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# A step forward to the joint management of the South China Sea fisheries resources: Joint works on catches, management measures and conservation issues

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ABSTRACT

Degradation of the fishery resources in the SCS has been frequently reported, and calls for international cooperation through establishing an international or multilateral fisheries management organization were frequently made in recent years. However, little progress has been observed in this regard and most resources in the region are not subject to any regional cooperative management, mainly due to the disputes of sovereign rights on the SCS. In order to bypass such disputes and take a practical step forward towards reaching the goal of joint management for the SCS fisheries, a 'bottom-up approach' was undertaken through holding a "SCS Fisheries Resources and Management Workshop" in 2017 which is a non-political, depoliticized and non-State driven forum with key SCS fishing actors providing and exchanging substantive information on their individual fisheries for building up mutual understanding and confidence as the first step for further collaboration on the management of SCS fisheries resources. Based on information from the Workshop and substantial joint works afterwards, for the first time, this study have successfully compiled and presented basic information on (1) the fisheries statistics from key fishing actors of the region, (2) the management measures implemented by each fishing actor, and (3) subjective evaluations from managers/scientists of the key fishing actors through a questionnaire study on the causes of the stock depletion and/or the key issues that should be addressed for any potential stock recovery. Several statistical issues have been identified, and a further review of the existing statistical systems of the participating parties was recommended as an important topic for future meetings. Communication and mutual understanding of the management measures designed for and implemented in the region are considered crucial for the future construction of any regional collaborative management scheme. High priority issues that were emphasized by the respondents of the questionnaire study include insufficient control on fishing capacity and fishing efforts as well as weak law enforcement; which may relate to the issues of insufficient enforcement resources, low policy priority and institutional weakness.

## 1. Introduction

The South China Sea (SCS), a Large Marine Ecosystem (LME), is home to at least 3365 known species of marine fishes and provides an estimated 12% of the world's total fishing catch, worth of US$21.8 billion [1]. The fisheries resources of the SCS is an important source of animal protein to the surrounding populations of China, Hong Kong, Macau, Taiwan, the Philippines, Malaysia, Brunei, Indonesia, Singapore, Vietnam, Thailand, and Cambodia (with a total population of about 2 billion in 2017 [2]), and the fisheries exploiting these resources are the core economic activities for the local communities. However, heavily populated coastal areas and high market demand for fisheries products have put immense fishing pressure on the fisheries resources in coastal waters throughout the SCS (see review in Ref. [3]). Uncontrolled fishing pressure has caused depletion of total fish stocks by 70–95% since the 1950s and decline of catch rates by 66–75% over the last 20 years, an indication of severe over-exploitation [3–5]. Such status is a result of, among other factors such as habitat degradation, improper management of the fisheries by nations in the region in terms of controls over, for example, fishing capacity, fishing efforts, fishing gears (using of destructive fishing practices), and fisheries subsidies [5–8].

Public concerns were raised on the status of these precious marine living resources [9,10], and calls were made for establishing an international or multilateral regional fisheries management organization (RFMO), or international marine protect areas and marine peace parks, in the region so as to effectively manage the resources in a cooperative manner [7,8,11,12]. However, such living resources are still managed, or unmanaged, by the surrounding fishing nations at their own discretion and are under severe over-exploitation pressures. The calls for conservation and management are mostly muffled by political disputes over the sovereign rights in the region; and such disputes have further worsened the resources status by encouraging regional competition of fishing in this open access region [7,13].

Establishing an international or multilateral RFMO is a type of 'top-down approach' (Chang and Hu, unpublished data[2]) in the sense that such approach is taken by the central governments of multiple states collectively and/or under the initiative of a few leading states, not by the concerned fishing industries and/or fisheries scientists. Such approach

[2] S.-K. Chang, N.-T.A. Hu, Taiwan's fisheries and the South China Sea: Development, policies, and prospects of regional cooperation. (unpublished data).

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would require first negotiating for the establishment of a cooperative management scheme through an agreed legally binding instrument (or the constitutive/constituent agreement for an envisaged RFMO) and then developing needed conservation and management measures through a pre-determined decision-making process under the framework of such legally binding instrument which establishes such RFMO. This approach has not been successfully taken in the SCS region in the last decades and is expecting to take years in the future due to competing territorial claims in the region and the lack of political trust among coastal nations or fishing actors [8,15]; but the fish cannot wait. In facing with such a painful reality, without another alternative approach or other substantive actions being taken, the fisheries will decline further, with dire consequences for the region [12].

