net/11540/6810>
- Cao, L., Chen, Y., Dong, S., Hanson, A., Huang, B., Leadbitter, D., ... Naylor, R. L. (2017). Opportunity for marine fisheries reform in China. *Proceedings of the National Academy of Sciences*, 114(3), 435–442. <https://doi.org/10.1073/pnas.1616583114>
- Cao, L., Naylor, R., Henriksson, P., Leadbitter, D., Metian, M., Troell, M., & Zhang, W. (2015). China’s aquaculture and the world’s wild fisheries. *Science*, 347(6218), 133–135. <https://doi.org/10.1126/science.1260149>
- Cashion, T., Al-Abdulrazzak, D., Belhabib, D., Derrick, B., Divovich, E., Moutopoulos, D. K., ... Zeller, D. (2018). Reconstructing global marine fishing gear use: Catches and landed values by gear type and sector. *Fisheries Research*, 206, 57–64. <https://doi.org/10.1016/j.fishres.2018.04.010>
- Chen, S. (1982). The East China Sea Bureau of Fisheries holding the summing-up meeting for

- the juvenile ratio inspection program (in Chinese). *Marine Fisheries*, (1), 38. Retrieved from <http://www.cqvip.com/qk/93342X/198201/15142671.html>
- Chen, W. (2016). Is the label 'minimal legislature' still appropriate? The role of the National People's Congress in China's political system. *The Journal of Legislative Studies*, 22(2), 257–275. <https://doi.org/10.1080/13572334.2015.1134909>
- Chen, Z. (2009). *Research on China fishery professional cooperative economic organization (dissertation in Chinese)*. Ocean University of China. Retrieved from <http://cdmd.cnki.com.cn/Article/CDMD-10423-2009171331.htm>
- Cheng, J., Cai, W., Cheung, W. P., & Pramod, G. (2006). An estimation of compliance of the fisheries of China with Article 7 (Fisheries Management) of the UN Code of Conduct for Responsible Fishing. *Evaluations of Compliance with FAO (UN) Code of Conduct for Responsible Fisheries, Fisheries Centre Research Reports*, 14(2).
- Cheng, J., Yan, L., Lin, L., & Yu, L. (1999). Analyses on the fishery ecological effect of summer moratoria in the East China Sea (in Chinese). *Journal of Fisheries Sciences of China*, 6(4), 81–85. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotal-ZSCK199904018.htm>
- Chong, K.-C., Dwiponggo, A., Ilyas, S., & Martosubroto, P. (1987). Some experiences and highlights of the Indonesian trawl ban: bioeconomics and socioeconomics. In *In Indo Pacific Fisheries Commission, Papers presented at the Symposium on Exploitation and Management of Marine Fishery Resources in Southeast Asia held in conjunction with the Twenty-Second Session of the Indo-Pacific Fishery Commission, Darwin, Australia* (pp. 16–26).
- Chuenpagdee, R., Morgan, L. E., Maxwell, S. M., Norse, E. A., & Pauly, D. (2003). Shifting gears: assessing collateral impacts of fishing methods in US waters. *Frontiers in Ecology and the Environment*, 1(10), 517–524. [https://doi.org/10.1890/1540-9295\(2003\)001\[0517:SGACIO\]2.0.CO;2](https://doi.org/10.1890/1540-9295(2003)001[0517:SGACIO]2.0.CO;2)
- Cocks, T., & Ba, D. (2017, June 10). Senegal detains seven Chinese trawling boats for illegal fishing. *Reuters*. Retrieved from <https://www.reuters.com/article/us-senegal-china-fishing/senegal-detains-seven-chinese-trawling-boats-for-illegal-fishing-idUSKBN1910Z4%0D>
- Coulter, P. B. (2019). *Measuring inequality: A methodological handbook*. Routledge.
- Csardi, G., & Nepusz, T. (2006). The igraph software package for complex network research. *InterJournal, Complex Systems*, 1695(5), 1–9.
- Daksueva, O., & Lin, J. J. (2018). The Role of Provinces in Decision-Making Processes in China: The Case of Hainan Province. In J. Spangler, D. Karalekas, & M. L. de Souza (Eds.), *Enterprises, Localities, People, and Policy in the South China Sea* (pp. 77–96). Springer.
- Davies, R. W. D., Cripps, S. J., Nickson, A., & Porter, G. (2009). Defining and estimating global marine fisheries bycatch. *Marine Policy*, 33(4), 661–672. <https://doi.org/10.1016/j.marpol.2009.01.003>
- De Groot, S. J. (1984). The impact of bottom trawling on benthic fauna of the North Sea. *Ocean Management*, 9(3–4), 177–190.
- Demestre, M., de Juan, S., Sartor, P., & Ligas, A. (2008). Seasonal closures as a measure of trawling effort control in two Mediterranean trawling grounds: effects on epibenthic communities. *Marine Pollution Bulletin*, 56(10), 1765–1773. <https://doi.org/10.1016/j.marpolbul.2008.06.004>
- Dong, N., & Zhong, C. (2006). The impact on the demand of seawater aquatic products by Chinese people's disposable income growth (in Chinese with English Abstract). *Journal of*

- Ningbo University (Liberal Arts Edition)*, 6, 107–114. Retrieved from http://en.cnki.com.cn/Article_en/CJFDTotol-NBDS200606019.htm
- Dunn, D. C., Boustany, A. M., & Halpin, P. N. (2011). Spatio-temporal management of fisheries to reduce by-catch and increase fishing selectivity. *Fish and Fisheries*, 12(1), 110–119. <https://doi.org/10.1111/j.1467-2979.2010.00388.x>
- Dureuil, M., Boerder, K., Burnett, K. A., Froese, R., & Worm, B. (2018). Elevated trawling inside protected areas undermines conservation outcomes in a global fishing hot spot. *Science*, 362(6421), 1403–1407. <https://doi.org/10.1126/science.aau0561>
- Eigaard, O. R., Bastardie, F., Hintzen, N. T., Buhl-Mortensen, L., Buhl-Mortensen, P., Catarino, R., ... Geitner, K. (2017). The footprint of bottom trawling in European waters: distribution, intensity, and seabed integrity. *ICES Journal of Marine Science*, 74(3), 847–865. <https://doi.org/10.1093/icesjms/fsw194>
- Fabinyi, M. (2012). Historical, cultural and social perspectives on luxury seafood consumption in China. *Environmental Conservation*, 39(1), 83–92. <https://doi.org/10.1017/S0376892911000609>
- Fabinyi, M., & Liu, N. (2014). Seafood banquets in Beijing: consumer perspectives and implications for environmental sustainability. *Conservation and Society*, 12, 218–228. <https://doi.org/10.4103/0972-4923.138423>
- Fabinyi, M., Liu, N., Song, Q., & Li, R. (2016). Aquatic product consumption patterns and perceptions among the Chinese middle class. *Regional Studies in Marine Science*, 7, 1–9. <https://doi.org/10.1016/j.rsma.2016.01.013>
- Fan, Y. (1998). The transfer of Western management to China: Context, content and constraints. *Management Learning*, 29(2), 201–221. <https://doi.org/10.1177/1350507698292005>
- Fang, F. (2018). Seeking the Theoretical Origins of Supply-side Structural Reform. *Social Sciences in China*, 39(4), 37–52. <https://doi.org/10.1080/02529203.2018.1519211>
- Fang, Q., Drugan, C. D. J., & Director, A. T. (2018). *Chinese Japanese Flying Squid (JFS) Fisheries Improvement Scoping Report*.
- Fang, S., Su, X., & Yang, S. (2002). Several factors that hindered the implementation of the catch quota regime (in Chinese). *China Fisheries Economics*, (6), 37–39. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotol-ZYJJ200206019.htm>
- FAO. (1996). *FAO Technical Guidelines for Responsible Fisheries*.
- FAO. (2006). *The state of world fisheries and aquaculture 2006*. Rome: FAO United Nations. Retrieved from <http://www.fao.org/3/a-a0699e.pdf>
- FAO. (2012). Feeding the growing aquaculture sector: an analysis. In *Report of the sixth session of the SUB-COMMITTEE ON AQUACULTURE Cape Town, South Africa, 26-30 March 2012* (p. 4). Cape Town: Rome (Italy) FAO.
- FAOSTAT. (2013). FAOSTAT database. *Food and Agriculture Organization of the United Nations, Rome, Italy*. Retrieved from <http://www.fao.org/faostat/en/#data/CL>
- Feinerer, I., Hornik, K., & Feinerer, M. I. (2019). Package ‘tm.’ *Corpus*, 10, 1.
- Fellows, I., Fellows, M. I., Rcpp, L., & Rcpp, L. (2018). Package ‘wordcloud.’
- Ferdinand, P. (2016). Westward ho—the China dream and ‘one belt, one road’: Chinese foreign policy under Xi Jinping. *International Affairs*, 92(4), 941–957. <https://doi.org/10.1111/1468-2346.12660>
- Ferraro, G., Brans, M., Guo, W., & Feng, T. (2009). An Intra-National Perspective on Regime Implementation: The Case of Marine Fisheries in China—Keen Conflicts and Hazy Contents. *Asia Pacific Journal of Public Administration*, 31(2), 147–169.

- <https://doi.org/10.1080/23276665.2009.10779361>
- Fewsmith, J. (2004). Promoting the scientific development concept. *China Leadership Monitor*, 11(30), 1–10.
- Fleisher, B., Li, H., & Zhao, M. Q. (2010). Human capital, economic growth, and regional inequality in China. *Journal of Development Economics*, 92(2), 215–231. <https://doi.org/10.1016/j.jdeveco.2009.01.010>
- Gagern, A., & van den Bergh, J. (2013). A critical review of fishing agreements with tropical developing countries. *Marine Policy*, 38, 375–386. <https://doi.org/10.1016/j.marpol.2012.06.016>
- Gao, G., & Fu, Z. (2017). Supervision mechanism for environmental law enforcement in China. In *2017 2nd International Conference on Politics, Economics and Law (ICPEL 2017)*. Atlantis Press. <https://doi.org/10.2991/icpel-17.2017.53>
- Gao, J., & Ping, Y. (2002). Discussion on the factors restricting the flow of human resources in China's marine capture fisheries (in Chinese). *Chinese Fisheries Economics*, (5), 16–17. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotat-ZYJJ200205005.htm>
- Geall, S., & Ely, A. (2018). Narratives and Pathways towards an Ecological Civilization in Contemporary China. *The China Quarterly*, 236, 1175–1196. <https://doi.org/10.1017/S0305741018001315>
- Gillett, R. (2008). *Global study of shrimp fisheries* (Vol. 475). Rome: Food and Agriculture Organization of the United Nations.
- Guler, A. T., Waaijer, C. J. F., & Palmblad, M. (2016). Scientific workflows for bibliometrics. *Scientometrics*, 107(2), 385–398. <https://doi.org/10.1007/s11192-016-1885-6>
- Guo, R. (2012). Global major progress and trends in the implementation of Agenda 21. *Chinese Journal of Population Resources and Environment*, 10(2), 3–11. <https://doi.org/10.1080/10042857.2012.10685071>
- Han, D., Shan, X., Zhang, W., Chen, Y., Wang, Q., Li, Z., ... Xie, S. (2018). A revisit to fishmeal usage and associated consequences in Chinese aquaculture. *Reviews in Aquaculture*, 10(2), 493–507. <https://doi.org/10.1111/raq.12183>
- He, J. (2015). Chinese public policy on fisheries subsidies: Reconciling trade, environmental and food security stakes. *Marine Policy*, 56, 106–116. <https://doi.org/10.1016/j.marpol.2014.12.021>
- He, P., & Balzano, V. (2011). Rope grid: a new grid design to further reduce finfish bycatch in the Gulf of Maine pink shrimp fishery. *Fisheries Research*, 111(1–2), 100–107. <https://doi.org/10.1016/j.fishres.2011.07.001>
- He, Q., Bertness, M. D., Bruno, J. F., Li, B., Chen, G., Coverdale, T. C., ... Pennings, S. C. (2014). Economic development and coastal ecosystem change in China. *Scientific Reports*, 4, 5995. <https://doi.org/10.1038/srep05995>
- Heilmann, S., & Melton, O. (2013). The reinvention of development planning in China, 1993–2012. *Modern China*, 39(6), 580–628. <https://doi.org/10.1177/00977700413497551>
- Hiddink, J. G., Jennings, S., Sciberras, M., Bolam, S. G., Cambiè, G., McConnaughey, R. A., ... Pitcher, C. R. (2019). Assessing bottom trawling impacts based on the longevity of benthic invertebrates. *Journal of Applied Ecology*, 56(5), 1075–1084. <https://doi.org/10.1111/1365-2664.13278>
- Hiddink, J. G., Rijnsdorp, A. D., & Piet, G. (2008). Can bottom trawling disturbance increase food production for a commercial fish species? *Canadian Journal of Fisheries and Aquatic Sciences*, 65(7), 1393–1401. <https://doi.org/10.1139/F08-064>

- Holland, D., Gudmundsson, E., & Gates, J. (1999). Do fishing vessel buyback programs work: a survey of the evidence. *Marine Policy*, 23(1), 47–69. [https://doi.org/10.1016/S0308-597X\(98\)00016-5](https://doi.org/10.1016/S0308-597X(98)00016-5)
- Huang, S., & He, Y. (2019). Management of China's capture fisheries: Review and prospect. *Aquaculture and Fisheries*. <https://doi.org/10.1016/j.aaf.2019.05.004>
- Jin, X. (2004). Long-term changes in fish community structure in the Bohai Sea, China. *Estuarine, Coastal and Shelf Science*, 59(1), 163–171. <https://doi.org/10.1016/j.ecss.2003.08.005>
- Kostka, G., & Zhang, C. (2018). Tightening the grip: environmental governance under Xi Jinping. Taylor & Francis.
- Kroodsma, D. A., Mayorga, J., Hochberg, T., Miller, N. A., Boerder, K., Ferretti, F., ... Block, B. A. (2018). Tracking the global footprint of fisheries. *Science*, 359(6378), 904–908. <https://doi.org/10.1126/science.aao5646>
- Laakso, M., & Taagepera, R. (1979). “Effective” number of parties: a measure with application to West Europe. *Comparative Political Studies*, 12(1), 3–27.
- Li, L., & Huang, J. (2005). China's accession to the WTO and its implications for the fishery and aquaculture sector. *Aquaculture Economics & Management*, 9(1–2), 195–215. <https://doi.org/10.1080/13657300590961546>
- Li, Y. (2011). “Eleventh Five-Year” fishery development has reached a new level in an all-round way-Summary of “11th Five-Year” fishery achievements (in Chinese). *China Fisheries*, (3), 11–19. Retrieved from <http://mall.cnki.net/magazine/article/SICA201103008.htm>
- Liang, C., & Pauly, D. (2017). Growth and mortality of exploited fishes in China's coastal seas and their uses for yield-per-recruit analyses. *Journal of Applied Ichthyology*, 33(4), 746–756. <https://doi.org/10.1111/jai.13379>
- Liao, J. (2017). Guangdong combats illegal fishing in summer moratoria (in Chinese). *Ocean and Fishery*, (9), 42–43. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotal-HYUY201709028.htm>
- Lin, X. (1987). Biological characteristics and resources status of three main commercial fishes in offshore waters of China (In Chinese). *Journal of Fisheries of China*, 11(3), 187–194. Retrieved from http://en.cnki.com.cn/Article_en/CJFDTOTAL-SCKX198703000.htm
- Lindkvist, K. B., Trondsen, T., & Xie, J. (2008). Restructuring the Chinese seafood industry, global challenges and policy implications. *Marine Policy*, 32(3), 432–441. <https://doi.org/10.1016/j.marpol.2007.08.009>
- Liu, H., Sun, L., Qi, J., & Yang, F. (2007). Comparison on marine fishery policy between China and South Korea (in Chinese). *Journal of the Pacific*, 12, 69–77. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotal-TPYX200712017.htm>
- Liu, Jiandang, Dai, X., Tang, J., Wang, D., & Liang, Z. (2017). The provincial governance quality in China: An empirical study of three dimensions. *Advances in Education Sciences Volume 13*, 179. Retrieved from <https://core.ac.uk/download/pdf/85162222.pdf#page=194>
- Liu, Jianguo, & Raven, P. H. (2010). China's environmental challenges and implications for the world. *Critical Reviews in Environmental Science and Technology*, 40(9–10), 823–851. <https://doi.org/10.1080/10643389.2010.502645>
- Liu, M., & De Mitcheson, Y. S. (2008). Profile of a fishery collapse: why mariculture failed to save the large yellow croaker. *Fish and Fisheries*, 9(3), 219–242. <https://doi.org/10.1111/j.1467-2979.2008.00278.x>
- Lou, J., & Chen, B. (2004). Suggestions on improving the moratorium regime for beam (shrimp)

- trawlers (in Chinese). *China Fisheries*, (1), 28–29. Retrieved from <http://www.cqvip.com/qk/90481x/200401/9121589.html>
- Magurran, A. E. (1988). *Ecological diversity and its measurement*. Princeton university press.
- Mallory, T. G. (2013). China's distant water fishing industry: Evolving policies and implications. *Marine Policy*, 38, 99–108. <https://doi.org/10.1016/j.marpol.2012.05.024>
- Mallory, T. G. (2016). Fisheries subsidies in China: Quantitative and qualitative assessment of policy coherence and effectiveness. *Marine Policy*, 68, 74–82. <https://doi.org/10.1016/j.marpol.2016.01.028>
- Mazor, T. K., Pitcher, C. R., Ellis, N., Rochester, W., Jennings, S., Hiddink, J. G., ... Suuronen, P. (2017). Trawl exposure and protection of seabed fauna at large spatial scales. *Diversity and Distributions*, 23(11), 1280–1291. <https://doi.org/doi.org/10.1111/ddi.12622>
- MOA. (2006). *The 11th Five-Year Plan for Fisheries (2006 - 2010) (in Chinese)*. Ministry of Agriculture (MOA), P.R.C. Retrieved from http://www.wanfangdata.com.cn/details/detail.do?_type=perio&id=zhongguosc200612001
- MOA. (2011). *The 12th Five-Year Plan for Fisheries (2011 - 2015) (in Chinese)*. Ministry of Agriculture (MOA), P.R.C. Retrieved from http://www.moa.gov.cn/nybgb/2011/dshiq/201805/t20180523_6142898.htm
- MOA. (2017). *The 13th Five-Year Plan for Fisheries (2016 - 2020) (in Chinese)*. Ministry of Agriculture (MOA), P.R.C. Retrieved from http://www.moa.gov.cn/nybgb/2017/derq/201712/t20171227_6131208.htm
- Mohanty, M. (2012). “Harmonious Society”: Hu Jintao's Vision and the Chinese Party Congress. *Economic and Political Weekly*, 12–16.
- Morris, E. K., Caruso, T., Buscot, F., Fischer, M., Hancock, C., Maier, T. S., ... Prati, D. (2014). Choosing and using diversity indices: insights for ecological applications from the German Biodiversity Exploratories. *Ecology and Evolution*, 4(18), 3514–3524. <https://doi.org/10.1002/ece3.1155>
- Muscolino, M. S. (2009). *Fishing wars and environmental change in late imperial and modern China* (Vol. 325). Harvard University Press.
- NBSC. (2019). National Bureau of statistics of China. Retrieved September 17, 2019, from <http://data.stats.gov.cn/easyquery.htm?cn=C01>
- O'Brien, K., & Li, L. (1999). Selective policy implementation in rural China. *Comparative Politics*, 31(2). https://doi.org/10.1163/9789004302488_017
- Oanta, G. A. (2018). International organizations and deep-sea fisheries: Current status and future prospects. *Marine Policy*, 87, 51–59. <https://doi.org/10.1016/j.marpol.2017.09.009>
- Oberle, F. K. J., Storlazzi, C. D., & Hanebuth, T. J. J. (2016). What a drag: Quantifying the global impact of chronic bottom trawling on continental shelf sediment. *Journal of Marine Systems*, 159, 109–119. <https://doi.org/10.1016/j.jmarsys.2015.12.007>
- Pala, C. (2013). Detective work uncovers under-reported overfishing. *Nature*, 496(7443), 18. <https://doi.org/10.1038/496018a>
- Pan, P., & Li, W. (2016). Status and evolution of China's summer moratorium regime (in Chinese). *China Fisheries*, (10), 36–40. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotal-SICA201610021.htm>
- Pan, P., Luo, J., & Hu, Y. (2016). Review on the Sino-Vietnamese Fishery Agreement (in Chinese). *China Fisheries Economics*, (06), 22–26. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotal-ZYJJ201606006.htm>
- Pascoe, S., Cogle, L., Punt, A. E., & Dichmont, C. M. (2012). Impacts of vessel capacity

- reduction programmes on efficiency in fisheries: the case of Australia's multispecies northern prawn fishery. *Journal of Agricultural Economics*, 63(2), 425–443.
<https://doi.org/10.1111/j.1477-9552.2011.00333.x>
- Pauly, D., Alder, J., Bennett, E., Christensen, V., Tyedmers, P., & Watson, R. (2003). The future for fisheries. *Science*, 302(5649), 1359–1361. <https://doi.org/10.1126/science.1088667>
- Pauly, D., Belhabib, D., Blomeyer, R., Cheung, W. W. W. L., Cisneros-Montemayor, A. M., Copeland, D., ... Le Manach, F. (2014). China's distant-water fisheries in the 21st century. *Fish and Fisheries*, 15(3), 474–488. <https://doi.org/10.1111/faf.12032>
- Pauly, D., & Zeller, D. (2015). Sea Around Us concepts, design and data. *Vancouver, BC*.
- Pipitone, C., Badalamenti, F., D'Anna, G., & Patti, B. (2000). Fish biomass increase after a four-year trawl ban in the Gulf of Castellammare (NW Sicily, Mediterranean Sea). *Fisheries Research*, 48(1), 23–30. [https://doi.org/10.1016/S0165-7836\(00\)00114-4](https://doi.org/10.1016/S0165-7836(00)00114-4)
- Pomeroy, R., Parks, J., Courtney, K., & Mattich, N. (2016). Improving marine fisheries management in Southeast Asia: Results of a regional fisheries stakeholder analysis. *Marine Policy*, 65, 20–29. <https://doi.org/10.1016/j.marpol.2015.12.002>
- Popkin, B. M. (2014). Synthesis and implications: China's nutrition transition in the context of changes across other low-and middle-income countries. *Obesity Reviews*, 15, 60–67.
<https://doi.org/10.1111/obr.12120>
- Pu, X., & Wang, C. (2018). Rethinking China's rise: Chinese scholars debate strategic overstretch. *International Affairs*, 94(5), 1019–1035. <https://doi.org/10.1093/ia/iyy140>
- Rafols, I., & Meyer, M. (2010). Diversity and network coherence as indicators of interdisciplinarity: case studies in bionanoscience. *Scientometrics*, 82(2), 263–287.
<https://doi.org/10.1007/s11192-009-0041-y>
- Roheim, C. A., Bush, S. R., Asche, F., Sanchirico, J. N., & Uchida, H. (2018). Evolution and future of the sustainable seafood market. *Nature Sustainability*, 1(8), 392–398.
<https://doi.org/10.1038/s41893-018-0115-z>
- Rosenberg, D. (2005). Managing the resources of the China Seas: China's bilateral fisheries agreements with Japan, South Korea, and Vietnam. *The Asia-Pacific Journal / Japan Focus*, 254.
- Shen, G., & Heino, M. (2014). An overview of marine fisheries management in China. *Marine Policy*, 44, 265–272. <https://doi.org/10.1016/j.marpol.2013.09.012>
- Simpson, E. H. (1949). Measurement of diversity. *Nature*, 163(4148), 688.
- Stiles, M. L., Stockbridge, J., Lande, M., & Hirshfield, M. F. (2010). Impacts of bottom trawling. *Oceana, Washington DC*.
- Stirling, A. (2007). A general framework for analysing diversity in science, technology and society. *Journal of the Royal Society Interface*, 4(15), 707–719.
<https://doi.org/10.1098/rsif.2007.0213>
- Su, S., Tang, Y., Chang, B., Zhu, W., & Chen, Y. (2020). Evolution of marine fisheries management in China from 1949 to 2019: How did China get here and where does China go next? *Fish and Fisheries*. <https://doi.org/doi:10.1111/faf.12439>
- Sumaila, U Rashid, Lam, V., Le Manach, F., Swartz, W., & Pauly, D. (2016). Global fisheries subsidies: An updated estimate. *Marine Policy*, 69, 189–193.
<https://doi.org/10.1016/j.marpol.2015.12.026>
- Sumaila, Ussif Rashid, Teh, L., Watson, R., Tyedmers, P., & Pauly, D. (2006). Fuel subsidies to global fisheries: Magnitude and impacts on resource sustainability. In R. U. Sumaila & D. Pauly (Eds.), *Catching more bait: a bottom-up re-estimation of global fisheries subsidies*

- (2nd Version, 2007) *Fisheries Centre Research Reports* (Vol. 14, p. 38). Fisheries Centre, the University of British Columbia, Vancouver, Canada.
- Sun, X., Gao, L., Ren, H., Ye, Y., Li, A., Stafford-Smith, M., ... Bryan, B. A. (2018). China's progress towards sustainable land development and ecological civilization. *Landscape Ecology*, 33, 1647–1653. <https://doi.org/10.1007/s10980-018-0706-0>
- Sun, Y. (2016). Promote the Environmental Protection Vertical Management System to Solve the Problems of Local Protectionism (in Chinese). *Environmental Protection*, 44(22), 21–24. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotat-HJBU201622013.htm>
- Sun, Z., Zhou, J., Wang, J., Zhao, Z., Zhuang, S., Chen, B., ... Meng, W. (2011). Investigation and analysis of trawl gears in the Yellow Sea and Bohai Sea (in Chinese). *Progress in Fishery Sciences*, 32(5), 126–134. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotat-HYSC201105020.htm>
- Tang, Q., Jia, X., Zheng, Y., Cheng, J., Wan, R., Wang, J., ... (2012). *Regional Oceanography of China Seas - Fisheries Oceanography (in Chinese)*. (Q. Tang, X. Jia, Y. Zheng, & J. Cheng, Eds.). Beijing: Maritime Press.
- Tao, L. S. R., Lui, K. K. Y., Lau, E. T. C., Ho, K. K. Y., Mak, Y. K. Y., de Mitcheson, Y. S., & Leung, K. M. Y. (2018). Trawl ban in a heavily exploited marine environment: Responses in population dynamics of four stomatopod species. *Scientific Reports*, 8(1), 17876. <https://doi.org/10.1038/s41598-018-35804-7>
- Travaille, K. L. T., Lindley, J., Kendrick, G. A., Crowder, L. B., & Clifton, J. (2019). The market for sustainable seafood drives transformative change in fishery social-ecological systems. *Global Environmental Change*, 57, 101919. <https://doi.org/10.1016/j.gloenvcha.2019.05.003>
- Walsh, M. L., Tromble, G. R., Patrick, W. S., & Morrison, W. E. (2015). Comparative analysis of US federal fishery management to the FAO ecolabelling guidelines: a self-assessment. *NOAA Technical Memorandum NMFS-OSF-1*. <https://doi.org/10.7289/V5DF6P70>
- Wang, S. D. H., & Zhan, B. (1992). Marine fishery resource management in PR China. *Marine Policy*, 16(3), 197–209. [https://doi.org/10.1016/0308-597X\(92\)90081-Y](https://doi.org/10.1016/0308-597X(92)90081-Y)
- Wang, W. (2012). China's Agenda 21: Strategic Choice and Practice Pursuing Sustainable Development. *China Population, Resources and Environment*, 5. Retrieved from http://en.cnki.com.cn/Article_en/CJFDTotat-ZGRZ201205001.htm
- Wang, Z. (2014). The Chinese dream: Concept and context. *Journal of Chinese Political Science*, 19(1), 1–13. <https://doi.org/10.1007/s11366-013-9272-0>
- Watling, L. (2013). Deep-sea trawling must be banned. *Nature News*, 501(7465), 7. <https://doi.org/10.1038/501007a>
- Watson, R., & Pauly, D. (2001). Systematic distortions in world fisheries catch trends. *Nature*, 414(6863), 534–536. <https://doi.org/10.1038/35107050>
- Weimin, M., & Mengqing, L. (2007). Analysis of feeds and fertilizers for sustainable aquaculture development in China. *FAO Fisheries Technical Paper*, 497, 141–190.
- Willette, D. A., & Cheng, S. H. (2018). Delivering on seafood traceability under the new US import monitoring program. *Ambio*, 47(1), 25–30. <https://doi.org/10.1007/s13280-017-0936-4>
- Wu, R., & Hu, P. (2019). Does the “Miracle Drug” of Environmental Governance Really Improve Air Quality? Evidence from China's System of Central Environmental Protection Inspections. *International Journal of Environmental Research and Public Health*, 16(5), 850. <https://doi.org/10.3390/ijerph16050850>

- Xiao, L., & Li, M. (2015). The glorious three decades of China's distant-water fisheries - an interview with Liu Shenli, Chairman of China Agricultural Development Group (in Chinese). *China Fisheries*, (4), 4–8. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotal-SICA201504003.htm>
- Xiao, L., & Li, Z. (2007). Shouldering the mission and safeguarding fisheries development in China - interview with the previous chief economic manager and previous director of fisheries bureaus Zho Youzhan (in Chinese). *China Fisheries*, (11), 4–7. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotal-SICA200711003.htm>
- Xue, G. J. (2006). China's distant water fisheries and its response to flag state responsibilities. *Marine Policy*, 30(6), 651–658. <https://doi.org/10.1016/j.marpol.2005.09.005>
- Xue, L., Lu, Z., Zhou, Y., & He, Z. (2011). Analyses on the development status of beam-trawl shrimp fisheries in Zhejiang (in Chinese). *Modern Fisheries Information*, 26(5), 6–8. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotal-XYYZ201105004.htm>
- Yan, L., Hu, F., Li, S., Liu, Y., Zhou, Y., & Liu, Z. (2007). The effect of summer moratoria and the reasonable utilization of the hairtail (*Trichiurus japonicus*) in the East China Sea (in Chinese). *Journal of Natural Resources*, 22(4), 606–612. Retrieved from <http://www.cqvip.com/qk/87801X/200722/25913994.html>
- Yang, Zhengyong, Li, S., Chen, B., Kang, H., & Huang, M. (2016). China's aquatic product processing industry: Policy evolution and economic performance. *Trends in Food Science & Technology*, 58, 149–154. <https://doi.org/10.1016/j.tifs.2016.09.004>
- Yang, Zhengyong, & Shen, X. (2005). Effects of the characteristics of natural resources on the transaction cost of the ITQ regime (in Chinese). *China Fisheries Economics*, (5), 25–28. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotal-ZYJJ200505007.htm>
- Yang, Zijiang, Liu, L., & Li, M. (2018). Development phases and important reforms of China's fisheries over past four decades (in Chinese). *China Fisheries*, (10), 23. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotal-SICA201810023.htm>
- Yu, C., Chen, Z., Chen, L., & He, P. (2007). The rise and fall of electrical beam trawling for shrimp in the East China Sea: technology, fishery, and conservation implications. *ICES Journal of Marine Science*, 64(8), 1592–1597. <https://doi.org/10.1093/icesjms/fsm137>
- Yu, Huiguo, & Yu, Y. (2008). Fishing capacity management in China: Theoretic and practical perspectives. *Marine Policy*, 32(3), 351–359. <https://doi.org/10.1016/j.marpol.2007.07.004>
- Yu, Huming. (1991). Marine fishery management in PR China. *Marine Policy*, 15(1), 23–32. [https://doi.org/10.1016/0308-597X\(91\)90040-I](https://doi.org/10.1016/0308-597X(91)90040-I)
- Yu, S., Shui, B., Ge, C., Xu, Y., & Ji, M. (2016). Problems in implementing fuel subsidy and suggested reforms (in Chinese). *Management Observation*, (33), 54–57. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotal-GLKW201633019.htm>
- Yue, D., Wang, L., Cao, K., Ming, J., & Liu, Z. (2017). Adjustment history and improvement measures of marine capture fishery resources enhancement and conservation fee: Taking Shandong and Zhejiang as examples. *China Agriculture Science Bulletin*, 33(32), 149–154 (in Chinese). Retrieved from <http://www.cnki.com.cn/Article/CJFDTotal-ZNTB201732026.htm>
- Zhai, F. Y., Du, S. F., Wang, Z. H., Zhang, J. G., Du, W. W., & Popkin, B. M. (2014). Dynamics of the Chinese diet and the role of urbanicity, 1991–2011. *Obesity Reviews*, 15, 16–26. <https://doi.org/10.1111/obr.12124>
- Zhai, L., & Pauly, D. (2019). Yield-per-recruit, utility-per-recruit, and relative biomass of 21 exploited fish species in China's coastal seas. *Frontiers in Marine Science*.

- <https://doi.org/10.3389/fmars.2019.00724>
- Zhang, F., & Ji, M. (2019). Adjustment Path of Marine Economic Industrial Structure in China's Coastal Provinces under the 'Belt and Road' Initiative. *Journal of Coastal Research*, 94(sp1), 593–596. <https://doi.org/10.2112/SI94-118.1>
- Zhang, H. (2016). Chinese fishermen in disputed waters: Not quite a “people’s war.” *Marine Policy*, 68, 65–73. <https://doi.org/10.1016/j.marpol.2016.02.018>
- Zhang, H., & Wu, F. (2017). China’s marine fishery and global ocean governance. *Global Policy*, 8(2), 216–226. <https://doi.org/10.1111/1758-5899.12419>
- Zhang, Jianguo. (2008). Improving the system of fishing closure and promoting the rational exploitation and utilization of fishery resources - In July 1995, China first implemented a comprehensive summer fishing closure system in the East China Sea and Yellow Sea (in Chinese). In *Proceedings of Chinese Fisheries Reform and Development Conference. Beijing: China Fisheries Association* (pp. 85–89). Retrieved from <http://cpfd.cnki.com.cn/Article/CPFDTOTAL-ZYYE200810002015.htm>
- Zhang, Jizhe, Li, X., & Tang, Y. (2015). The analysis of Chinese and Korea fishing under the framework of Sino-South Korean Fishery Agreement (in Chinese). *Fishery Modernization*, 42(1), 65–71. Retrieved from http://en.cnki.com.cn/Article_en/CJFDTotals-HDXY201501019.htm
- Zhang, S., Jin, S., Zhang, H., Fan, W., Tang, F., & Yang, S. (2016). Distribution of bottom trawling effort in the yellow sea and east China sea. *PloS One*, 11(11), e0166640. <https://doi.org/10.1371/journal.pone.0166640>
- Zhang, Wenbo, Liu, M., Sadovy de Mitcheson, Y., Cao, L., Leadbitter, D., Newton, R., ... Chen, X. (2020). Fishing for feed in China: Facts, impacts and implications. *Fish and Fisheries*, 21(1), 47–62. <https://doi.org/10.1111/faf.12414>
- Zhang, Wenjing. (2019, March 10). Commissioner MAI Kangseng calls for a ban on the use of frozen trash fish as fish feed in aquaculture. *Chinese People’s Political Consultative Conference*. Retrieved from <http://www.rmzxb.com.cn/c/2019-03-10/2307304.shtml>
- Zhang, X., & Vincent, A. C. J. Development history of China’s bottom-trawl fisheries. *PNAS (under Review)*.
- Zhong, Y., & Power, G. (1997). Fisheries in China: progress, problems, and prospects. *Canadian Journal of Fisheries and Aquatic Sciences*, 54(1), 224–238. <https://doi.org/10.1139/f96-265>
- Zhu, H., & Pei, Z. (2015). Study on legislative countermeasures of fishing boat management in Liaoning province (in Chinese). *Ocean Development and Management*, 32(4), 59–65. Retrieved from [http://www.caoe.org.cn/%0Afile/File/14369 03533.pdf](http://www.caoe.org.cn/%0Afile/File/14369%203533.pdf)
- Zhu, L., & Huang, S. (2014). The impact of fishery fuel subsidy policy on fishery resources and policy suggestions (in Chinese). *Journal of Shanghai Ocean University*, 23(4), 618–622. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotals-SSDB201404020.htm>
- Zou, K. (2003). Sino-Japanese joint fishery management in the East China Sea. *Marine Policy*, 27(2), 125–142. [https://doi.org/10.1016/S0308-597X\(02\)00086-6](https://doi.org/10.1016/S0308-597X(02)00086-6)

Table 1. Seven categories of China's policies touched on its bottom trawling fisheries.

Policy category	Abbreviation	Description
International laws and agreements	IA	International laws that were ratified by China, and fishery agreements signed with neighboring countries.
Overarching policy	OP	Development strategy, development opinion or outline, comprehensive regulations and laws, Five-Year Plan.
Ban & protection	BP	Restrictions on the use of bottom trawl in terms of time and/or space, including summer moratorium, permanent ban on using bottom trawlers, no-trawl zone, protection area for important stocks.
Input control	IC	Regulations on fishing gears, vessels, and permits; controls on the number of vessels and horsepower; economic incentives to reduce fishing efforts/capacity.
Output control	OC	Regulations on catch, including juvenile catch regulations, catch quota, and minimum catchable size.
Law enforcement	LE	Instructions, campaigns, and special actions to enhance law enforcement.
Subsidy	SS	Regulations on subsidy (e.g., fuel subsidy) to support the growth of fisheries.

Table 2. Summary of the properties of the five policy eras from 1949 to 2018.

Property	1 st Era (1949-1977)	2 nd Era (1978-1992)	3 rd Era (1993-2002)	4 th Era (2003-2012)	5 th Era (2013-2018)
General features	Planned fishing with limited management	Regime shift with input control	EEZ management with multiple regulations	Resource conservation with fuel subsidy	Fisheries transformation towards sustainability with bans ahead
Pressures & drivers	Food scarcity; low fishing capacity; conflicts between motorized trawlers and small-scale fisheries in China; declines of spawning stocks in the northern waters	Economic development and reforms; BTF depletion in inshore waters; growing consumption demand for fishery products	Constrained accession to traditional fishing grounds; intensified biomass trawling and overcapacity in the EEZ; growing consumption demand for fishery products; globalization & competition	Pervasive illegal fishing gears & practices; fishers' livelihood security; growing domestic and global consumption demand for fishery products after joining WTO	Eco-civilization development; illegal fishing in both domestic and distant waters; growing consumption demand for seafood in China
Policy priority	Expanding fisheries exploitation towards offshore waters	Developing aquaculture, offshore and distant-water fishing; protecting inshore fishery resources	Accelerating the development of distant-water fisheries and aquaculture; constrain domestic fishing capacity and output	Resource conservation in inshore water; social equality; reducing fishing capacity and constrain output in domestic waters	Sustainable and healthy development through institutional and industrial reforms; law enforcement
Landmark	No-trawl zone 1955	Accelerating fisheries development 1985 (a.k.a., No. Five Central Document)	China 21st Century Agenda 1994	Outline of China's Actions for Conserving Aquatic Biological Resources 2006 (i.e., Outline 2006)	Opinions on Advancing Sustainable & Healthy Development of Marine Fisheries 2013 (i.e., Opinions 2013)
Management strategy	Mainly focusing on exploitation with passive and piecemeal conservation measures, mainly in the Bohai Sea, Yellow Sea, and East China	Establishing multilayers of fishery government organizations, issuing more and diverse policies to control the fishing capacity in inshore waters and	EEZ management with multiple restrictions upon fishing vessels (number & horsepower), fishing seasons, and output; exporting fishing capacity to distant waters	Conducting plans to reduce fishing capacity while securing fishers' livelihoods, and advance the development of aquaculture, distant-water fisheries, and fish	Enhancing law enforcement; several new bans on trawl and trawlers; reducing fuel subsidy; standardizing fishing vessels while gradually scrapping old

Property	1 st Era (1949-1977)	2 nd Era (1978-1992)	3 rd Era (1993-2002)	4 th Era (2003-2012)	5 th Era (2013-2018)
	Sea.	protect fishery stocks		processing industries	ones
International laws & agreements	<i>Sino-Japanese Fishery Agreement 1975</i>	None	UNCLOS ratification 1996; Sino-Japanese Fishery Agreement 2000; Sino-Korean Fishery Agreement 2001	Sino-Vietnamese Fishery Agreement 2004	None
Overarching policy	None	Economic reform 1978; fishery development policies; Fisheries Law 1986	Sustainable development agendas; EEZ Law 1996; Fisheries Law 2000; overall plan for distant-water fisheries (2001 – 2010)	Outline 2006 and its implementation rules; Five-Year Plans for Fisheries	Opinions 2013 and its implementation rules; Five-Year Plans for Fisheries
Ban & protection	No-trawl zone in the Bohai Sea, Yellow Sea, and East China Sea; stock protection regulations in Bohai Sea	Bottom-trawl bans in the Bohai Sea; summer moratoria; fishery conservation areas; stock protection regulations	Progressively extending summer moratoriums	Improving summer moratoria, improving stock protection regulations, and regulations for fishery conservation area	Extending summer moratoriums, ban on pair trawls using multiple codends, ban on construction or purchase of new trawlers in China's EEZ
Input control measures	None	Fishing vessel & permit regulations; single control (upon total horsepower); minimum mesh size standard	Revised fishing vessel & permit regulations; double control; vessel scrapping programs	Enhanced double control, Minimum-Mesh-Size regime; fishing vessel inspection regulations; fishing permit provisions	Revised fishing permit provisions, vessel-scrapping and standardization; continued double control; constraining the growth of distant-water vessels
Output control measures	None	Juvenile catch ratio 1980	Zero Growth 1999 & Negative Growth 2000	None	Total allowable catch; juvenile catch ratio

Property	1st Era (1949-1977)	2nd Era (1978-1992)	3rd Era (1993-2002)	4th Era (2003-2012)	5th Era (2013-2018)
Subsidy	None	None	None	Fuel subsidy 2006 & its related measures	Reducing fuel subsidy
Law enforcement	None	None	None	Prohibiting trawlers hiding gears to circumvent moratoria; special actions to combat illegal fishing and gears in summer moratoria	Implementing regulations especially on minimum mesh size and fishing gears; enhanced special actions to combat illegal fishing

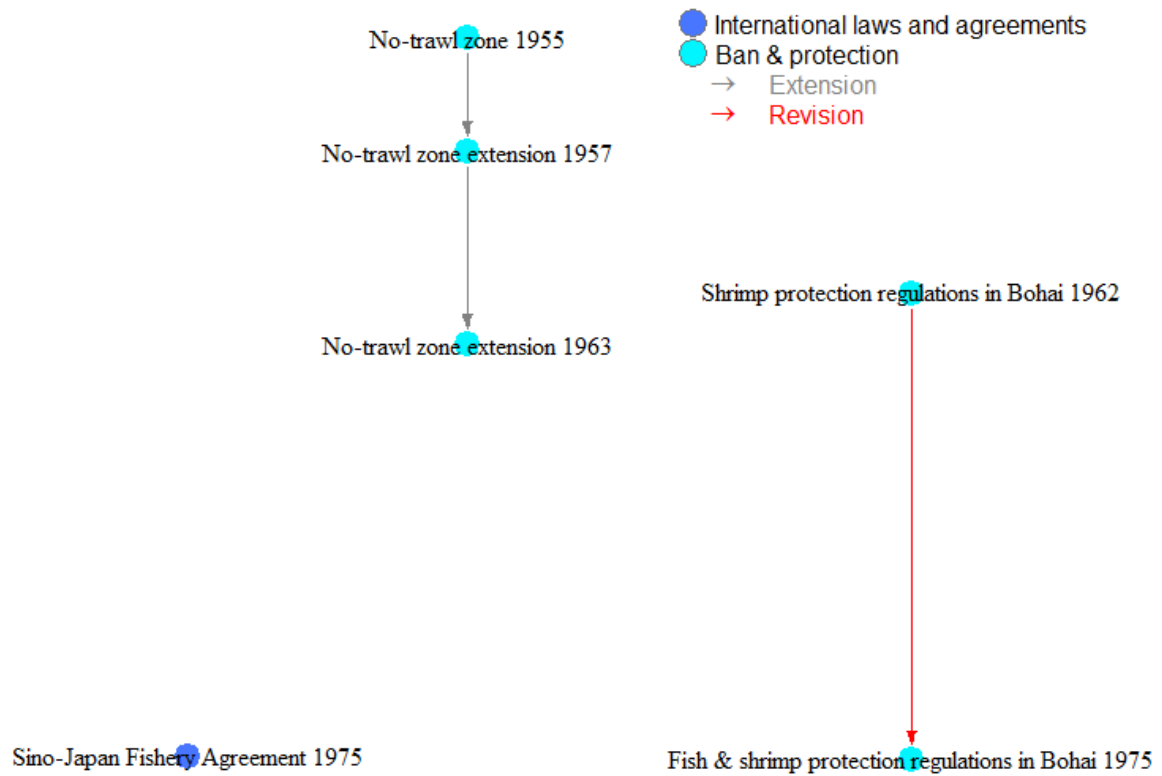


Figure 1. Network of policies on bottom trawling fisheries during the first era (1950 – 1977). Two types of links were depicted: extension, and revision. The policies were arranged with a rough top-down timeline (earliest policies on the top, more so within each category), and the different categories were lined up from the left to the right: international laws & agreements, and ban & protection.

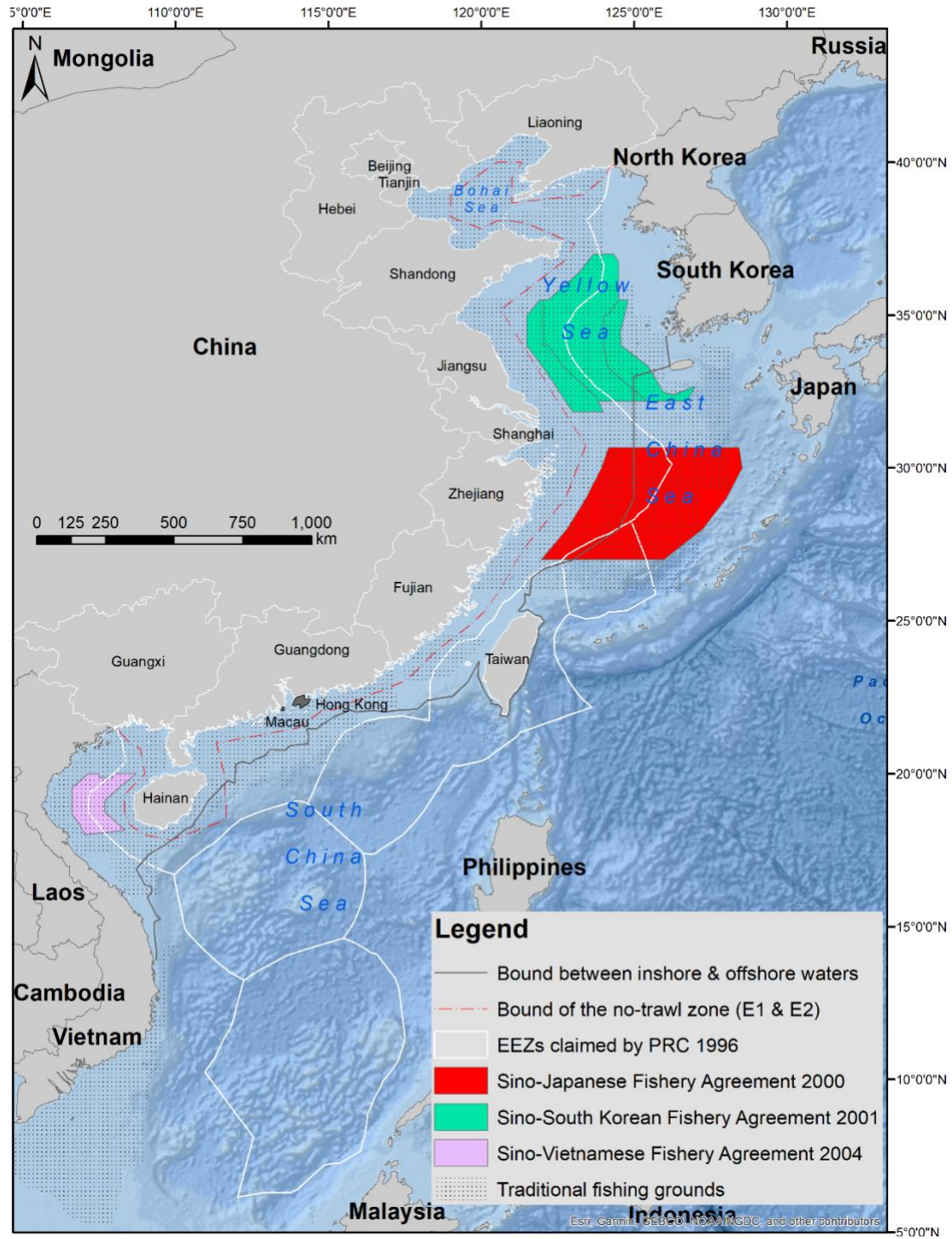


Figure 2. Map of China's coastal provinces and marine waters with illustrations of the no-trawl zone, its claimed EEZs, agreed zones under the bilateral fishery agreements with Japan, South Korea, and Viet Nam, and traditional fishing grounds for China's domestic bottom trawlers (based on data from Tang, 2012).

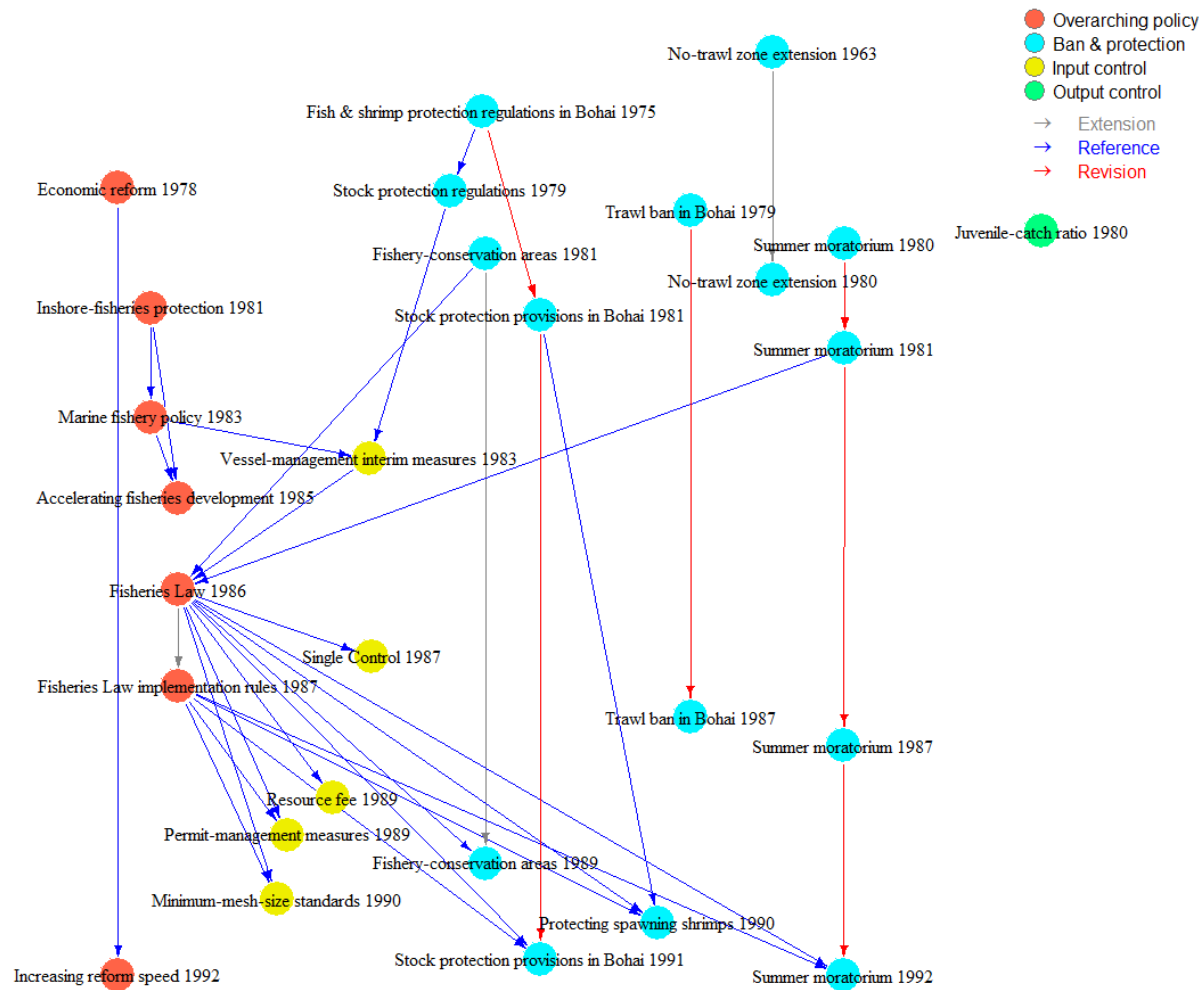


Figure 3. Network of policies touched on bottom trawling fisheries during the second era (1978 – 1992). Note that the two policies from previous era (no-trawl zone extension 1963, and fish & shrimp protection regulations in Bohai 1975) were embedded into the network to demonstrate the connections. Three types of links were depicted: extension, reference, and revision. The policies were arranged with a rough top-down timeline (earliest policies on the top, more so within each category), and the different categories were lined up from the left to the right: overarching policies, input control, ban & protection, and output control.