Fish are much more tangible objects of negotiation than sovereignty or historical entitlement claims, and thus sovereignty and sustainability need to be separated [7]. Therefore, Chang and Hu (unpublished data) proposed a 'bottom-up approach' for which no intergovernmental meeting is called; rather, only fisheries managers and scientists from SCS fishing actors participate in a forum of 'second-track' nature (explained later) so as to bypass the current disputes. The primary aims of such approach are to understand the status quo of the SCS fisheries and their management as the first step, and as a result of such understanding, collectively proposing the necessary conservation and management measures to be implemented by the SCS fishing actors through a gradual consensus and confidence building process, as suggested by D. Pauly to "discuss issues that you can agree on, and build trust" [16]. With such a bottom-up approach, multilateral collaboration on the coordination of collection and compilation of fisheries catch data and fisheries management information could go first before any regional legally-binding instrument is adopted and formal RFMO is established.

Based on this idea, a scientific workshop entitled "South China Sea Fisheries Resources and Management Workshop" (refer to as the Workshop hereinafter) was organized and held on 4–5 June 2017 by an academic institution, the Graduate Institute of Marine Affairs (GIMA) of the National Sun Yat-sen University (NSYSU), in Kaohsiung, Taiwan. National fisheries scientists and/or managers of the top seven fishing actors of the SCS, namely China (including Hong Kong), Viet Nam, Thailand, Malaysia, Indonesia, the Philippines, and Taiwan, in catch amount order, which contributed about 99% of the SCS total catch (estimated from Ref. [17]) were invited as 'participating parties'. Although two participating parties were absent from the Workshop at the last stage, they were contacted afterwards through email and face-to-face communications. The Workshop was conducted in a 'track two dialogue' fashion in which invitees who had governmental affiliation would speak on his or her own personal capacity, rather than speaking on behalf of his or her governments. The Workshop was also proceeded under the 'Chatham House Rule' [18], i.e., national fishery and management information were gathered and compiled without specifically naming or referring to the sources. Thus, no political talks occurred in the Workshop, and only information on fishing data and fisheries management practices of each participating parties was exchanged and compiled; the Workshop begins to function as a 'clearing-house mechanism' [19,20] [3] in the region for fisheries data and