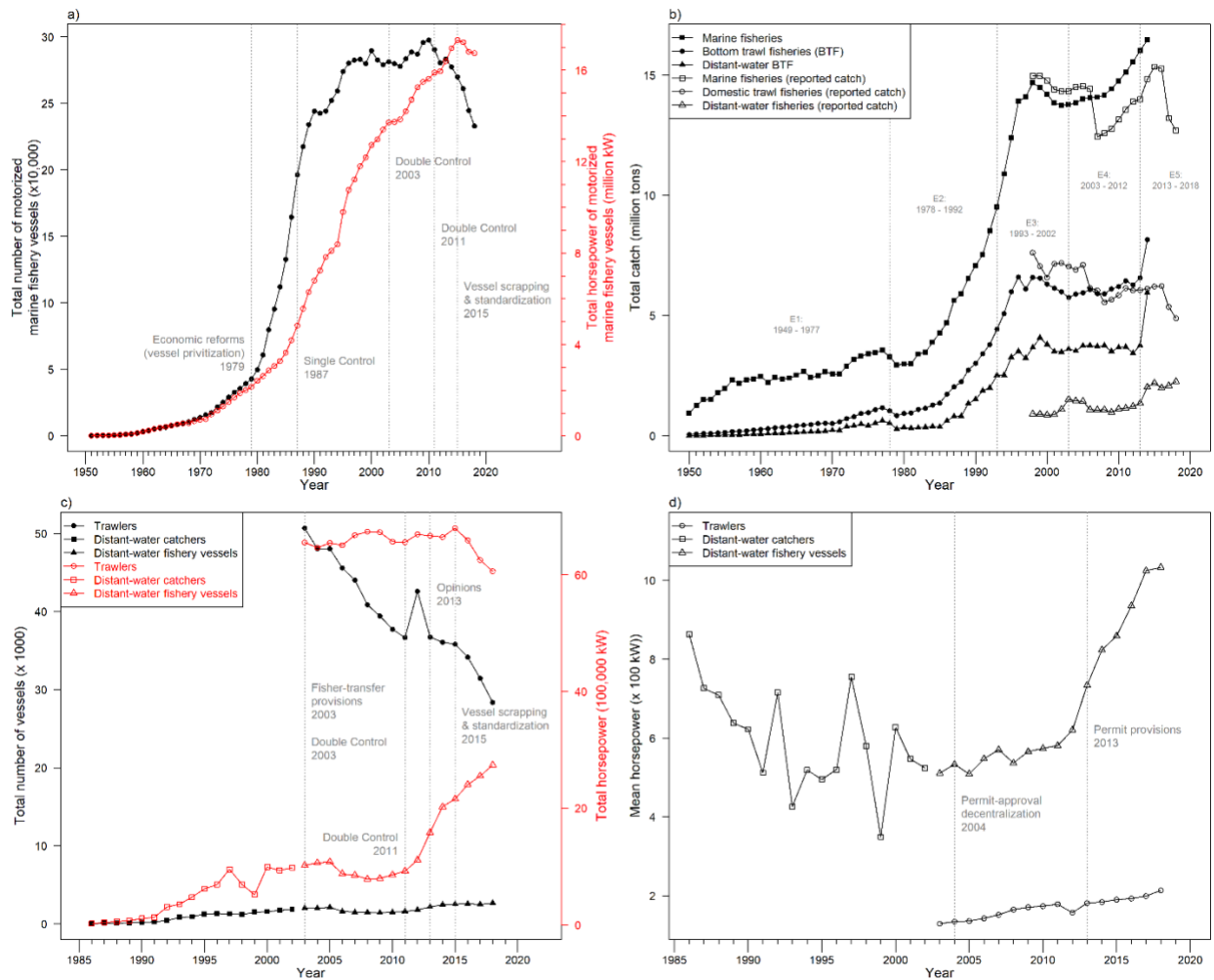


Figure 4. Timeseries plots of China's marine fishery inputs and outputs: a) total number and horsepower of motorized marine fishery vessels; b) total catches of marine fisheries, bottom trawl fisheries (BTF), distant-water BTF, reported catch of marine fisheries, reported catch of domestic trawl fisheries, and reported catch of distant-water fisheries; c) total number and horsepower of (motorized) trawlers (mostly bottom trawlers), distant-water catchers (mostly bottom trawlers, only available from 1985 to 2002), and distant-water fishery vessels (including fishing assistant vessels); and d) mean horsepower of (motorized) trawlers, distant-water catchers, and distant-water fishery vessels. Data sources: all the input data and the reported catches were from China Fishery Statistical Yearbooks (CFSY); other output data (i.e., total marine catch, total catch of BTF, and total distant-water BTF) were reconstructed estimates from Sea Around Us (www.seaaroundus.org) based on CFSY and estimates on unreported catches.

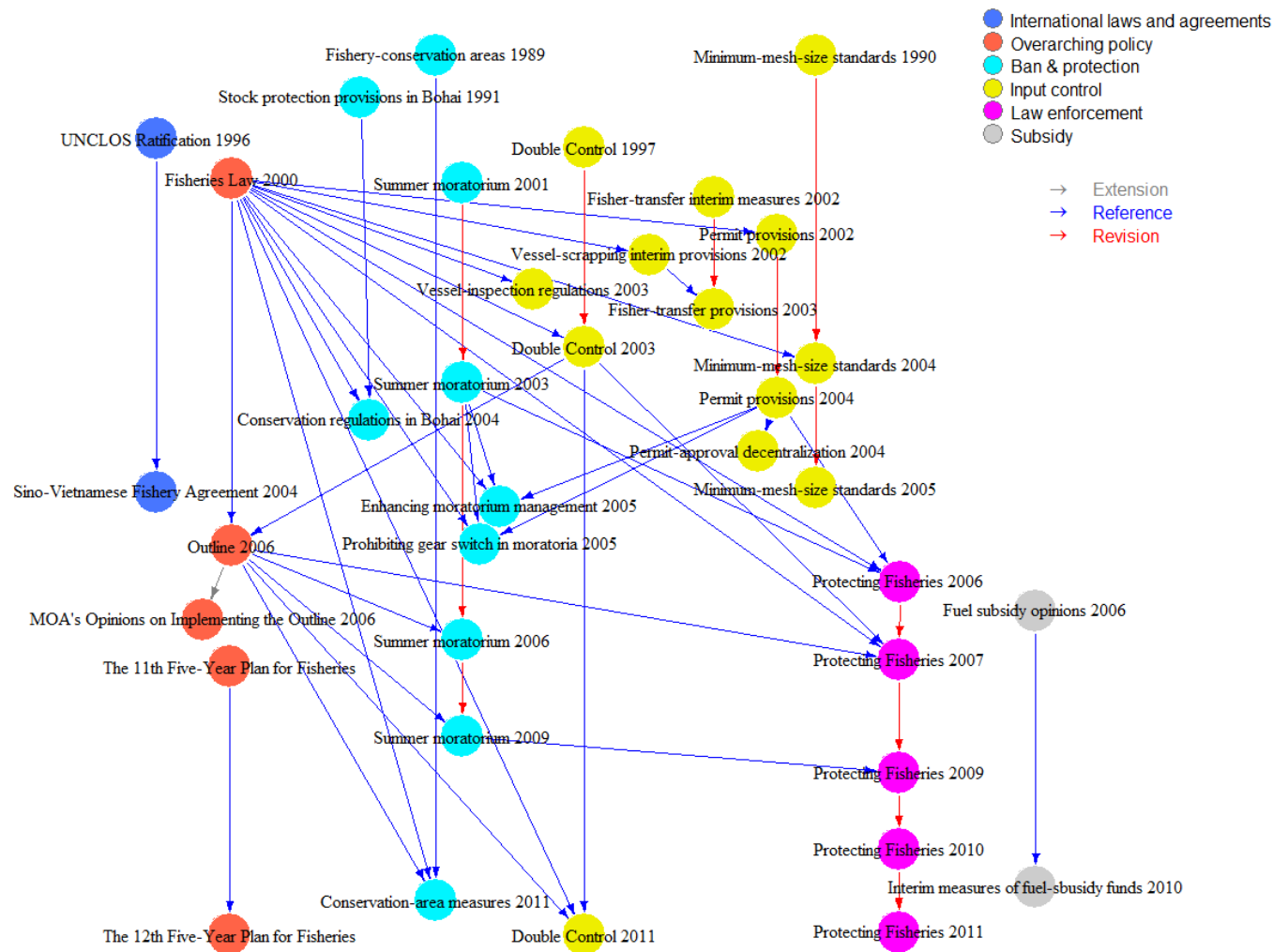


Figure 6. Network of policies touched on bottom trawling fisheries during the E4 (2003 – 2012). Note that the ten policies from previous era, e.g., Fisheries Law 2.0 (2000), were embedded into the network to demonstrate the connections. Three types of links were depicted: extension, reference, and revision. The policies were arranged with a rough top-down timeline (earliest policies on the top, more so within each category), and the different categories were lined up from the left to the right: international laws & agreements, overarching policies, ban & protection, input control, law enforcement, and subsidy.

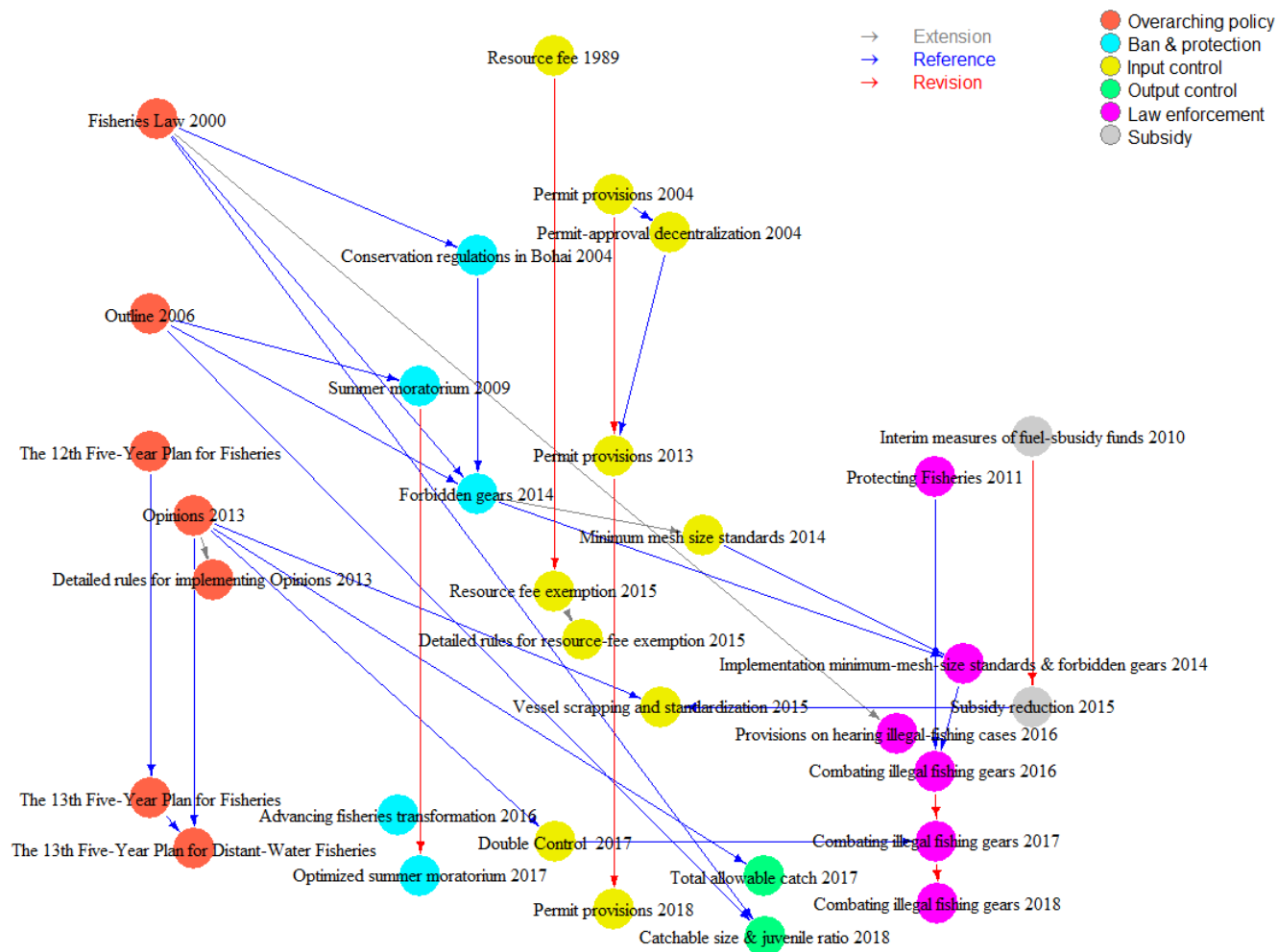


Figure 7. Network of policies touched on bottom trawling fisheries during the E5 (2012 – 2018). Note that the nine policies from previous era, e.g., Fisheries Law 2.0 (2000), were embedded into the network to demonstrate the connections. Three types of links were depicted: extension, reference, and revision. The policies were arranged with a rough top-down timeline (earliest policies on the top, more so within each category), and the different categories were lined up from the left to the right: overarching policies, ban & protection, input control, output control, law enforcement, and subsidy.

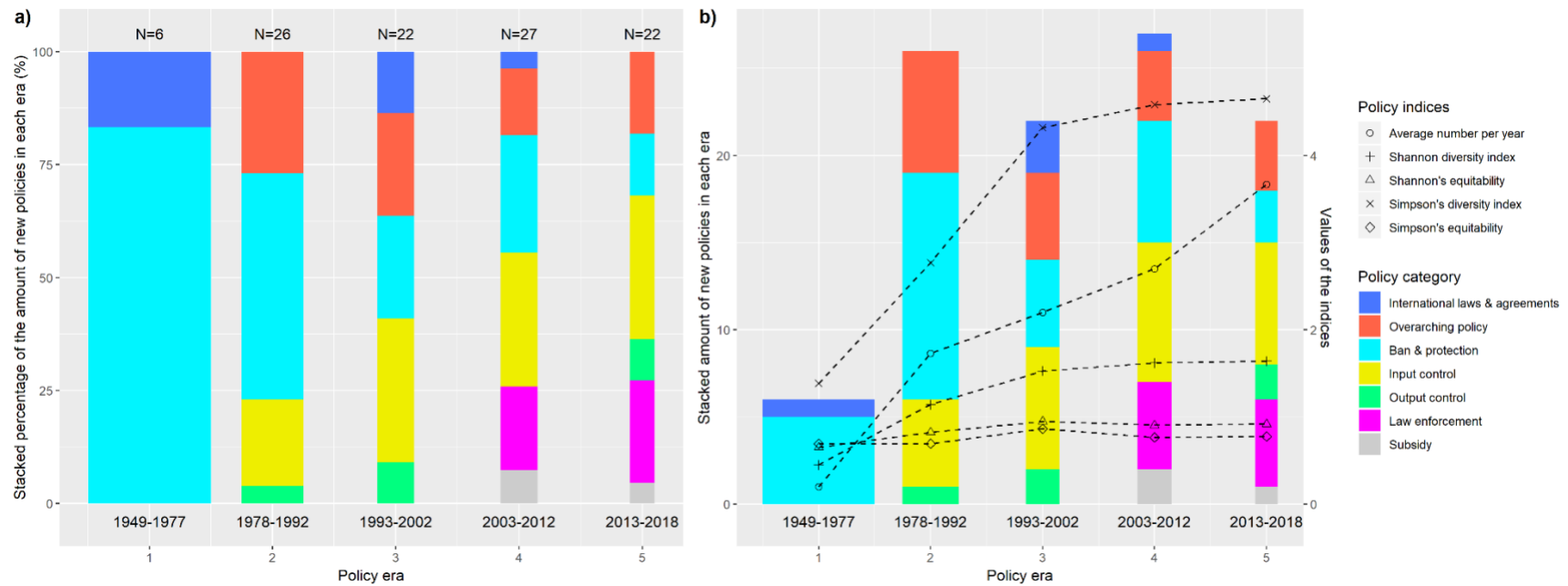


Figure 8. The evolution of China's policies across the five eras: a) stacked percentage of the amount of new policies in each era, and b) staked amount of new policies and values of the policy indices (diversity and evenness) in each era. The width of each bar is in scale with the length of each era.



Figure 9. Word clouds for China's policies on managing its bottom trawling fisheries in a) E1 (1949 – 1977), b) E2 (1978 – 1992), c) E3 (1993 – 2002), d) E4 (2003 – 2012), e) E5 (2013 – 2018), and f) all eras. Abbreviation: ntz, no-trawl zone.

Appendix S1. Supplementary Information for Methods

This appendix contains the following supporting information for the manuscript: 1) Tables S1.1 – S1.3, 2) structural changes of China's fisheries management bodies (including Figure S1.1), and 3) references cited.

Table S1.1 Terminology of the title of legal documents issued by the National People's Congress, State Council and its departments.

Chinese	English term	Level
法	Law	National People's Congress
五年规划	Five-Year Plan	State Council and its departments
纲要/议程	Outline/Agenda	State Council and National Congress of the Party
命令	Order	State Council and its departments
条例	Regulation	State Council and its departments
实施细则	Detailed Rules & Regulations	State Council and its departments
规定	Provision	State Council and its departments
办法	Measure	State Council and its departments
暂行条例	Interim Regulation	State Council and its departments
暂行规定	Interim Provision	State Council and its departments
暂行办法	Interim Measure	State Council and its departments

Table S1.2 Terminology of the title of regulatory documents issued by the State Council and its departments.

Chinese	English term	Level
通知/通告	Circular	State Council and its departments
决定	Decision	State Council and its departments
意见	Opinion	State Council and its departments
指示	Instruction	State Council and its departments
批准	Approval	State Council and its departments

Table S1.3. Definition of inshore, offshore, and distant waters in China, obtained from (Hongzhou Zhang & Wu, 2017).

Term	Definition
Inshore water	the Bohai, Yellow Sea, the area within N33, E125; N29, E125; N28, E124.5; N27, E123 in the East China Sea, and the area east to E112 within 80-meter isobath and west to E112 within 100-meter isobath in the South China Sea.
Offshore water	the water outside of the N33, E125; N29, E125; N28, E124.5; N27, E123 in the East China Sea (including the waters near Diaoyu/Senkaku islands) and the area east to E112 beyond 80-meter isobath and west to E112 beyond 100-meter isobath in the South China Sea.
distant water	the high seas and in the sea areas under the jurisdiction of other countries, excluding fishing activities in the Yellow Sea, the East China Sea, or the South China Sea.

Structural changes of China's fisheries management bodies

We here described the changes of China's fisheries authorities over past seven decades (1949 – 2018; Figure S1.1). To make it consistent with our narrative of the policy history, we adopted the five-era framework to do so.

Era 1 (1949 – 1977)

The authority for fisheries management was changed/renamed many times because of government reforms and political concerns (Tang, 2008; Zhang, 2018; Zhou & Li, 2009). Here we only demonstrate the main thread (Figure S1.1) for the ease of narrative, and one can find more miscellaneous and short periods of changes in Zhou & Li (2009). These authorities were:

(1) the Bureau of Fisheries Management (Jan. 1953 – May 1956, level II) of the Ministry of Agriculture (MOA, level I),

(2) the Ministry of Aquatic Products (May 1956 – May 1970, level I),

(3) the Ministry of Agriculture and Forestry (May 1970 – Mar. 1978, level I).

Additionally, three regional Commands of Marine Fisheries Exploitation were established, each in a separate marine zone (Agriculture, 2009): Yellow and Bohai Sea (in 1958), East China Sea (in 1959), and South China Sea (in 1974). The major responsibility of these Commands was to guide local fishing activities, secure operating safety, and protect Chinese fishers' rights in China's seas (Tang, 2008). In E1, fisheries policies were piecemeal and scattered, and fisheries management was in its infancy with inadequate budget and personnel, for three reasons (He 2015). First, fisheries only contributed a marginal proportion to China's agriculture production (Lin 1992). Second, like many other governmental functions, fisheries management was temporally paralyzed during the Culture Revolution and other disturbances (Xiao & Li, 2007). Third, during the administration of the Ministry of Agriculture and Forestry, the central government's agency for fisheries was degraded to a lower level of office and its function was thus reduced (Tang, 2008; Zhou & Li, 2009).

Era 2 (1978 – 1992)

There were several transitions of government organizations for fisheries management (Tang, 2008; Zhang, 2018; Figure S1.1). From March 1978 to May 1982, China's fisheries were administrated by the newly established State Bureau of Aquatic Products (SBAP, level I; Tang, 2008), which was under the supervision of the Ministry of Agriculture (MOA). In 1978, the SBAP established the affiliated Bureau of Fisheries and Fishing Port Surveillance (BFFP, level II) and started to take charge of the regional Commands of Fisheries Exploitation (level II) in the three marine zones (Bohai and Yellow Sea, East China Sea, and South China Sea; Tang, 2008). The establishment and supervision of these authorities marked the founding of present fisheries management system in China. In May 1982, SBAP, MOA, and the Ministry of Reclamation were united to be the Ministry of Agriculture, Pastoral, and Fisheries (MAPF), which was renamed back to the Ministry of Agriculture (MOA) in 1988 (Tang, 2008; Zhang, 2018). The fisheries authority was split into two parallel bureaus (level II) under the administration of MAPF (1982 –

1988) and then MOA (1988 – 1992): Bureau of Aquatic Product, and Bureau of Fisheries and Fishing Port Surveillance (BFFP; Tang, 2008). Accordingly, the original Commands of Fisheries Exploitation became the three Branches of Fisheries Management (BFMs, level III) affiliated to MAPF in 1983 (and MOA later; Tang, 2008). The responsibilities of these BFMs were also changed from guiding fishing activities and protecting Chinese fishers' lives, rights, and property to broader fisheries management including fishery resource protection (Tang, 2008). The Fisheries Law enacted in 1986 stipulated that local government (county and above levels) should set up fisheries management organizations in critical fisheries waters and fishing ports. Since ~ 1988, local fisheries authorities have been established in China's maritime provinces (Tang, 2008).

China's marine fishery-governance system then came to be full-fledged with 'two wings': one wing was the BFFP and its regional BFMs, and the other wing was the local fishery bureaus established by local governments. The responsibilities of these different levels of governments were divided by resource zones, fishing areas, and fleet sectors, and were well documented by Wang and Zhan (1992). The central fishery government provided guidelines and regulations to local fishery governments in terms of fisheries management, development, and conservation; but the local councils and government leaders were the true superior to local fisheries governments. This was a main loophole in China's fishery governance system that resulted on policy implementation failures (Yu and Yu 2008, and see more in discussion).

Era 3 (1993 – 2002)

China's administrative system of fisheries was adapted to the new era (Tang, 2008; Figure S1.1). The Chinese government recognized the need to enhance marine fisheries management facing the challenges in implementing an EEZ regime and bilateral fisheries agreements. In June 1994, MOA integrated the Bureau of Aquatic Products (level II) and the Bureau of Fishing

Port Surveillance (level II) into the Bureau of Fisheries and Fishing Port Surveillance (level II, Tang, 2008). Accordingly, in June 1995, MOA granted the authority of fishing port surveillance and fisheries safety management to its three regional Bureaus of Fisheries Management and renamed them as the Bureau of Fisheries and Fishing Port Surveillance of each marine zone (level III; Tang, 2008). In May 2000, the State Council approved MOA to establish the Command Center of Fisheries (level II), as a unified leadership to take in charge of law enforcement in fisheries and safeguarding China's marine rights and interests (Tang, 2008).

Era 4 (2003 – 2012)

The fishery administration organizations only had minor changes (Figure S1.1). In 2008, the State Council approved the renaming of MOA's organisations (Zhou & Li, 2009). The Bureau of Fisheries and Fishing Port Surveillance (for short: Fisheries Bureau) was renamed as Bureau of Fisheries (and kept the abbreviated title: Fisheries Bureau). The three regional Bureaus of Fisheries and Fishing Port Surveillance were also renamed in the same way. It was learned that the purpose was to simplify the title and strengthen the responsibilities of protecting aquatic biological resources and environments and safeguarding national fishery rights.

Era 5 (2013 – 2018)

The fishery authorities supervised by MOA were reconstructed following the government organization reform initiated by President Xi in 2013 (Figure S1.1). This reform aimed to reduce the number of organizations affiliated to the State Council and improve administrative efficiency. In March 2018, the First meeting of the 13th Session of the National People's Congress approved the Reform Program of the State Council. This reform program allocated the power of fishing vessel examination and supervision from MOA to the Ministry of Transport; it also reconstructed MOA into the current Ministry of Agriculture and Rural Affairs. Correspondingly,

the original authority of the regional Fisheries Bureaus in the three marine zones was also reduced in terms of fishing vessel examination and supervision.

References cited

- Agriculture. (2009, July 15). China's fishery administration continues - Written on the occasion of the establishment of the fishery administration (in Chinese). *Agriculture*. Retrieved from <http://www.agronet.com.cn/News/337538.html>
- Tang, Y. (2008). The establishment and development of the fishery administrations - MOA established the Command Center of Fisheries in May 2000 (in Chinese). In *Three Decades of China's Fishery Reform*. Retrieved from <http://cpfd.cnki.com.cn/Article/CPFDTOTAL-ZYYE200810002018.htm>
- Xiao, L., & Li, Z. (2007). Shouldering the mission and safeguarding fisheries development in China - interview with the previous chief economic manager and previous director of fisheries bureaus Zho Youzhan (in Chinese). *China Fisheries*, (11), 4–7. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotal-SICA200711003.htm>
- Zhang, Heng. (2018, March 1). New wave new start: Years of institutional reform - MOA was established in 1949, through twice of dismantlement and consolidation (in Chinese). *Economic Observer*. Retrieved from <http://www.eeo.com.cn/2018/0301/323410.shtml>
- Zhang, Hongzhou, & Wu, F. (2017). China's marine fishery and global ocean governance. *Global Policy*, 8(2), 216–226. <https://doi.org/10.1111/1758-5899.12419>
- Zhou, X., & Li, M. (2009). Review on China's fisheries over past six decades. *China Fisheries*, (10), 5. Retrieved from www.cnki.com.cn/Article/CJFDTotal-SICA200910005.htm%0D

Appendix S2 Supplementary Information for Results

This appendix contains the following supplementary information for Results: 1) Tables S2.1 – S2.4; 2) Figures S2.1 - S2.10; 3) Detailed narrative of the evolution of policies touched on China's bottom-trawl fisheries (BTF); and 4) references cited in the appendix.

Table S2.1. Inventory of 103 policies touched on China's bottom trawling fisheries. NTZ, no-trawl zone; MOA, ministry of Agriculture.