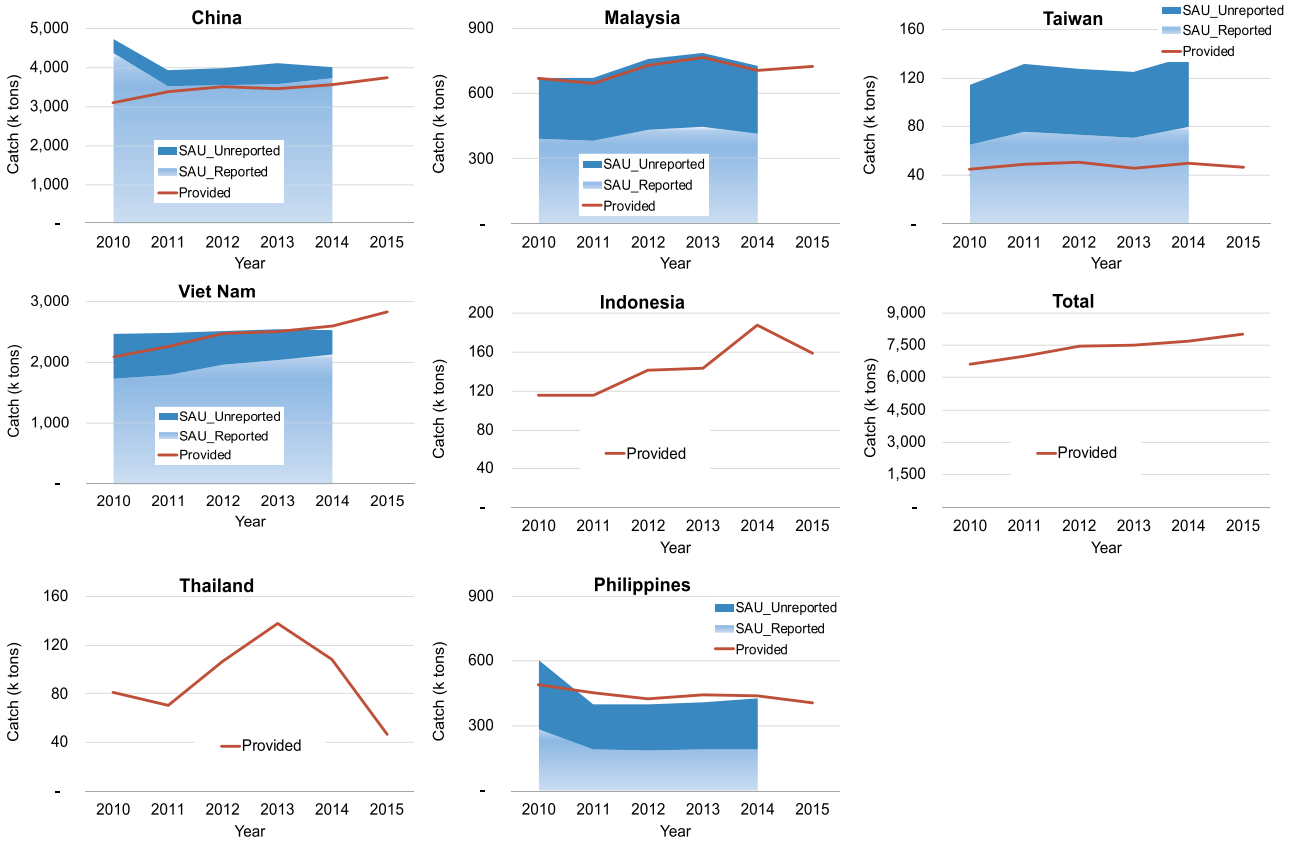


**Fig. 1.** Total SCS catches of the seven major fishing actors in the SCS, including those provided by participants of the fishing actors to this work (Provided) and those estimated by the *Sea Around Us* (SAU_Reported and SAU_Unreported) [17].

[3] For Convention on Biological Diversity, a Clearing-House Mechanism serves to: promote and facilitate technical and scientific cooperation within and between countries; develop a global mechanism for exchanging and integrating information on biodiversity; and, develop a human and technological network [19].

management information collection and sharing.

Three subjects having least political implications were discussed in the Workshop: fishery statistics, management measures, and key reasons leading to resource degradation along with key issues for recovery. Much new information was presented and discussed for the first time. The discussion in the Workshop was a starting point; further substantial efforts were made afterwards for clarifying catch estimates for the SCS region, screening and harmonizing the management measures implemented, and increasing sample size and analyzing opinions on the key issues. A total of 25 participants from the seven SCS fishing actors (hereinafter referred as 'participants' to this work) contributed to this work, including those attending the Workshop and those absent but were contacted afterwards. The major outcomes presented in this paper focus on the three aspects: (1) Fisheries of the SCS fishing actors, with information on the fishery status of recent six years (2010–2015); (2) Management measures of the SCS fishing actors, with information on the management measures taken by each SCS fishing actor; (3) Experts' (participants) opinions associating with the current depletion or future recovering of the SCS resources, presenting descriptive results of a questionnaire study on the issues that have driven the SCS fish stocks to a depleted status or that need to be addressed for recovering the stocks. This collective information sheds light on the status of the fisheries in the SCS and could thus form a substantive base for further exploration and improvement of the catch statistics systems in the region, for shaping regional fisheries management initiatives, and for identifying target issues necessarily to be tackled for conserving the resources in the SCS.

## 2. Fisheries of the SCS fishing actors

### 2.1. Fisheries information provided by participants

The SCS, as a LME, has high diversity of marine resources and exploited by various types of fishing gears. Although the resources are under immense fishing pressure, there is little compiled catch statistics on the fisheries. Participants to this work provided information regarding their SCS fisheries for the period of 2010–2015, including annual total catch of the SCS (according to the LME definition of the SCS [21]), and fishery-based and year-based information on the top three fisheries (in terms of catch amount): catches, number of vessels, and taxa of the three major target species. Summed up catch from all the seven fishing actors were in the range of 6.6–8.0 million mt which shows an increasing trend.

#### 2.1.1. China

China has the highest catch in the SCS. The catch figure increased from 3.0 million mt to 3.8 million mt during the period (Fig. 1). The main species caught were *Nemipterus*, *Trichiurus* and *Decapterus* spp (Table 1). Over 75% (75–82%) of the catches were made by the three major fishing gears of gillnet, trawl and others (including small longline and purse seine) (Fig. 2), composed of ~50,000 of small gillnet vessels (8–11 gross tonnage, GT) and ~9000 trawlers (65–95 GT) and ~6000 other fishing vessels (purse seiners size 65–95 GT and the rest <11 GT), mostly from the provinces of Guangdong, Guangxi and Hainan. Purse seine gear was increasingly being utilized since 2013. Overall, the number of fishing vessels was stable or slightly declined.

#### 2.1.2. Viet Nam

Viet Nam recorded a catch of 2.1 million mt in 2010, which increased to 2.8 million mt in 2015 (Fig. 1) and further increased in 2016. Three major fishing gears were used: gillnet (with ~38,000 vessels, about 90% of them were <90 horse power, HP), trawl (with ~21,000 vessels, about 35–65% of them were <90 HP), and lines (including longline and handline, with ~18,000 vessels, 80–90% were <90 HP) (Fig. 2) (altogether contributed 60–73% of the total catch). The number of fishing vessels decreased since 2010, especially the number of small-scale fishing vessels with an engine capacity of less than 90 HP, a result of fishery re-structuring policies focusing on reducing number of small-scale and coastal fishing vessels.