Code	Effective Date (Month/Day/Year)	Policy	Level	Importance	Successfully implemented or not?	Website or reference
E1-BP-1	5/8/1955	<i>NTZ 1955</i>	State	First law for trawl restriction	may succeeded before ~1979, but failed later	http://www.pkulaw.cn
E1-BP-2	7/26/1957	<i>NTZ extension 1957</i>	State	First extension of NTZ	may succeeded before ~1979, but failed later	http://www.pkulaw.cn
E1-BP-3	7/1/1962	<i>Shrimp protection regulations in Bohai 1962</i>	State	First law that provided clear regulations on mesh size, fishing closure time and area	may succeeded before ~1979, but failed later	(Sun et al., 2011; Tang et al., 2012)
E1-BP-4	10/1/1963	<i>NTZ extension 1963</i>	State		may succeeded before ~1979, but failed later	http://www.pkulaw.cn
E1-BP-5	1/1/1975	<i>Fish & shrimp protection regulations in Bohai 1975</i>	Ministry	First law for protecting multiple fish stocks although it is only for Bohai Sea	unknown	http://www.cnki.com.cn/Article/CJFDTot-TJSC1975Z1001.htm
E1-IA-1	12/22/1975	<i>Sino-Japanese Fishery Agreement 1975</i>	State	Initiative in moratorium seasons and conservation zones	No	http://www.chinabaike.com/law/gj/1379610.html
E2-OP-1	12/13/1978	<i>Economic reform 1978</i>	State	Historical shift in Chinese economic development	Yes	http://www.aisixiang.com/data/3398.html
E2-BP-1	2/10/1979	<i>Stock protection regulations 1979</i>	State	First law for nationwide 1) protection of fishery stocks, 2) demand for fishing permit, and 3) restrictions on mesh size and operation time of bottom trawlers	No	http://jiuban.moa.gov.cn
E2-BP-2	12/24/1979	<i>Trawl ban in Bohai 1979</i>	Ministry	First regulation for bottom-trawl ban	No	http://www.110.com

Code	Effective Date (Month/Day/Year)	Policy	Level	Importance	Successfully implemented or not?	Website or reference
E2-BP-3	1/1/1980	<i>Summer moratorium 1980</i>	Ministry	First regulation for summer moratorium and catch ratio of juvenile fish	No	(Tang et al., 2012)
E2-BP-4	1/1/1980	<i>NTZ extension 1980</i>	State	Extending NTZ to Fujian and SCS	No	(Zhu, 2009)
E2-OC-1	1/1/1980	<i>Juvenile-catch ratio 1980</i>	Ministry	First regulation for summer moratorium and catch ratio of juvenile fish	No	(Tang et al., 2012)
E2-BP-5	1/1/1981	<i>Stock protection provisions in Bohai 1981</i>	Ministry	Appended law for protecting fish stocks targeted by bottom trawlers in BS	No	http://jiuban.moa.gov.cn
E2-BP-6	4/1/1981	<i>Summer moratorium 1981</i>	Ministry	First law for summer moratorium	No	http://www.110.com
E2-BP-7	4/22/1981	<i>Fishery-conservation areas 1981</i>	State	First protection areas for protecting juvenile fishes from bottom trawlers	No	http://www.pkulaw.cn
E2-OP-2	5/4/1981	<i>Inshore-fisheries protection 1981</i>	State	Fishing offshore and aquaculture became the focus, and restated NTZ	Yes	http://www.gov.cn
E2-OP-3	9/1/1983	<i>Marine fishery policy 1983</i>	State	Demand developing fishery laws and regulations, enhancing management, protecting inshore fishery stocks, developing aquaculture, offshore and DW fishing	Yes	http://www.gov.cn
E2-IC-1	10/31/1983	<i>Vessel-management interim measures 1983</i>	Ministry	First law for implementing fishing permit, constraining license and update of inshore trawlers	No	http://www.law-lib.com
E2-OP-4	3/11/1985	<i>Accelerating fisheries development 1985</i>	State	Shifting focus to aquaculture and encourage distant-water fishing	Yes	http://www.gov.cn
E2-OP-5	7/1/1986	<i>Fisheries Law 1986</i>	State	First comprehensive law for fisheries management, confirming the regime of fishing permit, NTZ, and summer moratorium	No	http://www.npc.gov.cn

Code	Effective Date (Month/Day/Year)	Policy	Level	Importance	Successfully implemented or not?	Website or reference
E2-BP-8	5/1/1987	<i>Trawl ban in Bohai 1987</i>	Ministry	Second attempt of bottom-trawl ban in Bohai Sea by 1988	No	http://www.cnki.com.cn/Article/CJFDTot-SICA198705000.htm
E2-BP-9	5/1/1987	<i>Summer moratorium 1987</i>	Ministry	Summer moratorium in all seas except SCS	No	http://www.cnki.com.cn/Article/CJFDTot-SICA198705000.htm
E2-IC-2	5/1/1987	<i>Single Control 1987</i>	Ministry	First attempt to control fishing capacity (total number of vessels & engine power)	No	http://www.cnki.com.cn/Article/CJFDTot-SICA198705000.htm
E2-OP-6	10/14/1987	<i>Fisheries Law implementation rules 1987</i>	Ministry	First DRR for implementing the Law ; tightening license issuing to inshore large trawlers	No	http://jiuban.moa.gov.cn
E2-IC-3	1/1/1989	<i>Resource fee 1989</i>	State	First attempt to reduce fishing effort by collecting fishery resource fees	No	http://www.pkulaw.cn
E2-BP-10	5/1/1989	<i>Fishery-conservation areas 1989</i>	State	First protection areas for protecting spawning stocks targeted by bottom trawlers	No	http://www.cnki.com.cn/Article/CJFDTot-SICA198807014.htm
E2-IC-4	5/1/1989	<i>Permit-management measures 1989</i>	Ministry	Providing detailed rules for fishing permit policy	No	http://www.110.com
E2-IC-5	7/1/1990	<i>Minimum-mesh-size standards 1990</i>	State	First national standards for minimum mesh size for trawl nets	No	http://www.zbgf.org ; http://www.csres.com
E2-BP-11	11/8/1990	<i>Protecting spawning shrimps 1990</i>	Ministry	Providing regulations to protect spawning shrimps from trawlers	No	http://www.110.com
E2-BP-12	4/13/1991	<i>Stock protection provisions in Bohai 1991</i>	Ministry	Reinstate the bottom-trawl ban in Bohai Sea	No	http://jiuban.moa.gov.cn
E2-BP-13	1/1/1992	<i>Summer moratorium 1992</i>	Ministry	Summer moratorium in all seas except SCS; the length was cut down	No	http://wemedia.ifeng.com
E2-OP-7	1/18/1992	<i>Increasing reform speed 1992</i>	State		Yes	(Zhao, 1993)
E3-OP-1	3/25/1994	<i>China 21st Century Agenda 1994</i>	State	Provide overall strategic goals and measures for sustainable development in the 21st century	unknown	(Shijun, 1993)

Code	Effective Date (Month/Day/Year)	Policy	Level	Importance	Successfully implemented or not?	Website or reference
E3-BP-1	2/7/1995	<i>Summer moratorium 1995</i>	State	Flagging that summer moratorium became a national policy	Yes, but not so effective	http://www.law-lib.com
E3-IC-1	1/22/1996	<i>Vessel registration measures 1996</i>	Ministry	First measures for vessel registration	No	http://jiuban.moa.gov.cn
E3-OP-2	4/1/1996	<i>China 21st Century Ocean Agenda 1996</i>	Ministry	Provide overall strategic targets and general policies for sustainable fishery development in the 21st century	unknown	(SOA, 1996)
E3-IA-1	5/15/1996	<i>UNCLOS Ratification 1996</i>	State	Flagging the fishery management with an EEZ regime	Yes	http://www.gov.cn
E3-IC-2	4/28/1997	<i>Double Control 1997</i>	State	First double control policy	No	http://210.73.66.144:4601/law?fn=chl155s042.txt&truetag=1883&title=&contents=&dbt=chl
E3-IC-4	12/25/1997	<i>Permit management measures 1997</i>	Ministry	Enhancing the management of illegal vessels and fishing	No	https://www.lawxp.com
E3-IC-3	12/25/1997	<i>Vessel registration measures 1997</i>	Ministry	Enhancing the management of illegal vessels and fishing	No	http://jiuban.moa.gov.cn
E3-BP-2	4/2/1998	<i>Summer moratorium 1998</i>	Ministry	Enhancing fisheries conservation	Yes, but not so effective	http://jiuban.moa.gov.cn
E3-OP-3	6/26/1998	<i>EEZ Law 1998</i>	State	Enhancing EEZ management	Yes	http://www.un.org/depts/los/LEGISLATIONANDTREATIES/PDFFILES/chn_1998_eez_act.pdf
E3-BP-3	1/1/1999	<i>Summer moratorium 1999</i>	Ministry	Starting summer moratorium in all seas in China	Yes, but not so effective	http://jiuban.moa.gov.cn
E3-OC-1	1/1/1999	<i>Zero Growth 1999</i>	Ministry	Shifting focus from growth to sustainability	unknown	http://news.sina.com.cn
E3-BP-4	1/1/2000	<i>Summer moratorium 2000</i>	Ministry	Extending moratorium's time and space; exempting beam trawl from moratorium gears in YS and ECS	Yes, but not so effective	(Chen & Teligenbaiyi, 2010)
E3-OC-2	1/1/2000	<i>Negative Growth 2000</i>	Ministry	Moving further towards sustainability	unknown	http://www.people.com.cn

Code	Effective Date (Month/Day/Year)	Policy	Level	Importance	Successfully implemented or not?	Website or reference
E3-IA-2	6/1/2000	<i>Sino-Japanese Fishery Agreement 2000</i>	Ministry	Shrinking fishing grounds in ECS; first NGO agreement on fishing activities in dispute waters	Yes	(Xue, 2004)
E3-OP-4	12/1/2000	<i>Fisheries Law 2000</i>	State	Adding in regime of catch quota and minimum mesh size; adding regulations regarding to EEZ management	No	https://www.lawxp.com
E3-BP-5	1/1/2001	<i>Summer moratorium 2001</i>	Ministry	Revising area-time regulations to simplify management	Yes, but not so effective	(Chen & Teligenbaiyi, 2010)
E3-IA-3	6/3/2001	<i>Sino-South Korean Fishery Agreement 2001</i>	Ministry	Shrinking fishing grounds in YS	Yes	(Xue, 2004)
E3-OP-5	10/20/2001	<i>Distant-water fisheries plan (2001 - 2010)</i>	State	Supporting distant-water fisheries and providing development plans for the next decade	Yes	http://www.gov.cn
E3-IC-5	6/23/2002	<i>Vessel-scrapping interim provisions 2002</i>	Ministry	Providing temporal regulations to guide vessel scrapping	unknown	http://www.pkulaw.cn
E3-IC-6	7/30/2002	<i>Fisher-transfer interim measures 2002</i>	Ministry	Providing temporal regulations to guide the use of financial budget for fisher transfer and fishing transition	unknown	http://www.chinalawedu.com
E3-IC-7	12/1/2002	<i>Permit provisions 2002</i>	Ministry	Trawlers cannot operate other gears and other vessels cannot transform to trawlers; restricting construction and permit issuing for large trawlers; catch quota for several stocks (not implemented?)	No	http://www.gov.cn
E4-BP-1	1/1/2003	<i>Summer moratorium 2003</i>	Ministry	Requiring beam trawlers to be closed for one month (12 pm June 16 to 12 pm July 16)	unknown	http://news.sohu.com/77/56/news209105677.shtml
E4-IC-1	8/1/2003	<i>Vessel-inspection regulations 2003</i>	State	First regulations for fishing vessel inspection; endowing more power (e.g., gear/vessel confiscation) to law-enforcement officers to combat illegal vessels and fishing activities	No	http://www.gov.cn

Code	Effective Date (Month/Day/Year)	Policy	Level	Importance	Successfully implemented or not?	Website or reference
E4-IC-2	9/18/2003	<i>Fisher-transfer provisions 2003</i>	Ministry	Focusing on destructive fishing vessels including bottom trawlers	Yes, but not so effective	http://www.yyj.moa.gov.cn
E4-IC-3	11/12/2003	<i>Double Control 2003</i>	Ministry	Shifting from control to reduction; constrain the development of bottom trawlers in distant-water fisheries	Yes, but not so effective	http://www.yyj.moa.gov.cn
E4-BP-2	5/1/2004	<i>Conservation regulations in Bohai 2004</i>	Ministry	Prohibiting bottom trawling in Bohai, and broadening the focus from important fisheries resources to all marine organisms in fishery management	unknown	http://www.yyj.moa.gov.cn
E4-IA-1	6/30/2004	<i>Sino-Vietnamese Fishery Agreement 2004</i>	State	Shrinking fishing grounds in Beibu Gulf of SCS; first intergovernmental agreement	Yes	(Zou, 2005)
E4-IC-4	7/1/2004	<i>Permit provisions 2004</i>	Ministry	Facilitating the permit approval for large trawlers	Yes, but bad	http://www.law-lib.com
E4-IC-5	7/1/2004	<i>Minimum-mesh-size standards 2004</i>	Ministry	First time of labeling bottom trawlers as temporal gears; prohibiting inner net of cod-end in trawlers	No	http://www.pkulaw.cn ; www.doc88.com
E4-IC-6	7/20/2004	<i>Permit-approval decentralization 2004</i>	Ministry	Facilitating the permit approval for large trawlers	Yes, but bad	http://bjlawhyzx.com/falvfagui/f_g22016/42800.shtml
E4-BP-3	7/4/2005	<i>Prohibiting gear switch in moratoria 2005</i>	Ministry	Combating against overfishing and illegal vessels	unknown	http://www.moa.gov.cn
E4-BP-4	7/20/2005	<i>Enhancing moratorium management 2005</i>	Ministry	Combating against overfishing and illegal fishing	unknown	http://www.yyj.moa.gov.cn
E4-IC-7	8/3/2005	<i>Minimum-mesh-size standards 2005</i>	State	Increasing MMS and prohibiting double-layer trawls	No	https://doc.mbalib.com/view/3157147b2f3a4d82cc7c2e80cb7265fe.html
E4-OP-1	2/14/2006	<i>Outline 2006</i>	State	Providing strategic agenda for fisheries resource conservation; setting up vessel scrapping target by 2010	unknown	http://www.gov.cn

Code	Effective Date (Month/Day/Year)	Policy	Level	Importance	Successfully implemented or not?	Website or reference
E4-LE-1	4/17/2006	<i>Protecting Fisheries 2006</i>	Ministry	First time of conducting law enforcement patrolling during the summer moratorium (which continued each year since then)	unknown, and might be limited	http://www.moa.gov.cn
E4-BP-5	5/1/2006	<i>Summer moratorium 2006</i>	Ministry	Extending moratorium time for beam trawlers by one month	unknown	http://www.yyj.moa.gov.cn
E4-OP-2	5/15/2006	<i>MOA's Opinions on Implementing the Outline 2006</i>	Ministry	Highlight the priority of reducing trawlers in vessel scrapping target	unknown	http://www.yyj.moa.gov.cn
E4-SS-1	5/30/2006	<i>Fuel subsidy opinions 2006</i>	State	Providing fuel subsidy to fishing vessels including bottom trawlers	Yes, but bad	http://www.yyj.moa.gov.cn
E4-OP-3	11/7/2006	<i>The 11th Five-Year Plan for Fisheries</i>	Ministry	First time of publishing Five-Year Plan for fisheries; enhancing fishery resource protection through protecting juvenile fish and encouraging the use of selective gears; encouraging the development of distant-water fisheries and reducing the use of bottom trawlers	unknown	http://jiuban.moa.gov.cn
E4-LE-2	3/27/2007	<i>Protecting Fisheries 2007</i>	Ministry	Combating trawlers using electrical-pulse generator	unknown, and might be limited	http://www.moa.gov.cn
E4-LE-3	3/23/2009	<i>Protecting Fisheries 2009</i>	Ministry	Implementing the upgraded moratorium regime	unknown, and might be limited	https://code.fabao365.com/law_69589.html
E4-BP-6	5/1/2009	<i>Summer moratorium 2009</i>	Ministry	Extending moratorium by starting it half month early	unknown	(Chen & Teligenbaiyi, 2010)
E4-SS-2	1/1/2010	<i>Interim measures of fuel-subsidy funds 2010</i>	Ministry	Requiring a minimum of three-month fishing per year (domestic vessels only) to apply for fuel subsidy; no such an operation requirement for distant-water fishing vessels	Yes, but bad	http://www.gov.cn/gongbao/content/2010/content_1629134.htm
E4-LE-4	2/5/2010	<i>Protecting Fisheries 2010</i>	Ministry	Prioritizing the effort on examining and correcting identifiers	unknown, and might be limited	https://code.fabao365.com/law_472660.html

Code	Effective Date (Month/Day/Year)	Policy	Level	Importance	Successfully implemented or not?	Website or reference
E4-BP-7	3/1/2011	<i>Conservation-area measures 2011</i>	Ministry	First law for establishing, reviewing, and managing fishery-resource protection areas	unknown	http://www.gov.cn/gzdt/2011-01/10/content_1781549.htm
E4-IC-8	3/11/2011	<i>Double Control 2011</i>	Ministry	Continuing to reduce fishing capacity of bottom trawlers in domestic waters	No	http://www.yyj.moa.gov.cn
E4-LE-5	4/2/2011	<i>Protecting Fisheries 2011</i>	Ministry	Combating against maritime violence against law	unknown, and might be limited	www.pkulaw.cn
E4-OP-4	10/17/2011	<i>The 12th Five-Year Plan for Fisheries</i>	Ministry	Continuing to reduce fishing capacity; further supporting distant-water fisheries	unknown	http://jiuban.moa.gov.cn
E5-IC-1	1/1/2013	<i>Permit provisions 2013</i>	Ministry	Decentralization of approving fishing permit for large vessels at the provincial level.	Yes, but bad	http://jiuban.moa.gov.cn
E5-OP-1	3/8/2013	<i>Opinions 2013</i>	State	Releasing burden on fishers; remaining the focus on aquaculture; strictly reducing destructive gears such as bottom trawlers; advancing fisher transfer	unknown	http://www.gov.cn
E5-OP-2	7/5/2013	<i>Detailed rules for implementing Opinions 2013</i>	Ministry	Promoting the implementation and stimulating transformation and modernization of marine fisheries	unknown	http://www.yyj.moa.gov.cn
E5-BP-1	1/1/2014	<i>Forbidden gears 2014</i>	Ministry	Signaling new bans on trawlers	unknown	http://jiuban.moa.gov.cn
E5-LE-1	1/28/2014	<i>Implementing minimum-mesh-size standards & forbidden gears 2014</i>	Ministry	Consolidating the outcome from the special action projects	unknown	http://jiuban.moa.gov.cn
E5-IC-2	6/1/2014	<i>Minimum mesh size standards 2014</i>	Ministry	Emphasizing the Minimum Mesh Size regime	unknown	http://jiuban.moa.gov.cn
E5-IC-3	1/1/2015	<i>Resource fee exemption 2015</i>	Ministry	Releasing burden on small-business fishers	Yes	http://www.waizi.org.cn/shuishounews/1391.html
E5-IC-4	2/12/2015	<i>Detailed rules for resource-fee exemption 2015</i>	Ministry	Providing detailed rules for the reform policy	Yes	http://jiuban.moa.gov.cn

Code	Effective Date (Month/Day/Year)	Policy	Level	Importance	Successfully implemented or not?	Website or reference
E5-SS-1	9/6/2015	<i>Subsidy reduction 2015</i>	Ministry	Reducing subsidy for trawlers; gradually ban on double-boat and other destructive gears	Yes	http://www.gov.cn/xinwen/2015-07/13/content_2895987.htm
E5-IC-5	11/9/2015	<i>Vessel scraping and standardization 2015</i>	Ministry	Providing regulations to the use of the fund; giving priority to large destructive gears like bottom trawlers	unknown	http://jjs.mof.gov.cn/zhengwuxinxi/tongzhigonggao/201512/t20151217_1618410.html
E5-LE-2	4/25/2016	<i>Combating illegal fishing gears 2016</i>	Ministry	Calling for stricter ban on illegal gears	Yes	http://www.moa.gov.cn/nybgb/2016/diwuqi/201711/t20171127_5920784.htm
E5-BP-2	5/4/2016	<i>Advancing fisheries transformation 2016</i>	Ministry	Phasing out pair bottom trawlers and restrict single bottom trawlers in the 13th Five Year	unknown	http://www.gov.cn/zhengce/2016-05/22/content_5075683.htm
E5-LE-3	8/2/2016	<i>Provisions on hearing illegal-fishing cases 2016</i>	Ministry	Provide the first judicial guidelines on hearing illegal fishing cases	Yes	http://www.court.gov.cn/fabu-xiangqing-24271.html
E5-IC-6	1/12/2017	<i>Double Control 2017</i>	Ministry	Scrapping pair trawlers; forbidding purchase or construction of pair trawlers	unknown	http://www.moa.gov.cn
E5-BP-3	1/19/2017	<i>Optimized summer moratorium 2017</i>	Ministry	Extending moratorium, making all regions' closure start from the same date May 1st, making law enforcement easier	Yes	http://www.moa.gov.cn
E5-OP-3	2/20/2017	<i>The 13th Five-Year Plan for Fisheries</i>	Ministry	Demanding negative growth, continuing double control, scrapping double-boat bottom trawlers, combatting illegal fishing and gears	Yes	http://www.moa.gov.cn
E5-LE-4	4/17/2017	<i>Combating illegal fishing gears 2017</i>	Ministry	Demanding local law enforcement groups to implement mesh size standards, prohibiting the use of multiple layers of nets in trawlers	Yes	http://jiuban.moa.gov.cn
E5-OP-4	10/10/2017	<i>The 13th Five-Year Plan for Distant-Water Fisheries</i>	Ministry	Shifting focus from quantity to quality, zero growth in the number of companies	unknown	http://jiuban.moa.gov.cn

Code	Effective Date (Month/Day/Year)	Policy	Level	Importance	Successfully implemented or not?	Website or reference
E5-OC-1	1/12/2017	<i>Total allowable catch 2017</i>	Ministry	Scrapping pair trawlers; forbidding purchase or construction of pair trawlers	unknown	http://www.moa.gov.cn
E5-OC-2	2/12/2018	<i>Catchable size & juvenile ratio 2018</i>	Ministry	Providing standards for 15 commercial fish species (e.g., hairtail)	unknown	http://www.yyj.moa.gov.cn
E5-LE-5	11/2/2018	<i>Combating illegal fishing gears 2018</i>	Ministry	Combating electric trawling practices	Yes	http://www.moa.gov.cn
E5-IC-7	12/14/2018	<i>Permit provisions 2018</i>	Ministry	Strengthening restrictions on building or updating trawlers	unknown	http://www.moa.gov.cn

Table S2.2. Reported yearly marine catch by China's maritime provinces / municipalities in 2015, 2016, and 2017, compared with the expected targets based on the total allowable catch 2017. Data source: China Fishery Statistical Yearbooks 2015 – 2017.

Region	Reported catch in each year (metric tons)			Expected targets (metric tons)	
	2015	2016	2017	2016	2017
Tianjin	47,094	45,152	27,517	44,739	42,502
Hebei	250,447	247,836	234,049	237,925	226,028
Liaoning	1,107,857	1,081,531	552,000	1,052,464	999,841
Shanghai	16,997	16,910	14,801	16,147	15,340
Jiangsu	554,314	548,852	530,322	526,598	500,268
Zhejiang	3,366,966	3,470,631	3,093,263	3,198,618	3,038,687
Fujian	2,003,917	2,038,611	1,743,208	1,903,721	1,808,535
Shandong	2,282,340	2,292,190	1,749,591	2,168,223	2,059,812
Guangdong	1,505,126	1,480,536	1,441,363	1,429,870	1,358,376
Guangxi	652,028	652,919	610,758	619,427	588,455
Hainan	1,360,725	1,407,482	1,127,331	1,292,689	1,228,054
Total	13,147,811	13,282,650	11,124,203	12,490,420	11,865,899

Table S2.3. Reported yearly catch by China's trawlers in the maritime provinces / municipalities in 2015, 2016, and 2017, compared with the expected targets based on the total allowable catch 2017. Data source: China Fishery Statistical Yearbooks 2015 – 2017.

Region	Reported catch in each year (metric tons)			Expected targets (metric tons)	
	2015	2016	2017	2016	2017
Tianjin	35,932	30,147	16,625	34,135	32,429
Hebei	65,427	67,611	60,892	62,156	59,048
Liaoning	450,072	397,894	198,130	427,568	406,190
Shanghai	14,237	14,157	12,617	13,525	12,849
Jiangsu	74,543	78,717	77,736	70,816	67,275
Zhejiang	2,039,172	2,103,225	1,869,665	1,937,213	1,840,353
Fujian	770,590	778,343	670,599	732,061	695,457
Shandong	1,389,331	1,398,197	1,146,358	1,319,864	1,253,871
Guangdong	762,357	749,572	736,851	724,239	688,027
Guangxi	425,367	425,929	398,821	404,099	383,894
Hainan	181,900	182,511	166,810	172,805	164,165
Total	5,515,928	6,226,303	5,355,104	5,240,132	4,978,125

Table S2.4. The three-level management regimes defined by FOA in its regional guideline for tropical trawl fisheries in Asia (Funge-Smith, 2014).

Levels of management regimes	Typical features
Level 1:	No indicators or benchmarks in place
	Mainly input controls (mesh size restrictions)
	Artisanal zones that exclude trawling
	Other spatial measures or zones
	Seasonal closures
	Typically low levels of enforcement/poor compliance
	Limited data collection
Level 2:	Some indicators and benchmarks for management are identified
	Better implementation of the management measures than in level 1
	Some monitoring to inform the performance of measures
	Better enforcement/greater compliance
	Occasional review
Level 3:	Resource assessments undertaken
	Targets and trigger points set
	Specific regulations in place to achieve these targets
	Effective monitoring
	Good data
	Enforcement
	Regular review

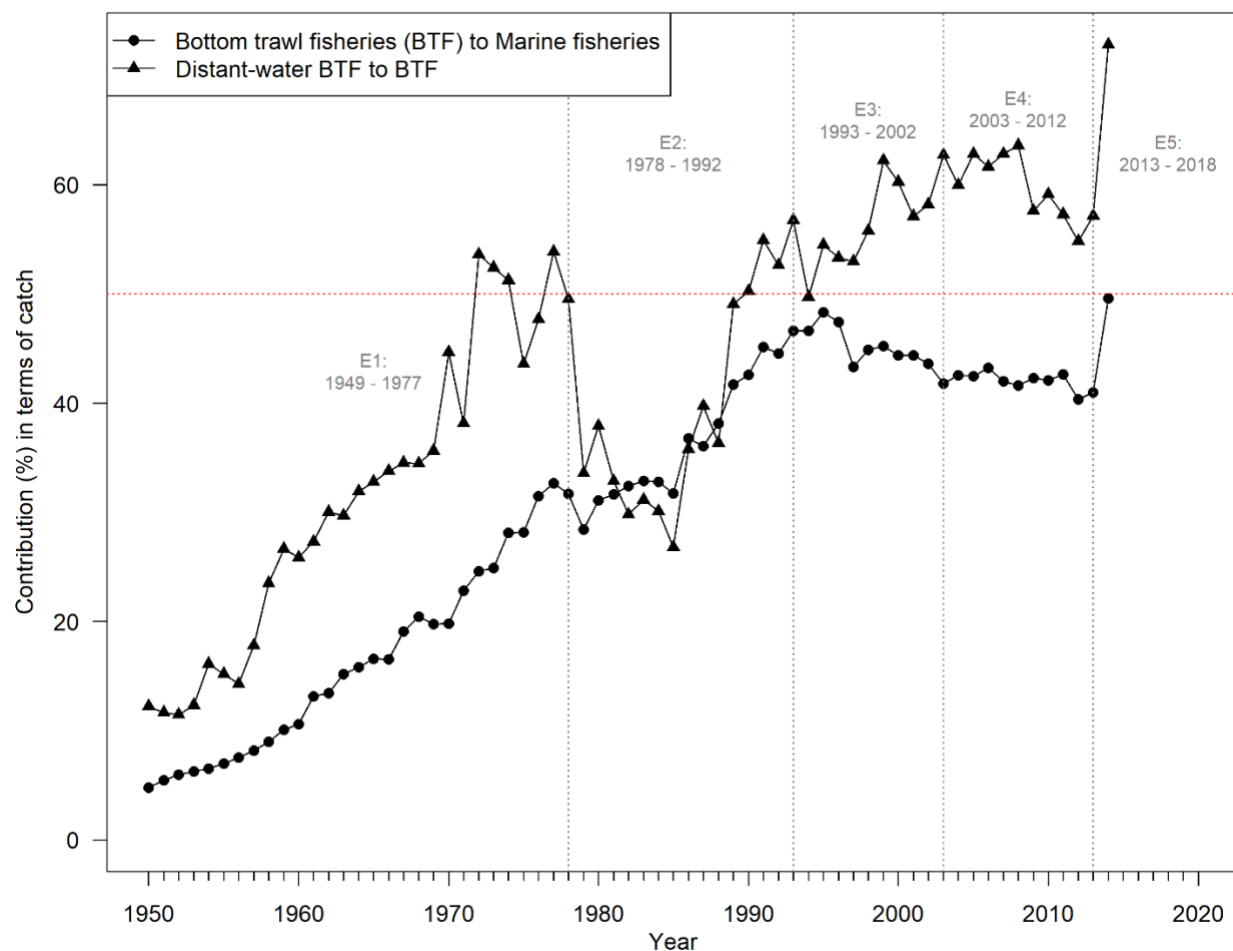


Figure S2.1. Contributions (%) of bottom trawl fisheries (BTF) to all marine capture fisheries, and of distant-water BTF to all BTF in China. The contributions were calculated based on the reconstructed catch data from Sea Around Us (available from 1950 to 2014). Here 'distant water' refers to the waters beyond the exclusive economic zones (EEZs) claimed by China.

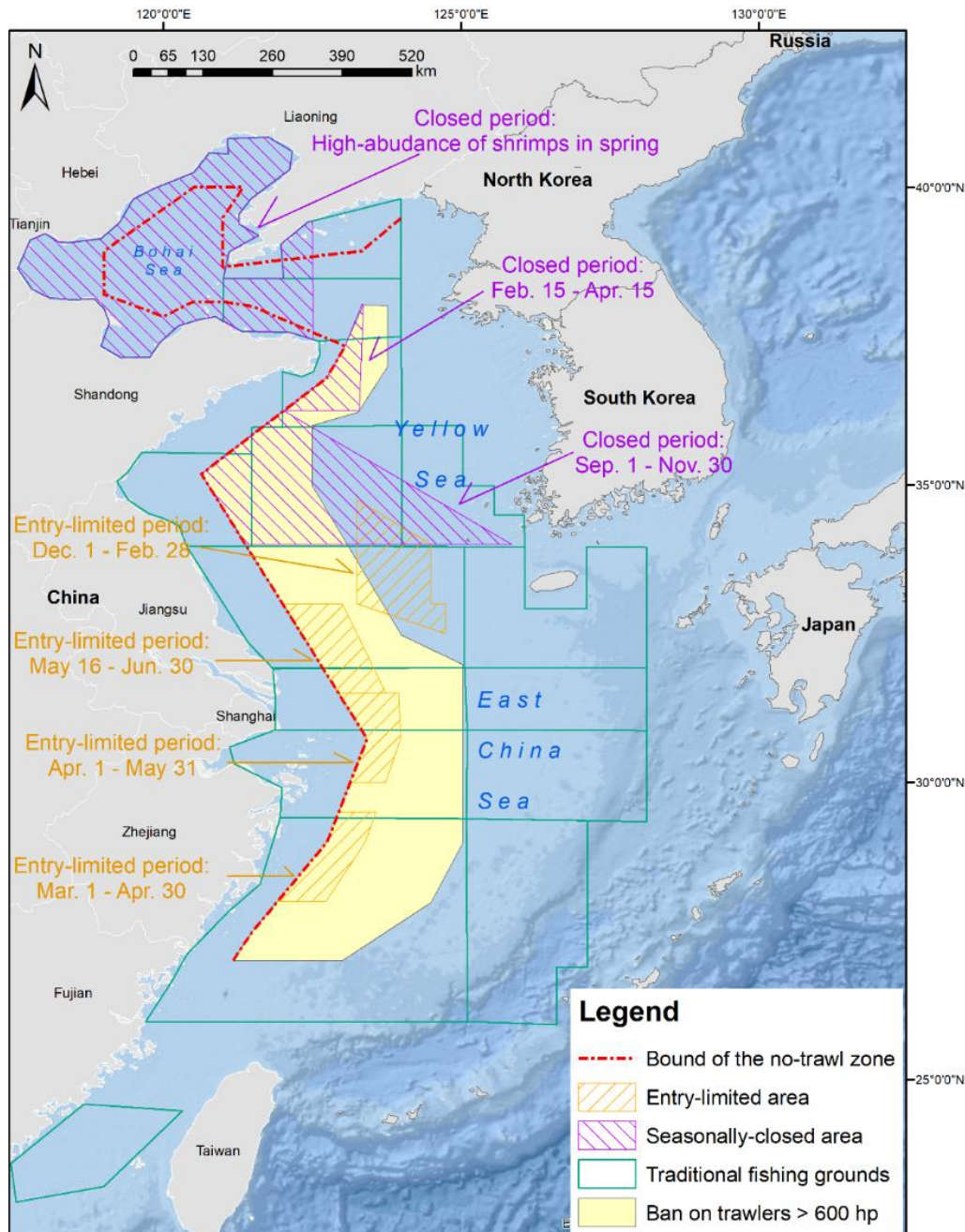


Figure S2.2. Spatial-related policies in the first era (1949 – 1977): 1) NO-TRAWL ZONE (west side of the bound line), 2) entry-limited area (quota-based fishing zones in specific periods), 3) seasonally-closed area (trawling closed in specific periods), 4) ban on trawlers > 600 hp (trawlers with a horsepower higher than 600 hp was banned in this area). The latter three were defined by *fish & shrimp protection regulations in Bohai 1975* and the *Sino-Japanese Fishery Agreement 1975*. The traditional fishing grounds for Chinese bottom trawling fisheries and maritime provinces within this area were also depicted. The bathymetry of the ocean was shown with a gradient of white-blue color (light means shallow).

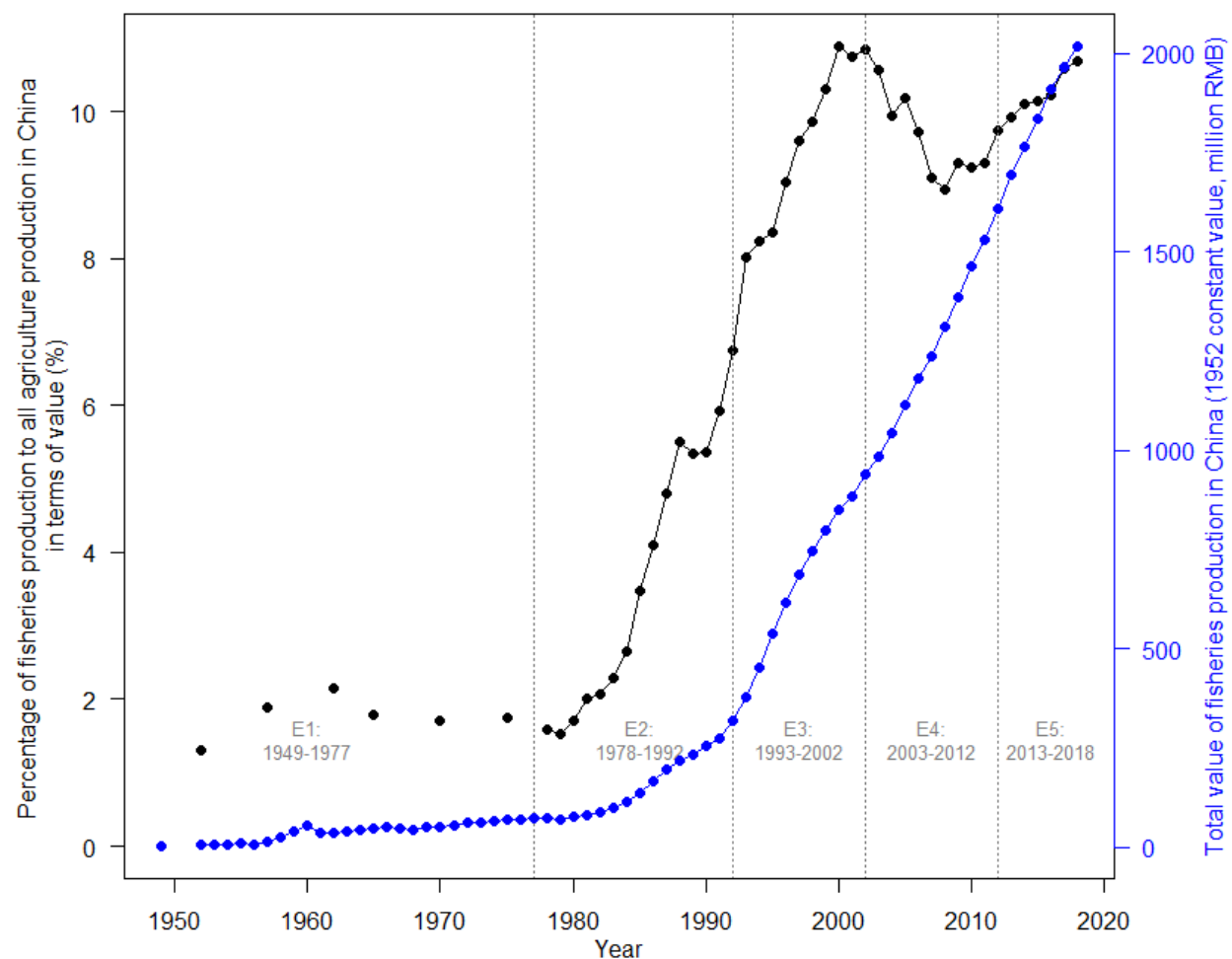


Figure S2.3. Percentage of fisheries production to all agriculture production in China and its absolute value (1952 constant value, RMB) from 1949 to 2018. The data were from China's National Statistics Bureau and some early years were not available.

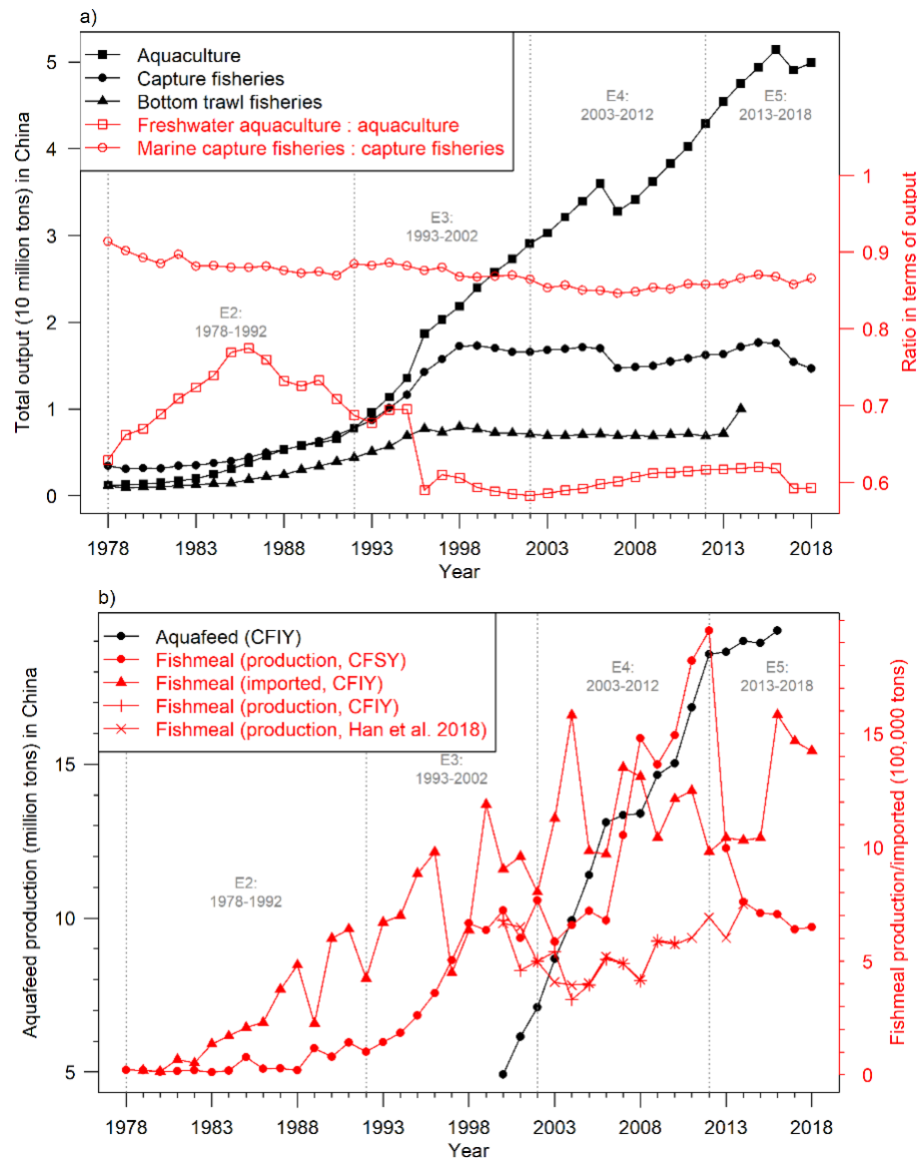


Figure S2.4. Trajectories of China's fisheries and aquaculture variables: a) (aquaculture vs. capture vs. bottom trawl fisheries) fisheries production (marine vs. freshwater), and b) aquafeed and fishmeal production/import from 1978 to 2018 (from E2 to E5). Here, the fishmeal production data were shown with three sources: China Fishery Statistical Yearbook (CFSY), China Feed Industry Yearbook (CFIY), and Han et al. 2018. Han et al. (2018) claimed that the data of fishmeal production shown on their Figure 2 (without specific methods) were from CFSY and CFIY (Han et al., 2018). However, we found that this was not the case at least for some data points as shown on our figure.

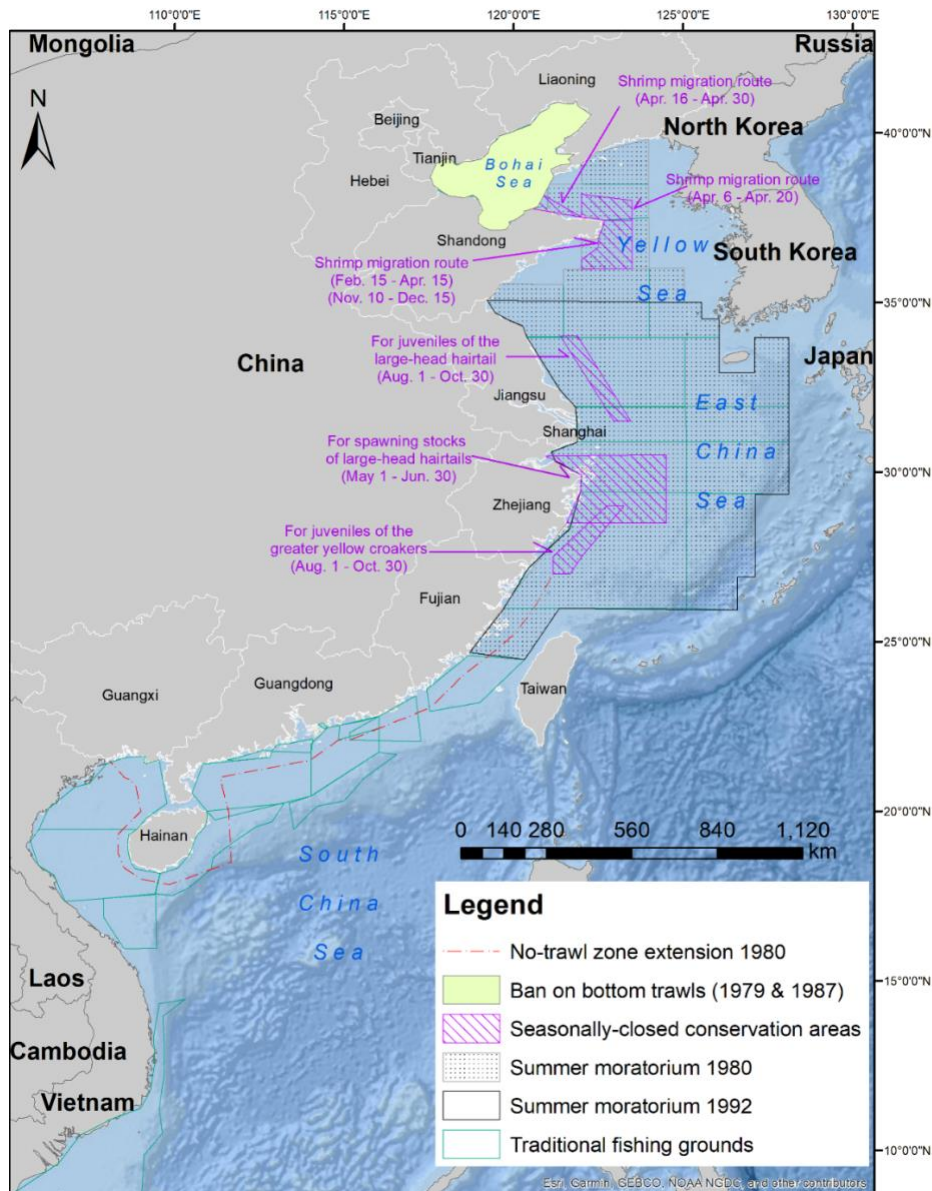


Figure S2.5. Spatial-related new policies in the second era: no-trawl zone extension 1980 (covering Taiwan Strait and the northern South China Sea), ban on bottom trawls in Bohai (1979 & 1987), seasonally-closed conservation areas for fishery stocks (shrimps, large-head hairtails, and greater yellow croakers, established in 1981 & 1989), summer moratoria (here only 1980 and 1992 were shown). Note that existing policies from the first era were not shown here.

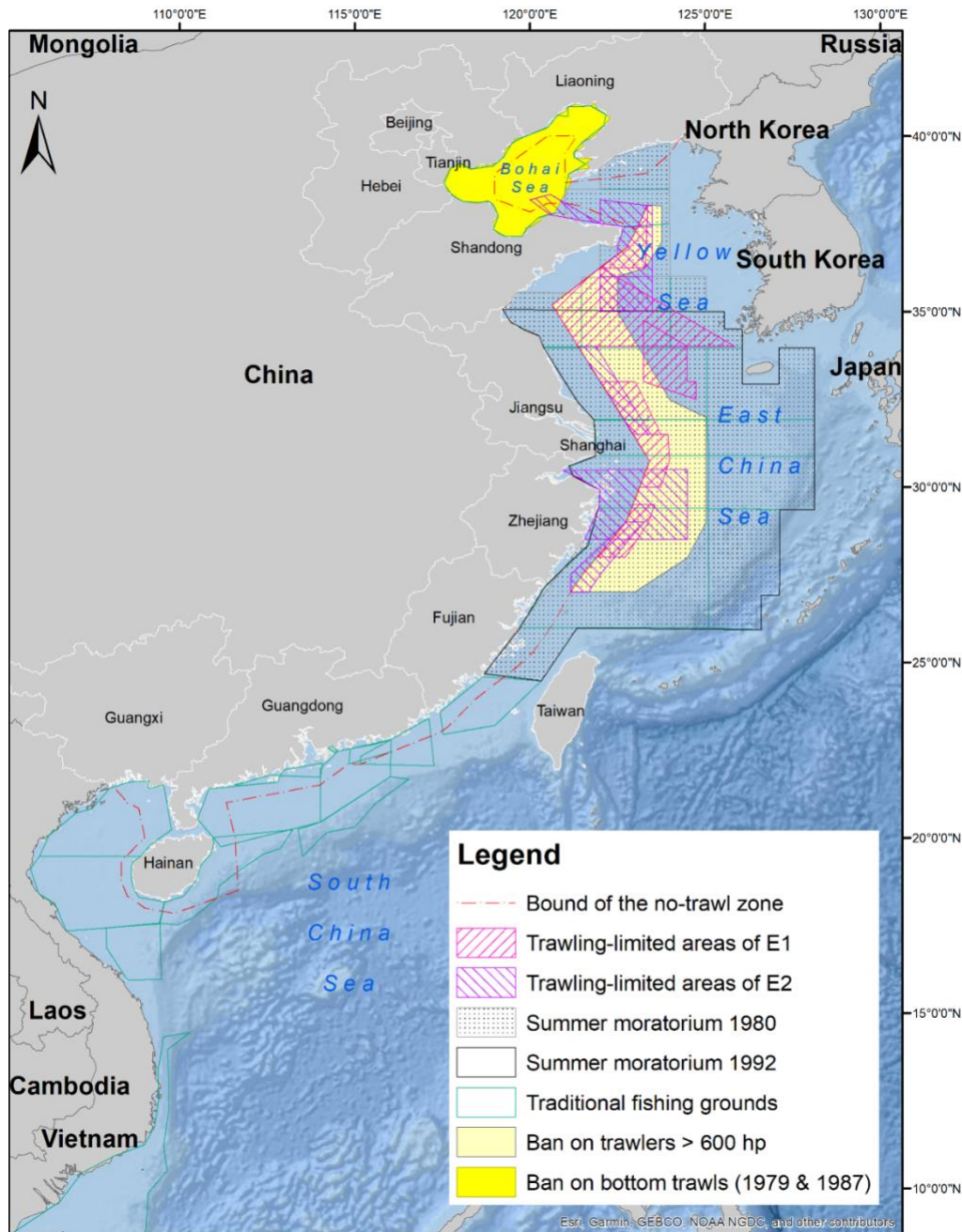


Figure S2.6. Spatial-related policies (E1 and E2 combined): trawling-limited areas (entry-limited areas and seasonally-closed conservation areas), summer moratorium, ban on trawlers with engine horsepower > 600 hp, ban on bottom trawls in the Bohai Sea (1979 & 1987).

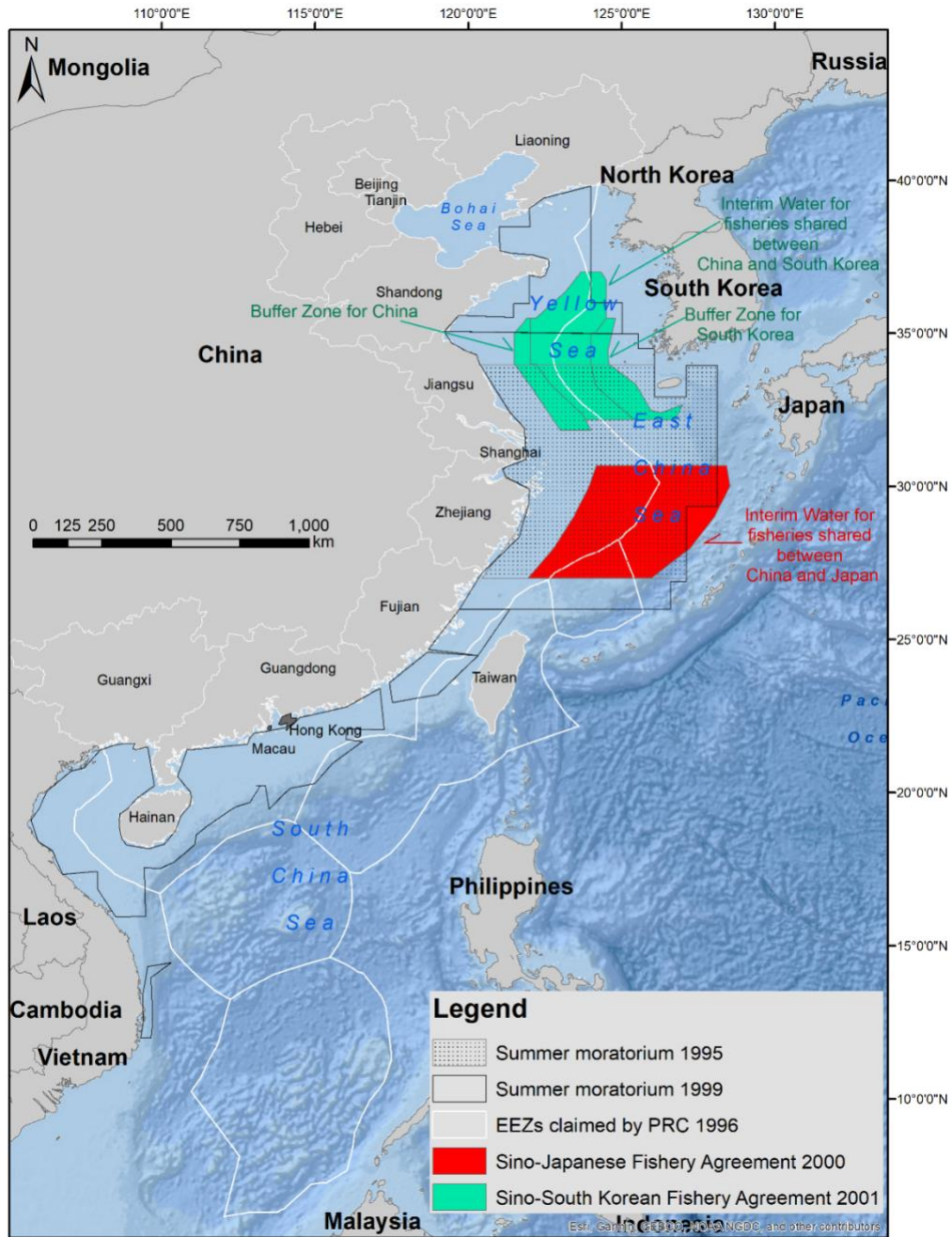


Figure S2.7. Spatial-related new policies in the third era: summer moratorium (only 1995 and 1999 were shown), Exclusive Economic Zones claimed by People's Republic of China (PRC), Sino-Japanese Fishery Agreement 2000, and Sino-South Korean Fishery Agreement 2001.

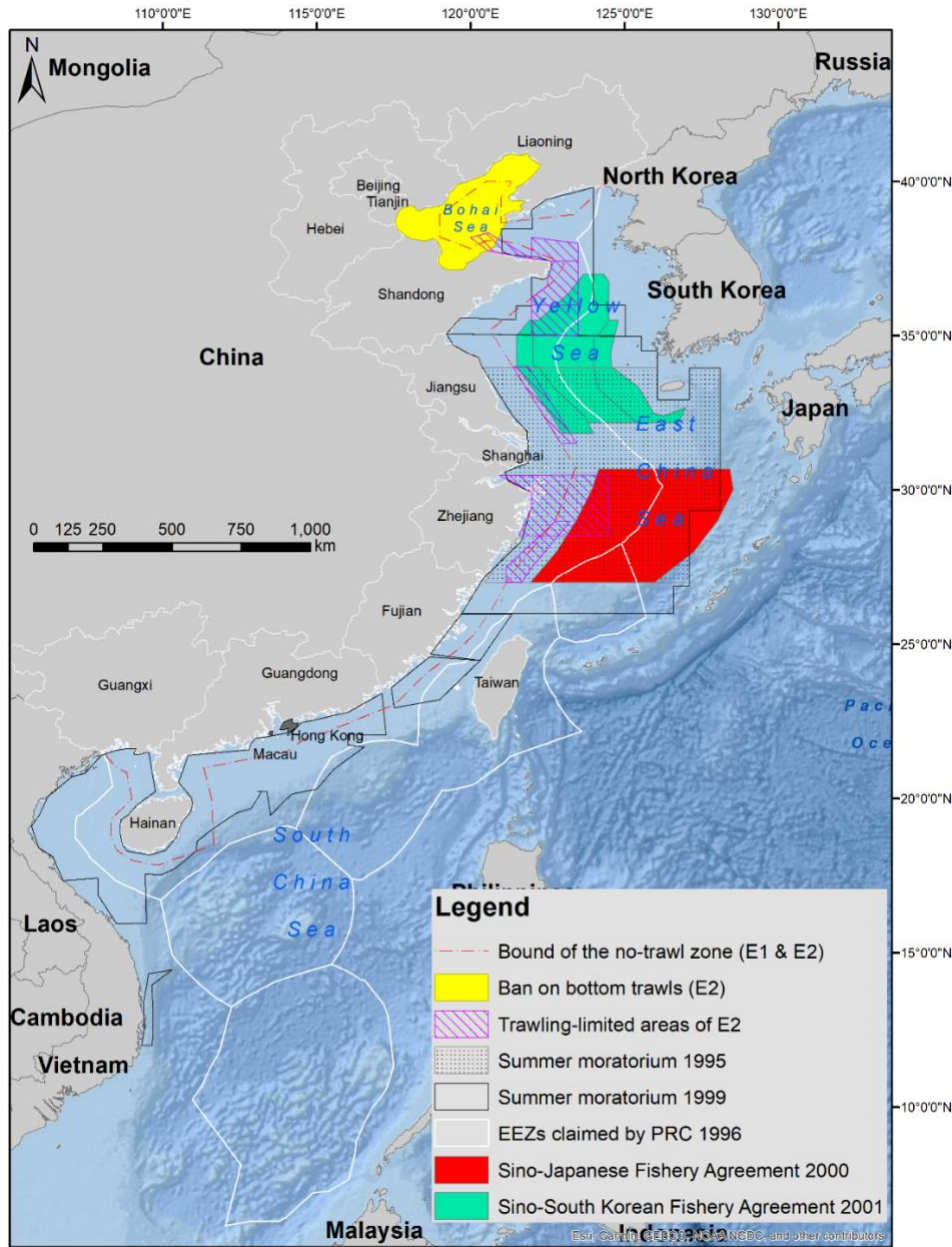


Figure S2.8. Spatial-related policies (E1, E2, and E3 combined): no-trawl zone (1955, 1957, 1963, and 1980), ban on bottom trawls (1979 & 1987), trawling-limited conservation areas (1981 & 1989), summer moratorium (only 1995 & 1999 were shown), EEZs claimed by China (i.e., PRC) in 1996, Sino-Japanese Fishery Agreement 2000, and Sino-South Korean Fishery Agreement 2001.