There is no official by-species and by-fishery statistics on Viet Nam marine catches. Estimated by scientists [22,23], the main taxa in the catch by major fishing gear were shown in Table 1. During the period, composition of 'trash fish' has gradually increased.

#### 2.1.3. Thailand

Total catch of Thailand in the SCS (not including the catch from the Gulf of Thailand) was 80,000 mt in 2010, increased to 137,000 mt in 2013 and then dropped to 108,000 mt in 2014 (Fig. 1). The catch was further down to 46,000 mt in 2015 and zero in 2016 due to many amendments to Thai fisheries legal framework in its response to the requests of the 'yellow card'[4] imposed by the European Commission on Thailand since April 2015, which was recently lifted on 8 January 2019 by the European Commission as recognition of its progress in tackling illegal, unreported and unregulated fishing [24]. In general, the catch from the SCS was about 5–15% of the total catch from the Gulf of Thailand. The catch was almost made by two major fisheries in the SCS, otter trawl and purse seine fisheries, consisting of ~1800 trawlers (14–25 m in length) and ~1000 purse seiners of similar size (Fig. 2). There was a proportion of catch made by anchovy purse seiners in 2013. The major taxa caught were *Rastrelliger*, *Nemipterus*, *Priacanthus, Sardinella* spp. and squids for the trawl fishery, and neritic tuna, *Decapterus* and *Rastrelliger* spp. for the purse seine fishery (Table 1).

#### 2.1.4. Malaysia

Catch in the SCS by Malaysia was in the range of 650,000 to 770,000 mt in the period, with highest record in 2013 (Fig. 1). The 2016 estimate was 19% increase of 2015. The three major fisheries were trawl, purse seine and driftnet fisheries, whose catch composed of around 85% of the total catch (Fig. 2). The numbers of vessels were generally 3200 trawlers and 700 purse seiners; for driftnet vessels, the number increased from 15,000 to 19,500 during the period. Major taxa by gear were shown in Table 1.

#### 2.1.5. Indonesia

Indonesian catch was estimated from national fisheries statistics of two landing sites which were West Kalimantan Province and Riau Island Province, assuming that most of the catch in these two sites were from the SCS. The annual catch estimate was in the range of 115,000 to 188,000 mt, with a general increasing trend from 2010 to 2014 and then declining slightly in 2015 (Fig. 1). The catch further declined in 2016, by 14%, owing to a decrease of vessel number. The major three fishing gears were driftnet (size 20–30 GT), purse seine (20–30 GT), and set gillnet (10–20 GT) before 2011 and hand lines (5–10 GT) since 2012, contributed 30–60% of the total catch. The number of driftnet vessels was ~2000 before 2015 and increased to 7600 in 2015; that of purse seine was gradually increased from <600 to ~1200 in 2014 and further to 5000 in 2015. The number of hand liners was ~5000 before 2015 and then declined. The significant increase of driftnet and purse seine fishing vessels was a result of the overall ban on trawl fishery in 2014 and the consequent shift of fishing gear from trawl to driftnet (mainly) and purse seine, as well as the shift of fishing ground from other Fisheries Management Areas (FMA) for purse seine fishery. Main species in the catch

[4] Under the EU Council Regulation No 1005/2008 of 29 September 2008, or the IUU Regulation, any third countries identified as non-cooperating in fighting against illegal, unreported and unregulated fishing (IUU fishing) may be subject to a formal warning (pre-identification or yellow card). If such non-cooperating countries fail to so improve their fisheries management laws, policies and enforcement, they will be formally identified as non-cooperating third country (identification or red card) and face with having their fish or fishery products banned from entering into the EU market, among other sanction measures.

**Table 1**
Major fish taxa in the catch of the SCS fishing actors, by gear. The gears, in gear code, listed are the top three major gears (in terms of catch) used by each fishing actor in each year of 2010–2015, including trawl (TR), otter trawl (OT), pair trawl (PT), gillnet (GN), drift gillnet (DGN), set gillnet (SGN), purse seine (PS), Taiwanese seine (TS), longline (LL), line-gear (LN, longline and handline), and handline (HL).