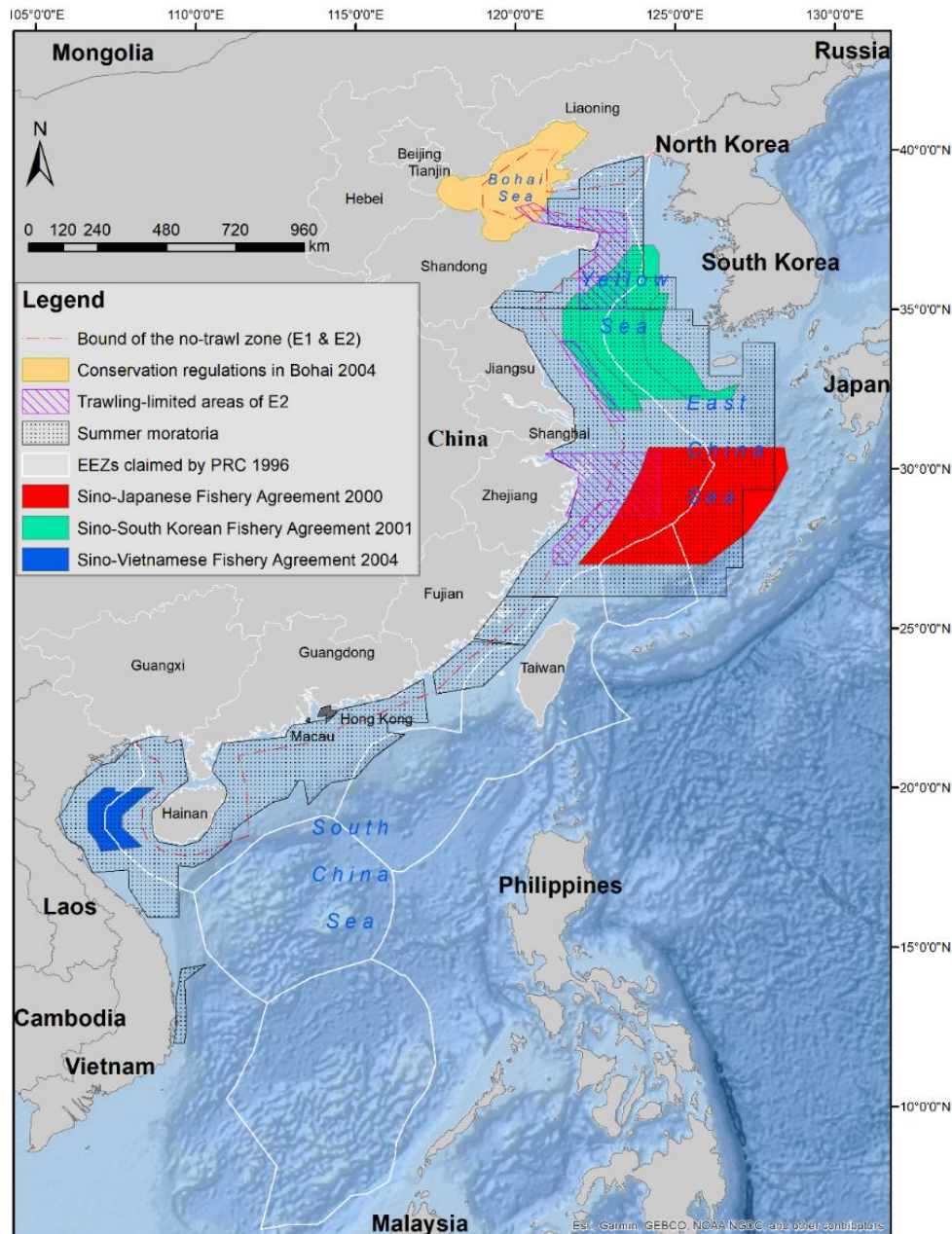


Figure S2.9. Spatial-related policies (E1, E2, E3, and E4 combined): no-trawl zone (1955, 1957, 1963, and 1980), conservation regulations in Bohai 2004 (exempted small trawlers with net opening < 30 m from the ban of 1979 & 1987), trawling-limited conservation areas (1981 & 1989), summer moratoria (spatial coverage was not changed, and only time and gear-specific arrangements were revised in 2003, 2005, 2006, and 2009), EEZs claimed by China (i.e., PRC) in 1996, Sino-Japanese Fishery Agreement 2000, and Sino-South Korean Fishery Agreement 2001, Sino-Vietnamese Fishery Agreement 2004 (entry-limited fishing zones co-managed by China and Vietnam depicted in blue).

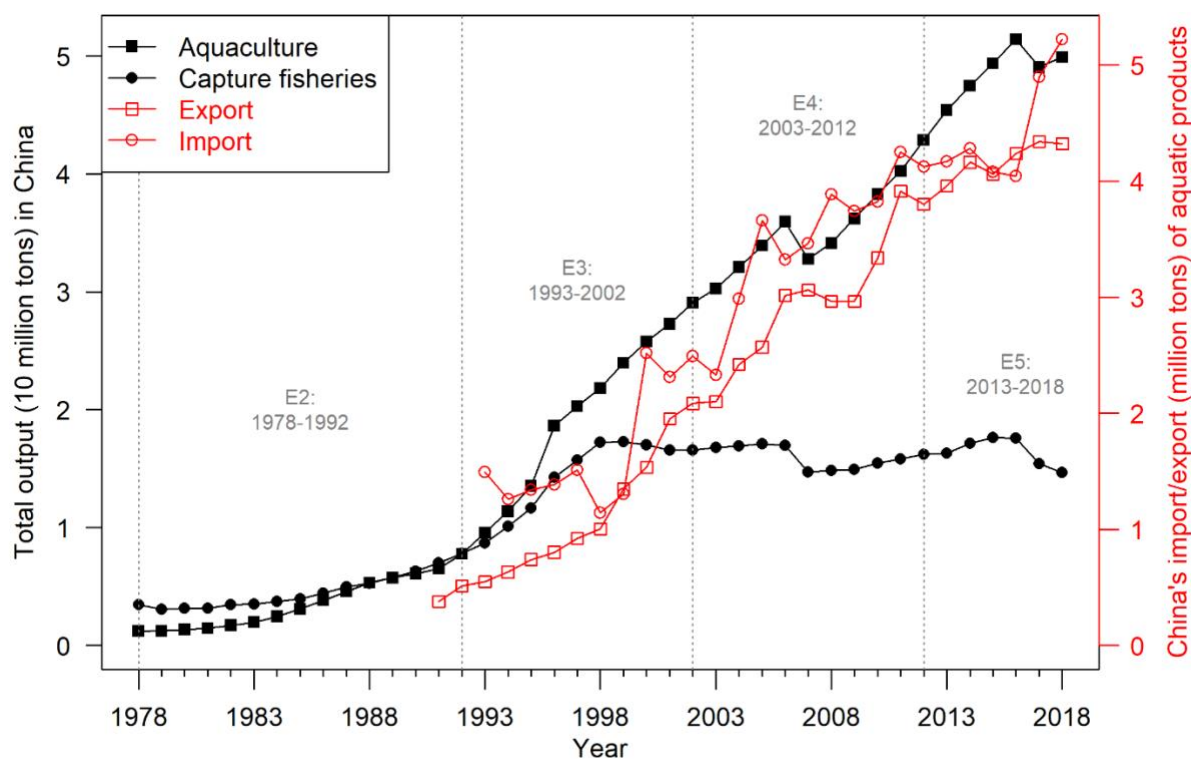


Figure S2.10. China's production from aquaculture and capture fisheries along with its annual export and import of aquatic products. Data source: China Fishery Statistical Yearbooks, 1979 - 2019.

Detailed narrative of the evolution of policies touched on China's bottom-trawl fisheries (BTF)

E1 (1949 – 1977): Planned Fishing with Limited Management

'No-trawl zone (NTZ)' (1955, 1957, 1963): *The first ever national regulations specifically for managing bottom trawlers in China.* From 1949 to the mid-1950s, conflicts grew between motorized bottom trawlers and wind-powered fishing vessels using stationary gears (e.g., gillnets, traps, cages) in China's inshore waters (Wang & Zhan, 1992). Many Japanese bottom trawlers also entered China's fishing grounds, which further intensified the conflicts and overexploitation in China's inshore fisheries (Xiao & Li, 2007). Facing this challenge, in 1955 the State Council enacted an *Executive Order on Motorized-Trawler Closure Zone (NTZ, ~ 12 nm offshore) in Bohai Sea, Yellow Sea, and East China Sea* (i.e., NTZ 1955). The declared objectives were to 1) protect China's inshore fishery resources, and 2) reduce conflicts between motorized trawlers and traditional wind-powered fishing boats. Meanwhile, China also established the Ministry of Fisheries in 1956 to enhance fisheries management. Later extensions of the NTZ in 1957, 1963, and 1980 in E2 (i.e., NTZ extensions 1957, 1963, & 1980) drew a polyline connecting a total of 40 base points from the Bohai Sea to Beibu Gulf of the South China Sea (Figures S2.5 & S2.6). All motorized trawlers (except fishery-research trawlers and shrimp trawlers holding special permits issued by the government) were banned on the inshore side of this polyline. The NTZ was divided into smaller areas under the jurisdiction of each administrative region, from the province/municipality to the county. However, the central government could preempt the local authorities in managing this zone, and the offshore water beyond it was under the jurisdiction of the central government (Wang & Zhan, 1992). This policy might be implemented in this era (and until ~ 1993), as suggested by the narrative in the later NTZ extension documents. During this period, trawlers were owned and controlled by the

government and the number was relatively small, which might facilitate the implementation. But since the widespread vessel privatization in ~1993 (Gao & Ping, 2002), the implementation of NTZs has been challenged by the explosive growth of the number of small and private trawlers. Additionally, small trawlers (horsepower < 44.1 kW & length < 12 m) were nominally allowed to fish at the inshore side of the NTZ by other policies issued in later eras (e.g., fishing permit regulations in 2004).

Stock protection regulations in the Bohai Sea (1962, 1975): *The first technical instruments for regulating trawlers by stipulating minimum mesh size and operation time & water.* In 1962, the State Council forwarded the *Interim Measures for Protecting Reproduction of Shrimps in Bohai Sea* (i.e., *shrimp protection regulations in Bohai 1962*; issued by the Ministry of Aquatic Products) to local governments. This is the first ever legal document for stock resource protection in China, although it only applied to the Bohai Sea. Later in 1975, the Ministry of Agriculture and Forestry issued a similar but more formal policy, the *Regulations for Protecting Reproduction of Commercial Fish and Shrimps in Bohai Sea* (i.e., *fish & shrimp protection regulations in Bohai 1975*). Minimum mesh size, restricted operation time and restricted fishing water for trawlers were detailed in these legal documents to protect spawning stocks of shrimps (in 1962) and commercial fish (in 1975) migrating into the Bohai Sea to spawn. However, little is known about whether this policy was implemented or effective.

The Sino-Japanese Fisheries Agreement (1975): *The first bilateral agreement for fisheries management that specified protection areas and fishing closure periods for specific fishing zones.* In 1955, almost the same time as Chinese central government issued the NTZ policy, the Chinese Fishery Association signed a non-governmental fishery agreement in the East China Sea with the Japan–China Fisheries Council (originally known as Japan–China Fisheries Enterprise Association) (Y. Chen & Teligenbaiyi, 2010). The major goal (for China) was to regulate fishing activities of Japanese fishing vessels in fishing grounds claimed in the policy

document. Later before 1975, three more non-governmental fishery agreements were negotiated and reached between China and Japan (Zou, 2003). During this period, as China's inshore fishery resources were gradually depleted, China's trawlers were moving offshore and entered fishing waters claimed by Japan. After the establishment of diplomatic relation between China and Japan in 1972, the two nations started to negotiate fishery cooperation in East China Sea and signed a formal bilateral agreement in 1975 – *Sino-Japanese Fisheries Agreement 1975* (Zou, 2003). This bilateral agreement inherited earlier non-governmental agreements, and confirmed several seasonal-closure zones for motorized trawlers and protected areas (i.e., NTZ) to conserve juvenile fish of commercially important species (e.g., bighead hairtail, great yellow croaker) (Yu & Yu, 2008; Zou, 2003). It is the earliest example of what has become a regular regional summer moratorium in China. However, perhaps because these conservation measures only covered a very limited areas and short time periods, the effectiveness were reported low (Chen & Teligenbaiyi, 2010; Shen & Heino, 2014).

E2 (1978 – 1992): Regime shift with Input Control

Stock protection regulations & fishery-conservation areas (1979, 1981, 1989, 1990, 1991): *Enhancing fisheries regulations and establishing more fishery-conservation areas for protecting spawning stocks and juveniles.* With increased concerns about overfishing, the central government organized a large-scale investigation into fishery resources in its four seas in the early 1970s (Yu, 1991). The aim was to provide a scientific basis for making new policies to protect fishery resources nationwide, to expand the traditional fishing grounds, and to find new ones (Yu, 1991). In 1979, the State Council enacted the first nationwide policy regarding to fishery resource protection – *Regulations on Protecting the Reproduction of Fisheries Resources*. The Regulations embraced some important regimes that were further narrated as follows, such as fishing permit, allowable catch quota, seasonal closure, fishery-conservation area, and gear restrictions (e.g., minimum mesh size) for fishing vessels (including bottom

trawlers) (Liu & Huang, 1999). Based on the nationwide investigation, the State Council established *Fishery-conservation areas for juveniles of greater yellow croakers and bighead hairtails in Yellow Sea and East China Sea* in 1981 (i.e., *fishery-conservation areas 1981*), and *Fishery-conservation areas for spawning stocks of bighead hairtails in Zhoushan* in 1989 (i.e., *fishery-conservation areas 1989*). The fishery authorities also issued a few policies regarding stock protection. In 1981, the State Bureau of Aquatic Products upgraded the *Regulations for Protecting Spawning Stocks of Commercial Fish and Shrimps in Bohai Sea (1975)* to *Provisions for Protecting Spawning Stocks of Aquatic Products in Bohai Sea* (i.e., *stock protection provisions in Bohai 1981*). The Ministry of Agriculture (MOA) issued the *Interim Provisions for Spawning Shrimps in the Bohai-and-Yellow-Sea Region* in 1990 (i.e., *protecting spawning shrimps 1990*; appended in 1997 & 2007 in latter eras), which delineated the range of spawning-migration routes of shrimps and determined the fishing closure period to protect the spawning stocks. In 1991, MOA also issued the *Provisions for Protecting Reproduction of Fisheries Stocks in Bohai Sea* (i.e., *stock protection provisions in Bohai 1991*) to replace the *Provisions for Protecting Reproduction of Aquatic Products in Bohai Sea (1981)*. However, little was known about the implementation or effectiveness of these conservation policies.

Bottom-trawl Bans in Bohai Sea (1979 & 1987): *The first two attempts to ban bottom trawlers in China's coastal waters.* The Bohai Sea is an important spawning grounds for many shrimps and fishes but overexploitation (and perhaps industrial pollutions) caused serious stock depletion (Zhong & Power, 1997). To strengthen the protection of fishery stocks, the State Bureau of Aquatic Products launched a bottom-trawl ban in the region, as mentioned by the *Circular about Adjusting the Fishing Closure Zone for Bottom Trawlers in Bohai Sea*, published on Dec. 24, 1979. However, this was not implemented for unknown reasons. Then the 2nd ban was launched in 1987 in the *Regulations on Fishery Production Arrangement in the East China Sea, Yellow Sea, and Bohai Sea*. The Regulations mandated that all bottom trawlers must be

forbidden from the Bohai Sea from 1988. The ban was also mentioned in the *Provisions for Protecting Spawning Stocks of Fisheries in Bohai Sea (1991)*. But once again, it was not implemented by local governments (Tang et al., 2012), perhaps because of social stability concerns and local protectionism (Yu & Yu, 2008).

‘Summer Moratoriums’ (Since 1980): *A major policy for protecting fish stocks from bottom trawling in China.* Closing fishing activities in breeding seasons is a traditional wisdom (and a common practice in ponds, lakes, and rivers) passed on from Chinese ancient ancestors more than three thousand years ago (Li, Jin, & Tang, 2012). The earliest documentation of such a practice is the “Yi Zhou Shu”, a compilation of historical documents of Zhou Dynasty (1046 – 771 BC) (Li, Jin, & Tang, 2012). However, Chinese marine fishers only started to practice this in late 1970s as many major fish stocks were overfished. In 1979, Zhejiang province began designating seasonal fishing-closure zones for BT during spawning seasons (Jul., Aug., and Sep.) of major demersal fish stocks (e.g., bighead hairtail), as a countermeasure to fisheries depletion (Tang et al., 2012). The State Bureau of Aquatic Products also took an action in 1980 by issuing a circular (cited by (Tang et al., 2012), but the original copy was not found) where ‘summer moratorium’ first appeared in the document of a central government agency (i.e., *summer moratorium 1980*). This moratorium regime was restated in another legal document published in 1981 – *Several Interim Provisions for Protecting Fishery Resources in the Yellow Sea and the East China Sea* (i.e., *summer moratorium 1981*). The government designated a two-month (July – August) moratorium in the Yellow Sea and a four-month (July – October) moratorium in the East China Sea every year. Since then, China has experimented with different arrangements in terms of moratorium time and area and adjusted them according to continuous surveys and assessments (Chen & Teligenbaiyi, 2010). For instance, in 1987, the four-month moratorium from N 24.5 to 34 degrees in the East China Sea was only imposed for trawlers with a horsepower < 183.9 kW, and all beam trawlers were exempted (i.e., *summer*

moratorium 1987). In 1992, the moratorium was only imposed for two months for all bottom trawlers (except beam trawlers) from N 27 to 35 degrees and for all bottom trawlers with a horsepower < 183.9 kw from N 24.5 to 27 degrees (i.e., *summer moratorium 1992*). The underlying reasons or science for making these regulations and revisions were not well documented in literature. The only information was provided by government policy documents which claimed that these were made 1) for the convenience of enforcement, 2) as a balance between fishery exploitation and resource conservation, and 3) according to the feedback from local governments and fishing industries. Little data was available about the effectiveness of these early-period moratoria.

Juvenile catch ratio (1980): *The first policy for reducing the impact of bottom trawlers upon juveniles.* In 1980, the State Bureau of Aquatic Products mandated inspection on juvenile catch ratio in fishing operations. This policy was cited in several studies (Pan & Li, 2016; Tang et al., 2012), but the original narrative of this policy was not found. There was little information about the implementation and efficacy of this policy. The East China Sea Bureau of Fisheries reported that they conducted the inspection on 95% of all fishing vessels in operation (belonged to nine fishery companies) during July 1 and October 17, 1981 (S. Chen, 1982). Based on this report, only 3.68% of the inspected vessels violated the regulation for juvenile catch ratio, and a total of 310 thousand RMB was fined.

Protecting Inshore Fisheries, Encouraging Aquaculture, Offshore and Distant-Water Fisheries (1981, 1983 & 1985, overarching policies): *A major policy change from focusing on capture fishery exploitation to preferentially develop aquaculture, offshore and distant-water fisheries.* From 1950 - 1981, the nation's fisheries development remained slow in terms of the increase rate of landing biomass, which did not meet consumption demand (Tu, 2009). The economic reform in 1979 left many gaps in policy for fisheries-management adjustment (Tu, 2009). Facing these challenges, the State Council forwarded the *Report of Current Issues in*

Fisheries Management by the State Bureau of Aquatic Products (SBAP) in 1981 (i.e., *Inshore-fisheries protection 1981*) to local governments and required them to follow this report to adjust fisheries production and management. Major issues pointed out in the Report included: 1) the depletion trend of inshore fisheries was not being reversed, 2) fishing overcapacity and surplus labor had become serious problems, and 3) local government needed to pay sufficient attention to the great potential for developing aquaculture. To deal with these issues, the SBAP provided detailed regulations in the Report to 1) *control construction and import of fishing vessels*, 2) *encourage offshore fishing and fishers' job transfer*, 3) *speed up aquaculture development*, and 4) *enhance fisheries management*.

In 1983, the State Council forwarded another report – *Report of Current Issues in Marine Fisheries Development* (i.e., *Marine fishery policy 1983*), which further highlighted the need to 1) *develop fisheries laws and regulations*, 2) *enhance fisheries management*, 3) *strictly protect, rationally utilize, and actively enhance inshore fisheries stocks (by releasing hatchery-reared juveniles)*, and 4) *vigorously develop aquaculture, offshore and distant-water fishing*. Under this guideline, local government paid more serious attention to fisheries laws and regulations and management-body development. Efforts at law-enforcement started to emerge (Xiao & Li, 2007). Many of the instructions of the above two policy documents were then adopted in the **No. 5 Central Document** in March 1985: *Instructions about Relaxing Policies and Accelerating Marine Fishery Development* (i.e., *accelerating fisheries development 1985*; by the Central Committee of CCP and the State Council). This Document is considered as a landmark national resolution related to fisheries reform (Zhong & Power, 1997). It decreed that '*aquaculture is the development priority; aquaculture, capture fisheries, and fish processing industry should be developed together*'. It also endorsed the strategy of accelerating the development of distant-water fisheries to reduce fishing pressures in China's waters. Although little was known about

the impact of these overarching policies on China's BTF, the share of output from waters beyond China's EEZs in its BTF increased after 1985 (Figure S2.1).

'Interim Measures for Marine Fishing-Vessel Management' (1983): *The first law for implementing fishing permits and constraining the number of inshore trawlers.* In order to enhance fishing-vessel management and protect inshore fishery stocks, in 1983, the Ministry of Fisheries, Pastoral, and Fisheries issued the *Interim Measures for Marine Fishing-Vessel Management* (i.e., *vessel-management interim measures 1983*). This document provided guidelines for implementing fishing permit and vessel inspection regimes and forbade the transformation of non-fishing boats to fishing vessels and of no-trawlers to inshore trawlers. However, little is known about the implementation or efficacy of these measures and they were replaced by latter updated policies.

Fisheries Law (1986): *Providing the first overarching and comprehensive law for fisheries management in China.* The *Fisheries Law of the People's Republic of China* (i.e., *Fisheries Law 1986*) was passed by the National People's Congress on 20 Jan. 1986 (effective on 1 July 1986, and appended in 2000, 2004, 2009, and 2013). The goals of formulating this highest-level law were to 1) *enhance the protection, proliferation, exploitation and rational utilization of fisheries resources*, 2) *develop aquaculture*, 3) *ensure lawful rights and interests of fisheries workers*, and 4) *boost fisheries production*. One of the most important contributions of this Law was anchoring the fishing-permit scheme as a national regime. The law mandated that every fishing vessel should first be examined by the vessel-inspection agency which issues a certificate. Then the vessel should be registered in the local port-surveillance office and given a fishing permit by central government fishery authority (e.g., MOA, for large trawlers) or provincial fishery authorities (for small trawlers and other no-trawler vessels). Once the fishing vessel was allowed to operate, local vessel inspectors had the right to check the vessel annually to ensure its safety and legitimacy.

China's fishing permits had three categories: general permit, special permit, and temporal permit (Wang & Zhan, 1992). Among them, the special permit was issued for specific short-term (e.g., fishing closure seasons) fishing activities in specific waters (e.g., no-trawling zone) for various purposes (e.g., research). The temporal permit was issued for one year and to a maximum of three-year extension (being approved by the provincial governments) and was given when the total horsepower exceeds the quota allocated by the central government. The temporal permit was required to be renewed annually and could not be transferred to a new vessel owner. The fishing-permit regime also mandated that vessels also needed to apply a limited fishing-gear quota from the local fishery authority.

Additionally, the Law embraced many previous initiatives including the NTZ, summer moratorium, and minimum mesh size. To facilitate the implementation of this law, between 1987 and 1990, China enacted the 1) *Detailed Regulations and Rules for Implementing the Fisheries Law* (i.e., *Fisheries Law implementation rules 1987*), 2) *Measures of Fishing Permit Management* (i.e., *permit-management measures 1989*), 3) *National Standards for Minimum Mesh Size of the Trawl Cod-end in East China Sea and Yellow Sea and in South China Sea* (i.e., *minimum-mesh-size standards 1990*). However, given the limited information, we could hardly assess the implementation effectiveness of the Fisheries Law and these following policies. The fishing permit system likely failed to control the overcapacity, given that the permits were issued based on the estimates of total allowable catch which has not been estimated (Huang & He, 2019). Moreover, given one of the goals of this Law was to boost fishery production, it might have encouraged the growth of BTF.

Single Control (i.e., reducing the horsepower of trawlers; 1987): China's first attempt to control fishing capacity. The 1979 government report by the State Bureau of Aquatic Products indicated that many major stocks were depleted especially due to the blind expansion of bottom trawlers (State Council 1979). The report mentioned that BT directly caused the collapse of

several high-value benthic stocks such as small yellow croakers and bighead hairtails. This report induced the State Council to announce a statement that required local governments to stabilize the total catch at the present level and to reduce trawling activities for the first time (without specific guidelines to do so). Another similar report about overcapacity issue in 1981 also called for strict control over the increasing number of vessels. However, these policies were not actually treated seriously by many local governments (Yu & Yu, 2008), perhaps because of the lack of specific regulations. As a response, in 1987, the central government initiated to set up quota for total horsepower of fishing vessels in each marine zone (i.e., *Single Control 1987*). The original narrative of the policy was not found. Some claimed that this policy, although achieved some positive outcomes, failed its control targets by mid-1990s for unknown reasons (Yu & Yu, 2008). In fact, the aggregated horsepower of motorized vessels continued to increase (Figure 4).

Resource Fee (a.k.a., Stock enhancement and protection fee, 1989): *The first economic instrument to discourage destructive fishing and to provide budget for stock enhancement and fishery management in China.* In 1988, the State Council approved the *Measures for the Collection and Use of Fishery-Resource Fee* (effective on 1 Jan. 1989; i.e., *resource fee 1989*). This document set up three levels of fees regarding different stocks: common stocks, high-value stocks, fishing-limited and protected stocks. For each fishing vessel (e.g., bottom trawler), the annual resource fee for common stocks was 1% - 3% of the average income of last three years earned by the same type of vessel in local. The fee increased to 3% - 5% for high-value stocks, and up to 3 times of the high-value stocks for fishing-limited and protected stocks (Yue et al., 2017). Meanwhile, the document required local governments to collect lower resource fees (or exempt resource fees) for vessels conducting offshore fishing, non-destructive fishing or fishing operations encouraged by the government, while requested higher resource fees (up to three times the average level) for fishing practices that should be phased out, were destructive (e.g.,

bottom trawling) or limited by the government. The incentives of this policy were: 1) to raise funds for stock enhancement and fisheries management such as law enforcement; 2) to prevent the increase of fishing effort and thus to protect fisheries resources as an economic leverage. As required by the Measures, 90% of the resource fee should be used by local fisheries governments, and the rest 10% should be allocated to the regional Branches of Fisheries Management of the three marine zones. Researchers have claimed that this resource-fee policy did support fishery stock enhancement and law enforcement in China (Huang & He, 2019). However, this policy was criticized as it was too low to reduce fishing effort as well as output (Yue et al., 2017).

E3 (1993 – 2002): EEZ Management with Multiple Regulations

***China 21st Century Agenda* (1994) & *China 21st Century Ocean Agenda* (1996)**

(Overarching policy): *Pivotal documents that illustrated China's strategic goals and measures for sustainable development in the 21st century.* To facilitate global sustainable development of humanity, the UN passed a landmark document, the 21st Century Agenda, in the UN Conference on Environment and Development in 1992 (a.k.a., Earth Summit). The Agenda highlighted the importance of sustainable exploitation of the seas, especially fisheries resources. As one of the five permanent members of the UN, China soon developed its own agenda accordingly. In 1994, China's State Council ratified the *White Papers of Chinese Environment and Development in the 21st Century* (i.e., *China 21st Century Agenda 1994*). This Agenda elaborated China's challenges, basic targets, strategies, and general measures of sustainable development, including marine fisheries. It pointed out that the ecological environment of China's seas was degrading and marine biological resources was depleting; the major issues in marine fisheries development were overfishing and the collapse of traditional fishery stocks; because China lacked fishery development plans and management, fishing capacity was out of control; and marine pollution was exacerbated. To address these issues, the Agenda set up

several general targets. One major target was to enhance marine resource management scheme through different measures, such as building 1) a multi-level government system, 2) a comprehensive law system, 3) and a comprehensive marine environment monitoring system. Another target was to fulfill sustainable fishery development and conservation through a variety of actions, including 1) improving fishery laws and regulations, 2) enacting ecological monitoring and protection action plans in China's seas, 3) actively developing mariculture (especially high-productivity and low-pollution ones) and distant-water fisheries, 4) reasonably exploit both domestic and high-sea fishery resources, and 5) conducting international cooperation to conserve fishery resources in China's seas through establishing fishery agreements.

To provide further detailed guidelines for ocean management, The State Oceanic Administration (China's central government authority for marine planning, legislation, and administration) published the ***China 21st Century Ocean Agenda*** in 1996. On the Ocean Agenda, China depicted five specific targets for marine fishery development: 1) strictly controlling the growth of fishing vessels and reducing the fishing effort to the level that can sustain the 'optimum' fishery exploitation; 2) implementing fishery management by law; 3) gradually establishing a catch quota regime and a paid-use regime for marine fishery resources; 4) ensuring population rebuilding to some extent with significant increases in the stock size and quality for some commercial fish stocks after 2010; 5) ensuring most commercial fish stocks be significantly recovered to a level that can maintain sustainable exploitation by 2050. To achieve these targets, the Ocean Agenda narrated a few general policies. A major policy related to BTF was to curtail inshore fishing capacity through legal, economic, scientific, and administrative means, such as 1) constraining trawling in coastal waters, 2) fishing gear and method innovation, 3) forbidding markets that harm juvenile fish, 4) enhancing NTZ and seasonal closure management, 5) establishing different types of fishery conservation areas and no-take zones.

Summer moratorium (1995, 1998, 1999, 2000, 2001): Making seasonal closure a national regime in marine fisheries management. In 1995, after more than a decade of local moratorium practices for BT in China's seas (except South China Sea), summer moratorium was approved by the State Council as a regular practice in marine fisheries management. But at the beginning, summer-moratorium zones for BT only included China's EEZs of the three northern seas: Bohai Sea, Yellow Sea, and East China Sea. In 1998, MOA extended the moratorium (in both time and space) in the Yellow Sea and East China Sea. The moratorium did not extend to the South China Sea until 1999, and beam trawlers operated in the East China Sea were not included until 2003. The reasons for the moratorium delays for a specific sea and gear were unknown, but we made some speculations. First, beam trawlers were widely used in the East China Sea to catch shrimps, which were economically important and might be less depleted than other fish stocks (e.g., small yellow croakers). Second, the summer moratorium was initially used to protect spawning stocks in the breeding season. This might have been seen less relevant in the South China Sea, where most fisheries stocks are tropical species that can spawn all year around. Third, trawling fisheries in the South China Sea were less developed in terms of the number of vessels and fisheries output than the fisheries in the northern seas. The fishery resource might not have been heavily depleted in the South China Sea until 1999, and thus a moratorium was not considered necessary in the early years. With regard to the implementation, coastal fishery authorities ensured that at least 95% of fishing vessels comply with this policy every year through their implementation efforts (Huang & He, 2019; Zhang, 2008). Some studies have shown that these moratoriums increased the annual catch and catch per unit effort (Cheng et al., 1999; Yan et al., 2007), but the moratoriums did not cover breeding seasons of all species, and the boosted fishing efforts after moratoriums counteracted the effect of stock rebuilding (Guo, 2002; Yu & Yu, 2008).

Fishing vessel and permit regulations (1996, 1997, 2002): *The first detailed regulations for vessel management and the first revisions on the fishing permit management calling for a catch quota system.* After enacting the Fisheries Law in 1986, MOA developed a series of more specific regulations (e.g., fishing permit) correspondingly. In 1996, the *Measures for Fishing Vessel Registration* was issued (i.e., *vessel registration measures 1996*). These Measures provided the first detailed regulations for fishing vessel management in China. In 1997, MOA appended the *Measures for Fishing Vessel Registration* and the *Measures for Fishing Permit Management (1989)*. The appended Measures (i.e., *vessel registration measures 1997* and *permit management measures 1997*) enhanced regulations about illegal vessels and fishing. In 2000, MOA organized the first national census of marine fishing vessels, which showed that there were still 67,200 illegal vessels without fishing permits, vessel registration certificates, and/or vessel inspection certificates; such vessels accounted for 27.5 % of all vessels (Huang, 2001). As a response to strengthen the control of fishing vessels, in 2002, MOA upgraded the *Measures for Fishing Permit Management (1997)* to the *Provisions on Fishing Permit Management* (i.e., *permit management provisions 2002*). The Provisions set up specific qualifications for obtaining fishing permits, defined allowable fishing areas, identified the maximum number of allowed fishing gears, and indicated punishments for violating the regulations. It stipulated that ‘trawlers cannot operate other gears and other vessels cannot transform to trawlers. It also endowed MOA the administrative power to control fishing-gear quota and fishing permit issuing for large trawlers (horsepower of major engine ≥ 441 kw). Meanwhile, the Provisions proposed, for the first time, to set up total allowable catch quota, which was, however, not implemented. This might result from the formidable costs in data collection (to set up the quota), law enforcement, bargaining, and surveillance, considering the diversity of fish stocks, massive sizes of marine waters, fishers, and fishing vessels in China (Fang, Su, & Yang, 2002; Yang & Shen, 2005).

Double Control (1997): *The 2nd and more stringent attempt to directly control fishing capacity.* Recognizing the failure of controlling fishing capacity in the previous attempt (i.e., the Single Control started in 1987), in 1997 the State Council launched a more rigorous policy called 'Double Control', which required local governments to take strict control over the total number of fishing vessels and total horsepower (all gear types included). This policy was integrated into China's Ninth Five-Year Plan (1996 – 2000) (Yu & Yu, 2008). To implement this policy, the MOA reissued fishing permits in the maritime provinces. However, once again this policy failed to constrain fishing capacity to the targeted level (Yu & Yu, 2008). Politically, this effort was doomed as local government leaders, who have the true authority in making and implementing local fishery policies, were reluctant to reduce their fishery productions which could influence their promotions (Yu & Yu, 2008). Additionally, the growing number of fishing participants, which remains a very challenging issue in China, also made this double control policy difficult to implement.

Exclusive Economic Zone and Continental Shelf Law (1998): *China's overarching law for implementing EEZ regime.* In June 1998, the *Exclusive Economic Zone and Continental Shelf Law* (i.e., *EEZ Law 1998*) was passed by the Standing Committee of the Ninth National People's Congress. This Law was intended to safeguard China's sovereign rights and jurisdiction over the EEZ and continental shelf and to protect China's maritime rights and interests. Little is known about the effect on China's BTF.

Zero Growth (1999) and Negative Growth (2000): *The first output control measures, shifting focus from production growth to sustainable development.* One of the objectives of the 1986 Fisheries Law was to strongly promote fishery development. Increasing output had remained the priority objective up to the late 1990s, although some policies were issued to protect inshore fishery resources. This political climate, together with China's assessment and promotion system for officials, overemphasized the increase in landings and provided a strong

incentive for officials to overreport catches (Yu & Yu, 2008). But the central government soon realized that its fishery production was unsustainable, and there was a need to remove this incentive (Yu & Yu, 2008). Therefore in 1999, MOA applied the 'Zero Growth' policy to its marine capture fisheries to control the irrational increase of fishing capacity and seek sustainable development. The 'Zero Growth' policy explicitly stipulated that the nation's marine catch in 1999 was not allowed to exceed the level in 1998. MOA considered this policy generally successful as the reported marine catch of that year only increased 0.06% compared with reported catch in 1998; the reported catch by trawlers decreased 7.3% (556,807 t) (BFMOA, 1999). In 2000, MOA further required a 'Negative Growth' in marine capture fisheries output. As a result, the reported annual catch in 2000 decreased 1.4% as opposed to that in 1999 (BFMOA, 2001). The 'Zero Growth' policy lasted in the following years and the reported total marine catch, as well as the reported catch by trawlers leveled off and never exceeded the ones in 1998 (except for total marine catch in 2015 & 2016; Figure 4b). Some suspected this might be a literally 'under-report' response from the local government to this central government policy (Yu & Yu, 2008). The reconstructed data (from Sea Around Us) showed that the catches of China's marine capture fisheries and BTF indeed decreased after 1998, but both catches returned to grow and overpassed the 1998's level in later eras (Figure 4b).

Fisheries Law 2.0 (2000): Adding a catch quota system and EEZ management as new national regimes, and highlighting that the fishing permit system is a national regime. Because the 1986 Fisheries Law became effective before the advent of UNCLOS and the Code of Conduct for Responsible Fisheries, China renewed the Fisheries Law to strengthen the conservation principle. The new amendment thus 1) incorporated regulations regarding the EEZ regime, 2) highlighted that fishing permit system in place since 1979 was a national regime, and 3) mandated fishing vessels operating in the waters under the bilateral fishery agreements to apply for fishing permits from the central government, 4) established a national catch quota

system and mandated middle-to-large fishing vessels to keep logbooks. Additionally, the appendment also provided specific administrative sanctions for noncompliance with the Law. However, little is documented about the implementation of this Law and its effect on BTF. The fishing permit regime was at least not fully implemented given the existence of large numbers of unregistered fishing vessels as we mentioned earlier. The catch quota system was literally not implemented as explained above in the *Provisions for Fishing Permit Management*. Besides, the sanctions were relatively low (< 50,000 RMB) compared with the benefits that could derive from violating the law, and reports about law enforcement were rare at least during this era.

Distant-Water Fisheries Plan (2001 – 2010): Accelerating the development of high-sea fisheries and providing a national development plan in the following decade. Around the turn of the 21st century, China's fishing vessels moved backward to inshore waters due to the shrinking of offshore traditional fishing grounds after implementing the EEZ regime and bilateral fisheries agreements (Mallory, 2013). To reduce the high fishing pressure in China's EEZs and implement China's 'going global' strategy, the State Council approved the first national development plan for distant-water fisheries (DWF, 2001 – 2010) in 2001. Unlike previous situation of DWF that mainly fished in other nations' EEZs under bilateral agreements, more investments were allocated to high-sea fisheries (e.g., building larger vessels). Such an investment did boost the contribution of high-sea fisheries to DWF according to government reports.

Vessel scrapping and fishers' job transfer (a.k.a., vessel decommissioning scheme, 2002): Providing regulations and subsidies to promote vessel scrapping and fishers' job transfer. Despite MOA issued policies (e.g., Single Control, Double Control, trawl bans in Bohai Sea) to control fishing capacity, the number of fishing vessels, especially small trawlers, operating in China's waters increased substantially after 1985 (Yu & Yu, 2008). Such an out-of-control situation resulted from multiple reasons including vessel privatization and local protectionism

(Yu & Yu, 2008). And then even worse, the bilateral fisheries agreements (with South Korea and Japan) forced many Chinese fishers back towards China, and intensified competition in inshore waters, imposing pressure on already depleted fish stocks and increasing the number of fishing accidents at sea. To diminish these effects and promote sustainable fisheries development, MOA and the State Administration of Work Safety enacted the *Interim Provisions on Fishing Vessel Scrapping* in May 2002 (effective since 23 Jun. 2002; i.e., *vessel-scrapping interim provisions 2002*; replaced by an updated regulation in 2007, see Era 4 below). This regulation provided tentative standards about the legitimate service life for different types of fishing vessels, which must be scrapped after the service. These standards (service life: 13 – 30 years) were determined by the vessel's material (i.e., wood, steel, fiberglass, and steel-mesh cement) and length (thresholds: 12, 24, 45, and 60 m for steel vessels; 12 and 24 m for wooden boats; no thresholds for other type of materials) (revised in the updated regulation in 2007). But the Provisions did not mention sanctions for noncompliance. MOA and the Ministry of Finance established a special fund with an annual budget of ~ 270 million RMB from 2002 - 2004. They allocated this fund to 1) buy fishing vessels (with a minimum horsepower of 20 kW and changed to 10 kW in 2007) from fishers and dismantle them (or sink them as artificial reefs), and 2) provide free training for the fishers to transfer their jobs to other occupations such as aquaculture, fish processing, marine shipping, and recreational fisheries (Li et al., 2009). To regulate the use of this special fund, they issued the *Interim Provisions of Using the Special Fund for Fishers' Job Transfer* in July 2002 (i.e., *fisher-transfer interim measures 2002*). They highlighted that the fund should preferentially target non-selective and destructive fishing vessels including bottom trawlers. Correspondingly, local governments gradually provided additional budgets to support this vessel decommissioning scheme in the following eras. This policy, although did stimulate a consecutive reduction in trawlers, still contains some loopholes (e.g., only for registered vessels in MOA's system).

E4 (2003 – 2012): Resource Conservation with Fuel Subsidy

Minimum-mesh-size standards (2003, 2005): *Providing the first regulations to implement the two gear-regulation regimes in marine fisheries.* The ‘allowable fishing gear’ regime and the ‘minimum mesh size’ regime were required policies by the Fisheries Law for conserving fish stocks in China. To implement the regimes, on 8 Oct. 2003, the MOA issued specific regulations for them – the *Circular on Implementing the Minimum-Mesh-Size Regime in Marine Fisheries* (effective since July 2004; i.e., *minimum-mesh-size standards 2004*). The Circular stipulated minimum mesh sizes for cod-ends of bottom trawlers: 54 mm in two northern seas (East China Sea & Yellow Sea), and 39 mm in the South China Sea. The minimum mesh sizes for bottom trawlers in these two regions were then adopted by the State Bureau of Quality Supervisory, Examination, and Quarantine, and the State Committee of Standardization Management in 2005. In the 2005 State Standards, the minimum mesh size of 54 mm was retained in the two northern seas and trawl nets with double-layer cod-ends, but the minimum mesh size was increased to 40 mm in the South China Sea (i.e., *minimum-mesh-size standards 2005*). However, these regulations were rarely implemented by local government because of the complexity and difficulty in law enforcement (authors’ own observations). MOA made further efforts to deal with this issue in the Era 5. In 2009, in order to guide further policy making, MOA conducted a national survey on fishing gears and methods.

Fishing vessel regulations (2003, 2005): *Providing more regulations for vessel management.* In June 2003, the State Council enacted the *Regulations on Fishing-Vessel Inspection* (effective in August 2003; i.e., *vessel-inspection regulations 2003*). The aims were to 1) provide standard regulations for vessel inspection, 2) ensure fishing vessels meet safety and operation requirements, and 3) reduce environmental pollutions. This is the first and only policy document that provided regulations on fishing vessel inspection in China. It authorized law-enforcement officers to confiscate illegal vessels that have not been certified in a vessel

inspection. This regulation is considered as a critical step for combating illegal fishing activities. Later in 2005, because some trawlers had been transformed to operate other unregulated fishing gears during summer moratorium, MOA issued an emergent circular to prohibit such illegal transition.

Vessel scrapping and fishers' job transfer (2003 - 2010): *The 2nd round of Double Control to reduce fishing capacity in China's EEZs.* After implementing the *Interim Provisions of Using the Special Fund for Fishers' Job Transfer Program (2002)*, on 5 Nov. 2003 the MOA and the Ministry of Finance (MOF) promulgated a more official version – *Provisions of Using the Special Fund for Fisher Transfer Program (i.e., fisher-transfer provisions 2003)*. The new provisions lowered the requirement and expanded the coverage for vessel scrapping. According to the *Interim Provisions*, the scrapped vessel's horsepower should be above 20 kW to be qualified for an allowance (and the higher horsepower, the higher allowance). The 2003 *Provisions* lowered this horsepower threshold to 10 kW and added fishing boats with 'temporal' permits (i.e., vessels operating temporal gears such as bottom trawlers) into the scrapping target. Additionally, the *Provisions* also increased the allowance standard and required local government to allocate additional budget to raise the standard. On 28 Nov. 2003, MOA further enacted an eight-year implementation program (2003 – 2010) to decommission domestic fishing vessels (i.e., *Double Control 2003*). The target was to scrap 30 thousand fishing vessels (i.e., catchers) and reduce a total of 1.269 million horsepower (10% of the level in 2002). The target was allocated into each maritime province. To this end, the central government provided the participating fisher a standard allowance of 5000 RMB/kW to scrap a fishing boat (which might be used to build artificial reefs). Local governments are required to add extra funds to raise the standard in order to attract more participants. In addition, building new vessels were also not allowed unless it was used to replace existing ones and inherit their licenses. Wooden boats, trawlers, and boats using other non-selective fishing gears (e.g., purse seine, stow nets) were

the priority targets of this scrapping program. This eight-year program was considered as very successful. According to MOA's report, the fulfillment of scrapped vessels by 2010 was 27,346 (91% of the target), and the reduced horsepower was 1.52 kW (120% of the target) (BFMOA, 2011). However, MOA also pointed out some challenges such as 1) unbalanced implementation among different regions, 2) few opportunities for fishers to transfer their jobs, 3) illegal construction and illegal vessels, and 4) difficulty in managing fishing gears.

Regulations on Conservation of Biological Resources in Bohai Sea (2004): *Enhancing the protection of fishery resources in the Bohai Sea but exempting small trawlers from the trawl ban.* The central government launched two rounds of trawl ban in the Bohai Sea respectively in 1979 and 1987. However, these attempts failed as perhaps there were too many fishers operating trawl nets in the area and local governments had to protect their interests. Given this challenge, in 2004 MOA enacted a new law – *Regulations on Conservation of Biological Resources in Bohai Sea* (i.e., *conservation regulations in Bohai 2004*). The new Regulations replaced the original *Regulations on Conservation of Fishery Resources in Bohai Sea (1991)*. The phrase change from 'fishery resources' to 'biological resources' implicated that MOA started to add those non-fishery resources (e.g., endangered marine species) into its management scope, as several wildlife conservation laws (e.g., Wild Animal Protection Law 1988) were referenced by the new Regulations. However, a major difference in terms of regulating trawlers between the previous and the new regulations was that smaller trawl nets (here, perimeter of the net opening < 30 m) were exempted from the previous trawl ban in the Bohai Sea, but they should meet the requirements on minimum mesh size. Such a revision can be viewed as a compromise between the central and local governments.

Provisions on Fishing Permit Management (Appendment in 2004): *Speeding up the application process for fishing permits of large marine trawlers.* The original *Provisions on Fishing Permit Management (2002)* did not mention how long the applications for fishing-gear

quota and fishing permit should be processed. Due to the speech by President Hu about 'speeding up administrative examination and approval process' in July 2004, MOA amended the Provisions on 1 July 2004 (i.e., *permit provisions 2004*). The amendment required that administrative examination and approval process for fishing-gear quota and fishing permits of large marine trawlers should be done in 40 and 35 days, respectively. On 20 July 2004, MOA further issued a circular to endow the administrative power of examining and approving fishing permits for large marine trawlers to the three regional Bureaus of Fisheries and Fishing Port Surveillance (i.e., *permit-approval decentralization 2004*). Such a decentralization policy might have facilitated the development of large marine trawlers.

Outline of China's Actions for Conserving Aquatic Biological Resources (2006):

Providing specific targets and long-term vision for aquatic conservation from 2006 to 2050, including specific targets on scrapping trawlers. In Feb. 2006, the State Council delivered the *Outline of China's Actions for Conserving Aquatic Biological Resources* (i.e., *Outline 2006*), which was created by MOA and relevant organizations. The goals of enacting this milestone policy document were to 1) implement the '*Scientific Outlook on Development*' and sustainable development strategy, 2) enhance national ecological development, and 3) conserve and reasonably use aquatic biological resources. The Outline 2006 anchored two specific targets by 2010 and 2020 respectively and a long-term vision by 2050. More specifically, the Outline 2006 adopted the previous vessel-scrapping target (by 2010) and added new vessel-scrapping target by 2020 – scrapping a total of 160 thousand fishing vessels with a total horsepower of 10 million kW. The long-term vision was to make sure that China has abundant aquatic biological resources and clean waters by the middle of the 21st century. To realize the above targets and the long-term vision, the Outline 2006 provided overarching policies to guide 1) fisheries conservation and stock enhancement, 2) aquatic biodiversity conservation and endangered species protection, 3) aquatic ecological protection and restoration, and 4) safeguard measures.

Later in 2006, MOA issued *Some Opinions for Implementing the Outline*, highlighting the priority of reducing trawlers in vessel scrapping targets.

Summer moratorium (2006 & 2009): *Extending moratorium time and enhancing control on bottom trawlers.* The Outline 2006 has driven the upgrading of summer-moratorium policy. On 17 April 2006, MOA extended the moratorium by one month for beam trawl in the East China Sea. The new version spanned a total of two months from 12 p.m. on 16 June to 12 p.m. on 16 August, while the previous one ended at 12 p.m. on 16 July (from 2003 to 2005). In 2009, MOA further extended the moratorium for all bottom trawls (except beam trawl) by moving the starting time half month ahead, from 1 June to 16 May. For beam trawl, the starting date was also moved half month ahead from 16 June to 1 June, but the moratorium length was kept (two months). Correspondingly, to implement these revisions, MOA launched other policies such as the 'special action program' narrated below. Few studies have examined the effects of these two versions of summer moratoriums on China's BTF. One study modeled the effect of the 2009 revision and predicted some improvements on annual catch and protection of spawning stocks of the largehead hairtail (*Trichiurus lepturus*, a major benthic fish stock that were overfished), but little effect on the small yellow croaker (*Larimichthys polyactis*, a traditionally important but depleted benthic fishery stock) (Yan et al., 2010).

Law enforcement special actions (every year since 2006): *Conducting law enforcement patrolling to combat illegal fishing during summer moratoriums.* Driven by the Outline 2006, new summer-moratorium regime, and the 'double control' policy, MOA launched a special action program for law enforcement from June to Oct. 2006 – 'Protecting Fisheries 2006'. The purposes were to 1) combat the illegal fishing vessels, which did not have at least one of the three valid documents (fishing permit, vessel-registration certificate, and vessel-inspection certificate), 2) combat illegal fishing in summer moratorium, 3) enhance fishing vessel management, and 4) examine safety facilities in fishing vessels. It endowed law enforcement

officials the power to 1) confiscate the illegal vessels with median-to-high horsepower (> 44.1 kW), and to detain other illegal vessels at non-home fishing ports – perhaps to avoid ‘local protection’. Since then, MOA continued the special action every year although the focus and purpose has been changed slightly. For instance, since 2007, enhancing the implementation of bilateral fisheries agreements has been one of the missions for the special action (i.e., *Protecting Fisheries 2007*). In 2007, MOA also highlighted the effort to combat illegal fishing, especially bottom trawlers using electrical pulse generators and fishing nets with mesh sizes smaller than the national standards. In 2009, due to the change in summer moratorium regime, the special action focused more on implementing the new summer moratorium arrangement (i.e., *Protecting Fisheries 2009*). The *Protecting Fisheries 2010* prioritized the effort on examining and correcting identifiers¹ of fishing vessels with a horsepower higher than 44.1 kW (or 60 hp) and established a ‘blacklist’ system for tracking those law breakers. In addition to this priority, the *Protecting Fisheries 2011* also focused on combating against maritime violence against law. However, little is known about the influence of these law enforcement campaigns on China’s BTF. Little is known about the effect of these law enforcement actions on China’s BTF.

Fuel subsidy (2006 & 2009): *Supporting local fishers to keep profits and livelihoods as crude oil prices increased.* Due to natural disasters and geopolitical conflicts, crude oil price continued to hike since 2003. Such price rises, especially in 2005, imposed a heavy burden on Chinese industries, including marine fisheries. Trawlers suffered the most as oil consumption can account for over 55% of their total operation cost (Xue et al., 2011). As a response, the State Council issued its opinions on the fuel subsidy policy for all impacted industries (including fisheries) in 2006 (i.e., *fuel subsidy opinions 2006*) (Yu et al., 2016). The amount of fuel subsidy received by a vessel owner depended on the horsepower of the vessel’s major engine.

¹ A code that was painted or pinned with an iron plate on the boat, similar to traffic licence plate and used as the unique identifier of each vessel. Some fishing vessels faked/alterd/copied an identifier to conduct illegal fishing.

Therefore, it might have encouraged trawl fishers to stay in fisheries and even use higher horsepower, which is not in concert with other policies (e.g., Double Control). To regulate the use of the subsidy, MOA and the Ministry of Finance enacted temporal regulations in December 2009 – *Interim Measures for the Use of Fuel Subsidy* (effective in Jan. 2010; i.e., *interim measures of fuel-subsidy funds 2010*). The Interim Measures stipulated that aquaculture vessels and many other motorized fishery vessels were also covered by the fuel subsidy policy. For fishing vessels (i.e., catchers except distant-water catchers), a minimum of three-month operation per year was required to claim for fuel subsidy. Such a mandatory standard was controversy as it might encourage overfishing in the domestic waters. According to China's yearly statistics from 2006 - 2012, fuel subsidy for fisheries was doubled (from 3.2 billion to 35.1 billion RMB), and the expenditure continued to rise except in 2009 due to economic crisis (BFMOA, 2019). Such high financial expenses and negative effects on capacity reduction ranked fuel subsidy as one of the most important and controversial subsidies in Chinese fisheries (He, 2015; Yu et al., 2016).