| Fish taxon | China | Viet Nam | Thailand | Malaysia | Indonesia | Taiwan |
|---|---|---|---|---|---|---|
| *Acropoma* spp. | | TR | | | | |
| *Auxis* spp. | | GN | | | | |
| Carangidae | | | PS[a] | | HL | GN TS TR |
| *Decapterus* spp. | TR GN PS[b] | | | PS | | |
| Demersal fishes | | | | | SGN | |
| *Epinephelus* spp. | | | | | | GN |
| *Evynnis* spp. | | TR[c] | | | | |
| Istiophoridae (billfishes) | | | | | | LL |
| *Katsuwonus pelamis* | | GN | | | | |
| *Leiognathus* spp. | | TR | | | | |
| *Loligo* spp. | | TR LN | | | | |
| *Lutjanus* spp. | | | | | HL | |
| *Muraenesox* spp. | | LN | | | | |
| *Nemipterus* spp. | TR GN PS[d] | GN | OT PT | TR | | |
| *Photololigo* spp. | | | TR PT | | | |
| *Priacanthus* spp. | | TR[e] | PT | TR | | |
| *Rastrelliger* spp. | | | PS[f] | PS DN | | |
| *Sardinella* spp. | | | OT PT PS | PS | | |
| *Saurida* spp | | | OT | TR PS | | |
| Sciaenidae | | TR | | TR | | TR |
| *Scomberomorus* spp. | | | | DN | DGN PS HL | TS |
| *Sepia* spp. | | | TR | | | |
| shark | | | | | | LL |
| shrimp | | | | | | TR |
| Small pelagic fishes[g] | | | | | PS SGN | |
| Sparidae | | | | | | TR GN |
| *Sphyraena* spp. | | | PT | | | |
| squid | | | TR | | | |
| Stromateidae | | | | | | TR |
| Tachysuridae | | | | DN | | |
| *Trichiurus* spp. | TR GN PS | | | | | |
| Tuna | | LN | PS | PS DN | DGN PS HL[h] | LL |

*Taxonomic information of this table may have covered those from the adjacent waters of the SCS.
[a] *M. cordyla*.
[b] Mainly *D. maruadsi*.
[c] Mainly *E. cardinalis*.
[d] *N. virgatus*.
[e] *P. macracanthus*.
[f] *R. brachysoma, R. kanagurta*.
[g] Scad, short-bodied mackerel, trevallies, *Sardinella* spp., Indian mackerel.
[h] Netric tuna.

were neritic tuna, small pelagic fish, snappers, trevallies and mackerels (Table 1).

#### 2.1.6. The Philippines

Based on the Fisheries Statistics of the Philippines[5] for the commercial and municipal fisheries [25] [6] in the seven provinces and cities of the Philippines adjacent to the SCS, the annual catch of the Philippines from the SCS ranged from 491,000 mt in 2010 to 407,000 mt in 2015 (Fig. 1), and further declined 4% in 2016. The catch could be broken down to 170,000–192,000 mt from the commercial fisheries (>3 GT) and 238,000–322,000 mt from the municipal fisheries (≤3 GT). Major fishing gears were purse seine, ring net, gillnet, lines and trawl, according to port monitoring programs for landing catch and effort. Main species in the catch include neritic and oceanic tunas, dolphin fish, mackerels, round scads, sardines and trevallies (Table 1).

#### 2.1.7. Taiwan

Taiwan has various types of gears operating in both coastal and distant waters, and there is no requirement for reporting catch from the SCS. Also because of no clear ecological boundary definition of the SCS in the north, there is no definitive SCS catch statistics on the part of Taiwan. Chang and Hu (unpublished data) reconstruct the catch series from detailed catch statistics and concluded that the SCS catch was in the range of 45,000–51,000 mt during the period without specific trend (Fig. 1). Main fishing gears were trawl, longline, gillnet and Taiwanese seine, a unique gear used by the Taiwanese mackerel fishery (Fig. 2); obviously, the catch from the trawl fishery continued to decline, mainly due to the fading of distant water trawl fishery that once took substantial catches from the SCS. Meanwhile, catches from Taiwanese seine increased continuously in the period. Major taxa were shown in Table 1.

### 2.2. Perception of status of the resources

Regarding the status of the resources in the SCS, almost all participants reported a general decline of catch status. For example, according to 12 joint surveys carried out by Viet Nam and China, the average catch rate in the Tonkin Gulf during 2014–2016 (64.2 kg/h) declined substantially from that of 2011–2013 (99.2 kg/h) and 2008–2010 (125.2 kg/h) [26,27]; a decline of trophic level in the catch was also reported, suggesting that both quantity and quality of marine resource in the central Tonkin Gulf had decreased. Degradation of the SCS ecosystem near China was also reported by participants, mainly due to coastal

[5] An official publication of the Philippine Statistics Authority.
[6] 'Municipal fishing' refers to fishing within municipal waters using fishing vessels of three (3) gross tones or less, or fishing not requiring the use of fishing vessels.