Five-Year Plans for Fisheries (2006 & 2011, overarching documents): *Providing strategic plans with clear targets for fisheries development and management for the first time in the history.* To better implement the Outline 2006, MOA issue the 11th Five-Year Plan for Fisheries (2006 – 2010) in Nov. 2006 and the 12th Five-Year Plan for Fisheries (2011 – 2015) in Oct. 2011. These Plans were considered as the overarching documents for guiding China's fisheries development and management. The former plan was the first time of conducting Five-Year Plan for fisheries in China; The plan aimed to 1) enhance fishery-resource conservation through protecting juvenile fish and encouraging the use of selective gears; 2) encourage the development of distant-water fisheries, and, importantly, 3) reduce the use of bottom trawlers. The latter plan continued the emphasis on reducing fishing capacity in domestic waters while supporting distant-water fisheries. However, there were no quantitative targets for these goals,

except for the fishing-capacity reduction (i.e., Double Control) in general. Moreover, the real targets and achievements on Double Control were unknown given they were not consistent among the government's reports and peer-reviewed literature. For instance, in the original document of the 11th Five-Year Plan, the Double-Control target was reducing 1) the total number of motorized marine fishing boats from 215,000 in 2005 to 192,000 in 2010 (i.e., scrapping 23,000 vessels), and 2) the total horsepower from 12.36 million kW to 11.43 million kW (MOA, 2006). These numbers were somehow revised to 231,000 catchers and 13.9 million kW in 2005 and 208,000 catchers and 12.96 million kW in 2010 in the review section (about the 11th Five-Year Plan for Fisheries) of the 12th Five-Year Plan for Fisheries (MOA, 2011). However, a review paper authored by an official from MOA claimed that the nation's target between 2006 and 2009 was only scrapping 7237 vessels, which is surprisingly low in contrast to the target of scrapping 23,000 vessel between 2005 and 2010 mentioned above; and it was claimed that the nation accomplished 69% of this target (Li, 2011).

Enhancing fishing-vessel management and double control in the 12th Five Year (2011):

Continuing to reduce fishing capacity of bottom trawlers in domestic waters. In 2011, MOA issued a circular to further enhance fishing-vessel management and double control in the 12th Five Year (2011 – 2015, i.e., *Double Control 2011*).

Interim Measures for Managing Conservation Areas of Fishery Germplasm Resources (2011): First legislation for establishing, reviewing, and managing fishery-conservation areas.

From 2007 to 2011, MOA has established 220 National Conservation Areas of Fishery Germplasm Resources (PAFG). With the growth in PAFG and the increasing conflicts with sea-use activities such as sea-filling projects, there was an urgent demand for legislation to enhancing the management of these protected waters. After broad consultation and studies, MOA enacted the *Interim Measures for Managing Protected Areas of Fishery Germplasm Resources* in Jan. 2011 (i.e., *conservation-area measures 2011*). The Interim Measures 1)

confirmed the requirements, approval procedure, and authority for establishing the PAFG, 2) defined administrative organizations and their responsibilities for protecting these waters, 3) stipulated human activities that were prohibited or limited in the PAFG, and further improved the procedure of environmental impact evaluation relevant to PAFG. But based on our observations in Hainan, Guangxi, and Guangdong, these measures were not be fully implemented. The voice of fisheries authority was relatively low in local government systems.

E5 (2013 – 2018): Fisheries Transformation towards Sustainability with Bans Ahead

Opinions upon Advancing Sustainable and Healthy Development of Marine Fisheries (hereafter, Opinions 2013; overarching policy): *Calling for transforming China's fishery industry towards sustainable and healthy development.* The State Council announced the Opinions 2013 in March shortly after the Chinese New Year of 2013, showing that marine fishery development has attracted the attention of China's top leaders. These goals covered the general targets for marine fishery output, mariculture scale, capture fisheries, fishing processing, fishers' income, fishing facilities and vessels, industry system development, and fishery conservation. Most of these targets were not quantitative and vague statements. For instance, the targets of the first phase were to 1) keep annual seafood output around 30 million tons (which is the level in 2012) and the mariculture area around 2.2 million ha (and constrain the sea-use area within 1.15 million ha); 2) effectively control inshore fishing capacity, continuously advance the comprehensive production capacity of offshore and distant-water fisheries, and scale up seafood deep-processing; 3) significantly improve fishery organizing level, and steadily improve fishers' income, 4) advance fishing-vessel facilities and fishing security, 5) modernize its fishery industry system and logistics system, and 6) significantly improve conservation and restoration of aquatic biological resources, and improving fishery ecological environment. To this end, the Opinions required that future work should 1) *focus on accelerating the transformation of the development mode of marine fisheries*, 2) *keep ecological protection as the priority*, 3) *combine*

the development of aquaculture and capture fisheries with the former as the major direction, 4) control inshore fisheries, 5) expand offshore fisheries, 6) develop distant-water fisheries, and 7) adhere to the combination of resource utilization and ecological protection.

More specifically, the Opinions clearly pointed out that the government should 1) *improve the fishing permit regime*, 2) *conduct pilot projects of ‘individual catch quota’ in inshore waters*, and 3) *strictly constrain fishing intensity in inshore waters*. Importantly, it also mentioned that fishery governments should *firmly restrict the construction of new bottom trawlers and fishing vessels using other destructive gears*. As a response, in July 2013, MOA issued its opinions on how to implement these central-government opinions (i.e., Detailed rules for implementing Opinions 2013). Among these implementation opinions, MOA specifically announced to start pilot projects on *‘individual catch quota’ and enhance law enforcement, especially combating illegal fishing vessels*. Since ~ 2017, several major fishing provinces, including Zhejiang and Shandong, and later in 2018 Liaoning, Guangdong, and Fujian, have pioneered in conducting such catch quota pilot projects; however, these projects did not cover trawling fisheries (Huang & He, 2019; Yang, Liu, & Li, 2018), perhaps due to the non-selective nature of trawls.

Resource-fee reforms (2015): Facing the dilemma between reducing burden on fishers and reducing fishing pressures. In December 2014, the State Council exempted the resource fee for small business fishery cooperatives including commercial households, as a measure to reduce financial burden on them and stimulate economic growth (effective in Jan. 2015; i.e., *resource fee exemption 2015*). Shortly after that, in Feb. 2015, MOA enacted a circular that provided detailed regulations for the resource exemption policy (i.e., *detailed rules for resource-fee exemption 2015*). In October 2017, MOA conducted surveys on the appended *Measures for the Collection and Use of Fishery-Resource Fee*. The appended Measures attempted to 1) divide the resource fee to two categories, i.e., exploitation fee and damage compensation fee, and 2) levy higher fees than previous levels of resource fee. This indicates MOA’s willingness to

use the new resource fees as economic leverage to reduce fishing pressure in China's waters. However, the appended Measures have not been officially enacted yet, perhaps due to its contradictory effect against the spirit of the State Council for reducing burden on fishers.

Trawl-reduction policies (2013, 2016, 2017): *Launching a new wave of trawl bans and reductions.* The number of trawlers decreased gradually since 2003 after the vessel scrapping and Double Control policies were in place. However, there was an abrupt increase in 2012 for unknown reasons (Figure 4c). Perhaps because of this trend, in Nov. 2013, MOA issued the *Circular on Banning 13 Types of Fishing Gears Including Pair Trawls Using Multiple Codends with a Single Piece of Webbing* (effective on 1 January 2014; i.e., *forbidden gears 2014*). The Circular cited three overarching documents (Fisheries Law, Regulations on Protecting Biological Resources in Bohai Sea, and the Outline 2006) as the legal basis. The goal was to 1) enhance fishing gear management, 2) consolidate the achievements on the special actions for combating illegal fishing gears, and 3) protect marine fishery resources. In addition to the pair trawls using multiple codends with a single piece of webbing, 12 other destructive and non-selective fishing gears including various rakes, traps, and beach seines were on the ban list. The Circular endowed local law-enforcement organizations the right to inspect and confiscate these banned gears and deduct (partly or fully) the fuel subsidy (of the year) for fishing vessels using these gears in fishing practices.

In May 2016, MOA issued the *Guidance of the Ministry of Agriculture on Accelerating the Adjustment of the Fisheries Structure and Mode Transfer* (i.e., *accelerating fisheries transformation 2016*), which was based on the leaders' speech in the National Conference of Fishery and Fishery Management in April 2016. In this document, MOA highlighted the focus on reducing fishing capacity and pressure in China's waters through 1) implementing further input and output controls, 2) launching pilot projects of 'individual catch quota', 3) phasing out pair bottom trawls and other non-selective and destructive gears, and 4) standardizing fishing gears

and operation methods. In January 2017, MOA further issued the *Circular on Further Strengthening Control of Domestic Fishing Vessels and Implementing Total Allowable Catch in Marine Fisheries Management* (i.e., *Double Control 2017*). Within this document, MOA prohibited the construction and import of new fishing vessels into domestic waters, and forbidden permit issuing for building pair bottom trawlers. These prohibitions were not fully implemented until Jan. 2019 (R. Guo, personal communication, May 10, 2019).

Other input-control regulations (2013, 2015, 2018): *Providing new regulations for regulating fisheries inputs (vessels and horsepower).* In 2013, MOA enacted the appended *Provisions on Fishing Permit Management* (i.e., *permit provisions 2013*), which *decentralized the power of fishing-permit approval for large trawlers to provincial fishery governments*. In Nov. 2015, MOA provided specific measures for using the vessel-scraping and -standardization funds (i.e., *vessel scrapping and standardization 2015*). The measures emphasized that *'pair trawlers, as well as other destructive gears, have the priority to be scrapped, and upgrading these destructive gears will not be subsidized by the government'*. In December 2018, MOA enacted the newly revised *Provisions on Fishing Permit Management* (i.e., *permit provisions 2018*). Compared with the 2013 version, the new Provisions *prohibited application of fishing-gear quota for the construction of pair trawlers*. Otherwise, the new Provisions also made several revisions such as redefining the three levels (large, medium, small) of marine fishing vessels based on vessel length rather than horsepower as in 2013 (as horsepower can be mislabeled). The new policy mandated that *moderate ($12\text{ m} \leq \text{length} < 24\text{ m}$) and large ($\text{length} \geq 24\text{ m}$) trawling vessels are not allowed to fish within the NTZ*. If these vessels need to fish within the zone due to traditional operation habits, local governments should report this to MOA. *Small vessels ($\text{length} < 12\text{ m}$), especially those using stationary gears, should only be operated within the zone and not cross the provincial/municipal administrative boundaries*.

Fuel subsidy reduction (2015): *Reducing subsidy for trawlers, with an aim to gradually phase out pair trawlers and other destructive gears.* The fuel subsidy has been criticized both domestically and internationally for its counteracting effect on other resource-protection policies (He, 2015; Sumaila et al., 2006; Zhu & Huang, 2014). The leaders in MOA also realized this serious impact and attempted to negotiate with the Ministry of Finance (MOF), who allocated the subsidies, to reduce / withdraw this harmful policy (R. Guo, personal communication, Jan. 10, 2017). Given the crude oil price was going downward in recent years, the two governments encountered a good opportunity to make a deal. In September 2015, MOA and the MOF issued the *Circular on Adjusting Fuel Subsidy Policy and Advancing Sustainable and Healthy Development of Fisheries* (i.e., *subsidy reduction 2015*). This circular addressed the conflict between the fuel subsidy policy and the ‘vessel scrapping’ policy. It highlighted that fuel subsidy will no longer depend on fuel consumption. The goal is to reduce fuel subsidy by 40% from 2014 to 2019. It allocated 20% of the fuel subsidy fund to support vessel-scrapping and updating projects. The new policy also mentioned that pair trawlers should be phased out gradually. It demanded that the provincial governors are fully responsible for implementing the new fuel-subsidy policy as a measure to better enforce it in each province. Although little was known about the effect of this reform on China’s BTF, it presumably facilitated the trawl reduction in later years (Figure 4c).

Optimized summer moratorium (2017): *Extending moratorium and addressing some issues in former versions.* Previously, the starting time for summer moratorium in different seas (or for different gears in the same sea) were not consistent. Such inconsistency induced some fishers to fish over the boundary of the seas, and some drift-net vessels illegally operate trawl nets (as some drift nets were exempted from the summer moratorium). On 19 January 2017, to solve this problem, MOA published the new summer moratorium arrangement by a circular (i.e., *optimized summer moratorium 2017*). The circular embraced all drift nets in the summer

moratorium leaving only hooks and lines being exempted. It also started the summer moratorium for all demanded gears from 1 May, although the ending data remained variable for different gears as usual. The closure period for bottom trawlers was extended to three – four months for different gears and regions. In 2018, this new summer moratorium was slightly adjusted for fixed gears, which was then mandated to also start moratorium from 1 May. Few studies have examined the effect of this reform.

The 13th Five-Year Plan for Fisheries (2017): *Providing new overarching plans for the development of marine fisheries.* In February 2017, MOA issued the *13th Five-Year Plan for Marine Fisheries Development (2017 – 2020)*. This new Five-Year Plan mandated 1) a negative-growth policy to constrain the domestic annual marine catch below 10 million tons, 2) a continuous double-control policy by scrapping another 20 thousand fishing vessels (a total horsepower of 1.5 million kW) especially pair trawlers, and 3) further combatting illegal fishing and gears. In October 2017, MOA also issued the *13th Five-Year Plan for Distant-Water Fisheries*. This Plan indicated a vision shift from encouraging development to seeking development quality and fisheries upgrading. It mandated that 1) the number of distant-water vessels should be kept lower than 3,000 by 2020, and 2) the number of companies should remain as the same as in 2016. Meanwhile, more resources should be allocated to 1) professionalize, standardize, and modernize these vessels, 2) cultivate cooperatives that can be internationally competitive, and 3) improve the management system to curtail illegal fishing in foreign waters. The effects of these Plans on China's BTF are to be seen in the future.

Circular on Implementing the Provisions on Minimum Catchable Size and Juvenile Catch Ratio for 15 Commercial Fish Stocks Including Large-head Hairtails (hereafter, catchable size & juvenile ratio 2018): *Providing the first national standards on minimum catchable size and juvenile catch ratio for important fish stocks.* To protect juvenile fish and advance marine fish-stock rebuilding and sustainable exploitation, MOA compiled and enacted

these standards for 15 commercial fish stocks, such as the large-head hairtail. More specifically, the *catchable size & juvenile ratio 2018* mandated that catch ratio of juveniles (by weight) per fishing trip should not higher than 50% in 2018, 30% in 2019, and 20% in 2020 afterwards. The Circular indicated that juvenile-fish protection became more serious in law enforcement. However, little is known about whether these good-intentioned standards were implemented or not. Given the expected difficulty in law enforcement, these new standards may not be implemented yet.

Law-enforcement regulations (2013 - 2018): Promoting law enforcement for multiple policies. In January 2014, MOA issued a circular to further promote the implementation of the *minimum-mesh-size standards 2014* and *forbidden gears 2014*. To facilitate the law enforcement on the resource-fee reform, In April 2016, MOA published a circular to demand continuously combating ‘annihilation nets (a.k.a., jue hu wang)’ and other illegal fishing gears including trawls (i.e., *combating illegal fishing gears 2016*). In August 2016, the Supreme Court of Justice enacted the *Provisions on Hearing Illegal-fishing Cases*, as the first judicial guidelines in dealing with illegal fishing in China. In April 2017, MOA delivered the *Circular on Combating Illegal Fishing Gears for the Year 2017* (i.e., *combating illegal fishing gears 2017*). This Circular emphasized the combating focus of 2017 was illegal fishing gears that violate the ‘minimum mesh size’ regime and using additional inner nets (such as those in trawl codends and other gears). In 2018, MOA determined to launch a one-year special action (Oct. 2018 – Nov. 2019) to strike illegal fishing gears that using electrical pulse devices (i.e., *combating illegal fishing gears 2018*). These law-enforcement enhancing measures might gradually become routine in China’s fisheries management, but little was known about the effect on BTF to the present.

References cited

BFMOA. (1999). *China fishery statistical yearbook 1999 (in Chinese)*. Beijing: China Agriculture Press.

- BFMOA. (2001). *China fishery statistical yearbook 2001 (in Chinese)*. Beijing: China Agriculture Press.
- BFMOA. (2011). *China fishery statistical yearbook 2011 (in Chinese)*. Beijing: China Agriculture Press.
- BFMOA. (2019). *China fishery statistical yearbooks 1979 - 2019 (in Chinese)*. China Agriculture Press, Beijing (in Chinese).
- Chen, S. (1982). The East China Sea Bureau of Fisheries holding the summing-up meeting for the juvenile ratio inspection program (in Chinese). *Marine Fisheries*, (1), 38. Retrieved from <http://www.cqvip.com/qk/93342X/198201/15142671.html>
- Chen, Y., & Teligenbaiyi, B. (2010). The summer moratorium regime in China's marine fisheries (in Chinese). *Hebei Fisheries*, (9), 46–50. Retrieved from <http://mall.cnki.net/magazine/article/HBYU201009018.htm>
- Cheng, J., Yan, L., Lin, L., & Yu, L. (1999). Analyses on the fishery ecological effect of summer moratoria in the East China Sea (in Chinese). *Journal of Fisheries Sciences of China*, 6(4), 81–85. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotat-ZSCK199904018.htm>
- Fang, S., Su, X., & Yang, S. (2002). Several factors that hindered the implementation of the catch quota regime (in Chinese). *China Fisheries Economics*, (6), 37–39. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotat-ZYJJ200206019.htm>
- Funge-Smith, S. (2014). APFIC/FAO Regional Expert Workshop on Regional guidelines for the management of tropical trawl fisheries in Asia, Phuket, Thailand, 30 September-4 October 2013. *RAP Publication*, (2014/01).
- Gao, J., & Ping, Y. (2002). Discussion on the factors restricting the flow of human resources in China's marine capture fisheries (in Chinese). *Chinese Fisheries Economics*, (5), 16–17. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotat-ZYJJ200205005.htm>
- Guo, C. (2002). The summer moratorium regime needs to be improved. *Fisheries Administration*, 3, 19–20.
- Han, D., Shan, X., Zhang, W., Chen, Y., Wang, Q., Li, Z., ... De Silva, S. S. (2018). A revisit to fishmeal usage and associated consequences in Chinese aquaculture. *Reviews in Aquaculture*, 10(2), 493–507. <https://doi.org/10.1111/raq.12183>
- He, J. (2015). Chinese public policy on fisheries subsidies: Reconciling trade, environmental and food security stakes. *Marine Policy*, 56, 106–116. <https://doi.org/10.1016/j.marpol.2014.12.021>
- Huang, K. (2001). Exploration on fishing permit management method (in Chinese). *China Fisheries Economics*, (4), 31. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotat-ZYJJ200104017.htm>
- Huang, S., & He, Y. (2019). Management of China's capture fisheries: Review and prospect. *Aquaculture and Fisheries*. <https://doi.org/10.1016/j.aaf.2019.05.004>
- Li, M., Jin, X., & Tang, Q. (2012). Policies, regulations, and eco-ethical wisdom relating to ancient Chinese fisheries. *Journal of Agricultural and Environmental Ethics*, 25(1), 33–54. <https://doi.org/10.1007/s10806-010-9288-9>
- Li, P., Liang, N., Yuan, F., & Liu, Q. (2009). Implementation effectiveness of fishers' job-transfer

- policies in Guangdong coast (in Chinese). *China Fisheries Economics*, (1), 79–83. Retrieved from <http://mall.cnki.net/magazine/article/ZYJJ200901024.htm>
- Li, Y. (2011). “Eleventh Five-Year” fishery development has reached a new level in an all-round way-Summary of “11th Five-Year” fishery achievements (in Chinese). *China Fisheries*, (3), 11–19. Retrieved from <http://mall.cnki.net/magazine/article/SICA201103008.htm>
- Liu, X., & Huang, S. (1999). A preliminary analysis of China’s fishing permit regime (in Chinese). *Marine Fisheries*, (3), 101–104. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotal-HTYY199903002.htm>
- Mallory, T. G. (2013). China’s distant water fishing industry: Evolving policies and implications. *Marine Policy*, 38, 99–108. <https://doi.org/10.1016/j.marpol.2012.05.024>
- MOA. (2006). *The 11th Five-Year Plan for Fisheries (2006 - 2010) (in Chinese)*. Ministry of Agriculture (MOA), P.R.C. Retrieved from http://www.wanfangdata.com.cn/details/detail.do?_type=perio&id=zhongguosc200612001
- MOA. (2011). *The 12th Five-Year Plan for Fisheries (2011 - 2015) (in Chinese)*. Ministry of Agriculture (MOA), P.R.C. Retrieved from http://www.moa.gov.cn/nybg/b/2011/dshiq/201805/t20180523_6142898.htm
- Pan, P., & Li, W. (2016). Status and evolution of China’s summer moratorium regime (in Chinese). *China Fisheries*, (10), 36–40. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotal-SICA201610021.htm>
- Shen, G., & Heino, M. (2014). An overview of marine fisheries management in China. *Marine Policy*, 44, 265–272. <https://doi.org/10.1016/j.marpol.2013.09.012>
- Shijun, G. (1993). China’s Agenda 21”: China’s program in implementing the sustainable development strategy. *China Population, Resources and Environment*, 3(4), 11–16.
- SOA. (1996). *China Ocean Agenda 21 (in Chinese)*. State Oceanic Administration Beijing.
- Sumaila, U. R., Teh, L., Watson, R., Tyedmers, P., & Pauly, D. (2006). Fuel subsidies to global fisheries: Magnitude and impacts on resource sustainability. In R. U. Sumaila & D. Pauly (Eds.), *Catching more bait: a bottom-up re-estimation of global fisheries subsidies (2nd Version, 2007) Fisheries Centre Research Reports* (Vol. 14, p. 38). Fisheries Centre, the University of British Columbia, Vancouver, Canada.
- Sun, Z., Zhou, J., Wang, J., Zhao, Z., Zhuang, S., Chen, B., ... Meng, W. (2011). Investigation and analysis of trawl gears in the Yellow Sea and Bohai Sea (in Chinese). *Progress in Fishery Sciences*, 32(5), 126–134. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotal-HYSC201105020.htm>
- Tang, Q., Jia, X., Zheng, Y., Cheng, J., Wan, R., Wang, J., ... (2012). *Regional Oceanography of China Seas - Fisheries Oceanography (in Chinese)*. (Q. Tang, X. Jia, Y. Zheng, & J. Cheng, Eds.). Beijing: Maritime Press.
- Tu, F. (2009). Key transitions in the fisheries development history of the New China - Reasons for enacting the No. Five Central Document and its impact (in Chinese). *China Fisheries Economics*, (1), 11–14. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotal-ZYJJ200901008.htm>
- Wang, S. D. H., & Zhan, B. (1992). Marine fishery resource management in PR China. *Marine Policy*, 16(3), 197–209. [https://doi.org/10.1016/0308-597X\(92\)90081-Y](https://doi.org/10.1016/0308-597X(92)90081-Y)

- Xiao, L., & Li, Z. (2007). Shouldering the mission and safeguarding fisheries development in China - interview with the previous chief economic manager and previous director of fisheries bureaus Zho Youzhan (in Chinese). *China Fisheries*, (11), 4–7. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotol-SICA200711003.htm>
- Xue, G. (2004). The LOSC and China's Practice: Sino-Japanese and Sino-Korean Fisheries Agreements. *Maritime Studies*, 2004(139), 1–8.
- Xue, L., Lu, Z., Zhou, Y., & He, Z. (2011). Study on Status of the Beam Shrimp Trawl Fishery in Zhejiang Province. *Modern Fisheries Information*, 26(5), 6-8 (in Chinese).
- Yan, L., Hu, F., Li, S., Liu, Y., Zhou, Y., & Liu, Z. (2007). The effect of summer moratoria and the reasonable utilization of the hairtail (*Trichiurus japonicus*) in the East China Sea (in Chinese). *Journal of Natural Resources*, 22(4), 606–612. Retrieved from <http://www.cqvip.com/qk/87801X/200722/25913994.html>
- Yan, L., Liu, Z., Li, S., Ling, Ji., Li, J., & Li, Z. (2010). Effects of new summer close season of trawl fisheries on fishery ecology and resource enhancement in East China Sea (in Chinese). *Marine Fisheries*, 32(2), 186.
- Yang, Zhengyong, & Shen, X. (2005). Effects of the characteristics of natural resources on the transaction cost of the ITQ regime (in Chinese). *China Fisheries Economics*, (5), 25–28. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotol-ZYJJ200505007.htm>
- Yang, Zijiang, Liu, L., & Li, M. (2018). Development phases and important reforms of China's fisheries over past four decades (in Chinese). *China Fisheries*, (10), 23. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotol-SICA201810023.htm>
- Yu, Huiguo, & Yu, Y. (2008). Fishing capacity management in China: Theoretic and practical perspectives. *Marine Policy*, 32(3), 351–359. <https://doi.org/10.1016/j.marpol.2007.07.004>
- Yu, Huming. (1991). Marine fishery management in PR China. *Marine Policy*, 15(1), 23–32. [https://doi.org/10.1016/0308-597X\(91\)90040-I](https://doi.org/10.1016/0308-597X(91)90040-I)
- Yu, S., Shui, B., Ge, C., Xu, Y., & Ji, M. (2016). Problems in implementing fuel subsidy and suggested reforms (in Chinese). *Management Observation*, (33), 54–57. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotol-GLKW201633019.htm>
- Yue, D., Wang, L., Cao, K., Ming, J., & Liu, Z. (2017). Adjustment history and improvement measures of marine capture fishery resources enhancement and conservation fee: Taking Shandong and Zhejiang as examples. *China Agriculture Science Bulletin*, 33(32), 149-154 (in Chinese). Retrieved from <http://www.cnki.com.cn/Article/CJFDTotol-ZNTB201732026.htm>
- Zhang, J. (2008). Improving the system of fishing closure and promoting the rational exploitation and utilization of fishery resources - In July 1995, China first implemented a comprehensive summer fishing closure system in the East China Sea and Yellow Sea (in Chinese). In *Proceedings of Chinese Fisheries Reform and Development Conference*. Beijing: China Fisheries Association (pp. 85–89). Retrieved from <http://cpfd.cnki.com.cn/Article/CPFDTOTAL-ZYYE200810002015.htm>
- Zhao, S. (1993). Deng Xiaoping's southern tour: elite politics in post-Tiananmen China. *Asian Survey*, 33(8), 739–756.
- Zhong, Y., & Power, G. (1997). Fisheries in China: progress, problems, and prospects. *Canadian Journal of Fisheries and Aquatic Sciences*, 54(1), 224–238.

<https://doi.org/10.1139/f96-265>

Zhu, L., & Huang, S. (2014). The impact of fishery fuel subsidy policy on fishery resources and policy suggestions (in Chinese). *Journal of Shanghai Ocean University*, 23(4), 618–622. Retrieved from <http://www.cnki.com.cn/Article/CJFDTotat-SSDB201404020.htm>

Zhu, Y. (2009). *An evaluation on the effect of China's summer moratoria (Dissertation in Chinese)*. Ocean University of China.

Zou, K. (2003). Sino-Japanese joint fishery management in the East China Sea. *Marine Policy*, 27(2), 125–142. [https://doi.org/10.1016/S0308-597X\(02\)00086-6](https://doi.org/10.1016/S0308-597X(02)00086-6)

Zou, K. (2005). The Sino-Vietnamese agreement on maritime boundary delimitation in the Gulf of Tonkin. *Ocean Development & International Law*, 36(1), 13–24.