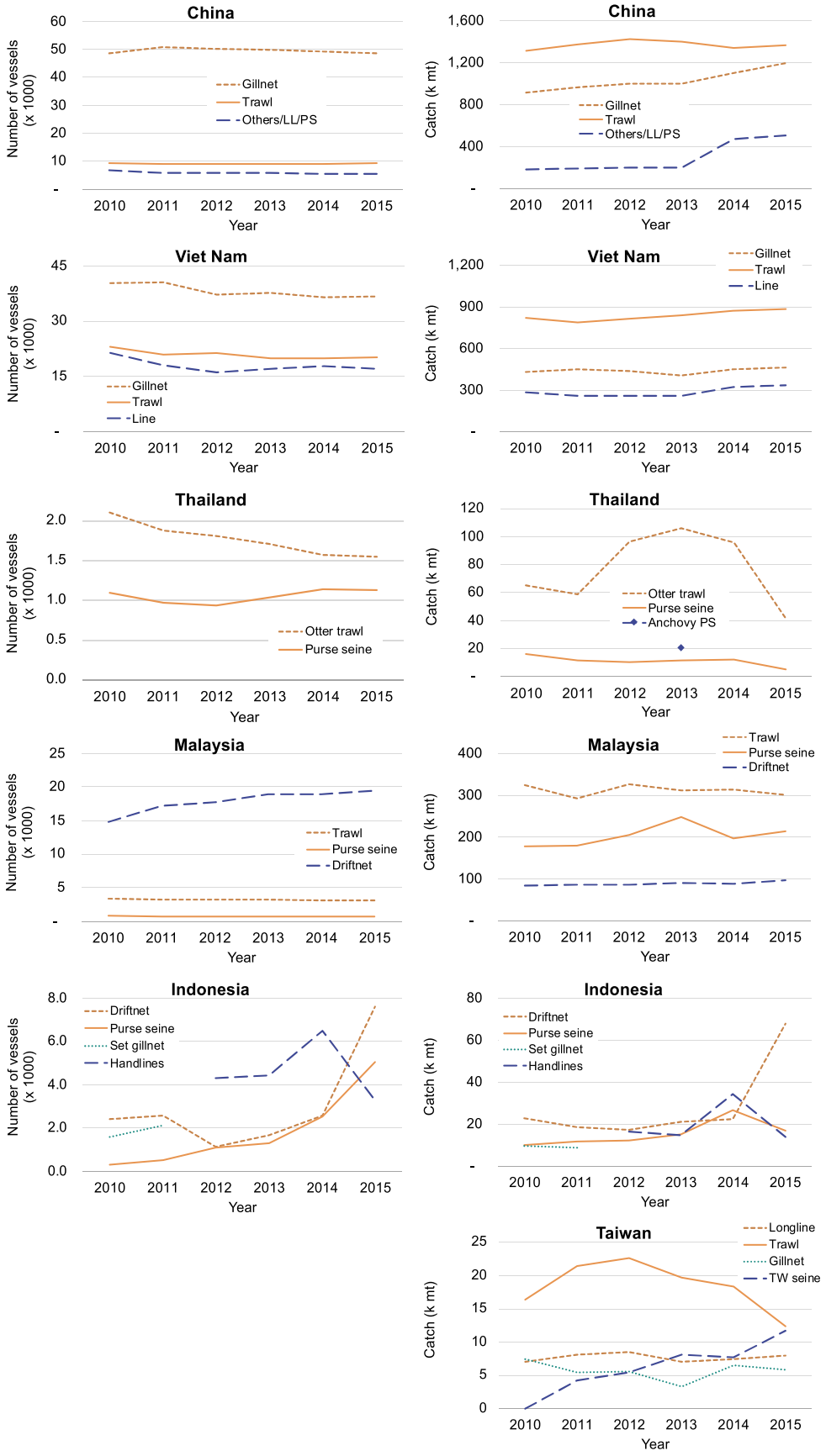


**Fig. 2.** Total catches and number of powered fishing vessels of the seven major fishing actors in the SCS, by the three major fishing gears of each fishing actor.

industrialization and dense maritime activities. Overfishing, destructive fishing practices, marine pollution, and the degradation of unique natural habitats are widespread problems in the region. In the SCS adjacent to Thailand, severe degradation of fish resources occurred, which in turn resulted in lower catch rates and large quantities of small low value/-trash fish in the catch (including juveniles of large commercial species). The degradation was attributed by participants to the lack of control over those ever-increasing fishing vessels and the development of new fishing technologies in the past 30 years, resulting in excessive fishing capacity and fishing effort.

However, conflicting information indicating steady growth of catch from the same region with the same group of fishing vessels was also reported by some participants who expressed the dilemma that managers faced with when considering restructuring their fisheries. Some argued that the increase of catch might just be a superficial phenomenon of recovery of marine resources which can mask the serious problem of fishing-down-marine-food-webs [7,28], a problem that impacts the biodiversity of the SCS. Thus, reality behind such conflicting information deserves further study.

### 2.3. Quality of the catch statistics

High diversity of marine resources, high complexity of fishing gears, and vast, various sized fishing vessels (especially from small coastal fisheries) fishing in the region, as a whole, has rendered the complication and perplexity in establishing and maintaining sound statistical systems for the SCS nations. In this regard, the quality of national catch statistics provided by participants might be very variable. However, these statistics could still contribute base figures for understanding the exploitation status of the SCS fisheries and publicizing such statistics could provide opportunities for further review and betterment of the various national statistics systems. In addition, these statistics were provided by participants who are supposed to know about the background and implications of the statistics better than non-native researchers. An example on this particular matter is that the SCS catch figures provided by participant from Taiwan are much lower than the estimates in Ref. [3], which was resulted from that some of the catch figures of Taiwanese distant water fisheries were mistakenly incorporated into the SCS estimates due to unfamiliarity of the components of Taiwan's distant water fisheries statistics on the part of non-native researchers.

*Sea Around Us* is a research initiative that assesses the impact of fisheries on the marine ecosystems of the world [17,29] and currently provides the most informative statistics through science-based processes [30,31] for depicting the catch status of the SCS which have been frequently cited in literature (e.g., Refs. [3,4,32]). Total catch estimates of the SCS of the most recent five years (2010–2014) available from the *Sea Around Us* are in the range of 9.2–10.1 million mt. The *Sea Around Us* also provides catch figures by countries and includes both official reported data and reconstructed estimates of unreported data (including major discards) [31]. The national SCS catches provided by participants and the reported and unreported catches estimated by the *Sea Around Us* (the SAU_Reported and SAU_Unreported) are juxtaposed in Fig. 1. As expected, various degrees of discrepancies among these figures are shown by almost every fishing actor. The provided estimates from China are close to the SAU_Reported; those from Viet Nam, Malaysia are almost identical to the accumulated sum of SAU_Reported and SAU_Unreported for later years. For catches from the Philippines, the total catch is close to the accumulated sum, while the commercial catch alone (not shown here) is close to the SAU_Report.

The SCS catch estimates provided by Thailand (92,000 mt averaged across the period) are higher than SAU_Reported (18,000 mt) but are much lower than the accumulated sum of SAU_Reported and SAU_Unreported (722,000 mt). The difference was attributed from the difference in estimation baseline: the estimates from Thailand were from the SCS water, and those from the *Sea Around Us* covered all Thai waters (including the Gulf of Thailand and Andaman Sea, [33]).

Estimates provided by Indonesia and Taiwan are much lower than the SAU_Reported and SAU_Sum. For the Indonesian case, the average available catch was 144,000 mt (estimated from two landing sites facing the SCS), much lower than 680,000 mt of the SAU_Reported. Different estimation baselines were considered as the main reason leading to such discrepancies, as occurred in the Thailand's case.

Excluding Thailand, Indonesia and Taiwan, the differences between provided catch estimates and the SAU estimates were generally not substantial. However, in order to improve the accuracy of estimates, further cooperation with the *Sea Around Us* for clarification of differences, standardization of estimation baselines and/or improvements of statistical system are encouraged.

## 3. Management measures of the SCS fishing actors

Many management measures have been developed and implemented by each fishing actor of the SCS; some of them are newly designed to respond to public concerns about the state of the resources. Based on literature reviews and inputs from participants, Table 2 summarizes the general management measures implemented by the Governments of the participants. Those measures were categorized into three kinds in the Table, namely, input control, output control and technical instruments or tools, while the last one was further broken into instruments relating to fish size, fishing location and season, monitoring and enforcement, and resource enhancement.

### 3.1. Input control

All the seven SCS fishing actors have certain fishing capacity control measures, and some of them even possess double control systems that control both total number of powered fishing vessels and their total engine power (China [34]) or vessel tonnage (Taiwan and Malaysia). Unfortunately, the double control system is not overall effective in China mainly owing to limited inspection by local governments, illegal fishing and the increase of fisher numbers [32,34]. China, Thailand and Taiwan have also implemented buyback programs to reduce the number of fishing vessels. Indonesia controls the granting of fishing license from the central Government only to the vessels up to 150 GT.

All the seven SCS fishing actors have fishing license or agreement control programs. Most of them are zone-based, i.e., some 'areas' can only be fished by certain 'vessels'. The definitions of 'area' and 'vessels' are either by both distance from shore and size of vessels (e.g., area with $<$ 5nm from shore can only be fished by vessel $<$10 gross registered tonnage, GRT, in Malaysia) or simply by specifying the regions (see the following examples). Viet Nam, Malaysia,[7] the Philippines and Taiwan applied the former approach while Thailand (having two zones: Gulf of Thailand and Andaman Sea) and Indonesia (designating 11 Fisheries Management Areas, FMAs) applied the latter one. Recently, like Indonesia, the Philippines enacted a law to establish FMAs. The former area-based control approach is not necessarily associated with licenses; rather, some of them are implemented through certain fishing agreements based on vessel sizes and similar to the 'Fishing Zone Control' approach as described in Section 3.3.2. In addition to the area-based control, Taiwan has also operated a species-based fishing license control that sets control over the total allowable number of licenses limited to fishing on the specific species, e.g., for precious coral, larval anchovy and Pacific bluefin tuna.

The Philippines regulated fishing grounds of 15 km from shore that could only be accessed by municipal fishers. China and Taiwan had

[7] Malaysia basically defines the zones by distance from shore. For example, Zone A is the waters within 5 nm from coastline, and Zone B is the waters between 5 and 12 nm, etc. Such scheme considers not only the size of vessels, but also the types of fisheries.

**Table 2**
Summary information on the management measures implemented by the seven major SCS fishing actors.

| | China | Vietnam | Thailand | Malaysia | Indonesia | Philippines | Taiwan |
|---|---|---|---|---|---|---|---|
| **1. Input control** | | | | | | | |
| Capacity control | ✓ double control & buyback program | ✓ vessel number | ✓ buyback program | ✓ double control | ✓ Max. size of fishing vessels and size of fishing gear | ✓ double control | ✓ double control & buyback program |
| Fishing license/ agreement control | ✓ ? | ✓ zone-based | ✓ zone based | ✓ zone based | ✓ zone based | ✓ zone-based | ✓ zone-based & species based |
| Limited entry system (fishers) | | | | | | ✓ 15 km from shore only for municipal fishers | |
| Subsidy for temporary leave | ✓ | | | | | | ✓ |
| Alternative livelihoods projects | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Gear-shifting program | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **2. Output control** | | | | | | | |
| Catch reduction goals | ✓ zero growth/ negative growth | ✓ 2020 reduction goal | | | | ✓ through harvest control rule with reference points | |
| Catch limits | | ✓ by fishing area | ✓ TAC (managed through transferred effort limit) | | | | ✓ species based |
| **3. Technical instruments** | | | | | | | |
| **(1) fish size** | | | | | | | |
| Cod-end mesh size regulation on trawl | ✓ 40 mm | ✓ 40 mm for fish; 30 mm for shrimp; | ✓ 40 mm | ✓ 38 mm | ✓ totally banned | ✓ 30 mm, banned in some areas | |
| Fish size control | | ✓ sardinella, scad, hailtail, etc | | | ✓ Lobster, swimming crab | ✓ eel, sea cucumber | ✓ crab |
| **(2) fishing location and season** | | | | | | | |
| Fishing zone control | | ✓ 3 zones | ✓ 2 zones | ✓ 4 zones | ✓ 1 zone in the SCS | ✓ 2 zones | ✓ 3 zones for trawl fishery |
| Marine protected area (MPA) | ✓ Xisha | ✓ 16 MPAs | ✓ 25,593 $km^2$ | ✓ 90 MPAs (10,400 $km^2$) | ✓ 18.5 mil ha | ✓ small MPAs in western coast | ✓ Dongsha |
| Closed fishing area/ seasons | ✓ summer fishing moratoria | ✓ various areas/ seasons | ✓ various areas/seasons, species-based | | | ✓ various areas/ seasons | ✓ gear-based and species-based |
| **(3) monitoring and enforcement** | | | | | | | |
| Landed catch/effort monitoring | ✓ some provinces | ✓ catch certification | ✓ declaration and inspection | ✓ collected by fisheries staff | ✓ port sampling | ✓ declaration and inspection | ✓ (declare and inspect) |
| Logbooks | ✓ commercial | ✓ commercial | ✓ commercial | ✓ commercial | ✓ commercial | ✓ commercial | ✓ commercial and gear-based |
| Port inspection | ✓ | ✓ | ✓ | ✓ | ? | ✓ | ✓ |
| CDS/certificate | ? | ✓ | ✓ | ? | ? | ? | ✓ |
| Observer program | ✓ | ✓ special projects | ✓ high seas | | ✓ specific projects | ✓ high seas and EEZ | ✓ routinely |
| Vessel monitoring | ✓ VDR | ✓ VMS for ≥ 90 HP offshore fisheries | ✓ VMS for >30 GT in Thai waters, EMS for >30 GT outside | ✓ AIS, VMS for >70 GRT | ✓ VMS for >30 GT | ✓ VMS for >150 GT | ✓ VMS for various fisheries, VDR for all fisheries |
| **(4) resource enhancement** | | | | | | | |
| Artificial reefs establishments | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Fish hatcheries and nurseries. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

subsidy schemes to encourage temporal leave from fishing for fishing vessels conforming to certain conditions.

All fishing actors have adopted policies to encourage fishers shifting their livelihood from fishing to alternative ones such as marine ecotourism (e.g., whale, shark or dolphin watching), sports fishing tourism, or other jobs (e.g., community-based dress making). Incentives are also provided to encourage shifting fishing gears, for example most fishing actors encouraged shifting gears from trawl to gillnet or other environment-friendly gears. The Philippines banned Danish seine and encouraged fishers shifting to other gears.

### 3.2. Output control

China adopted a "zero growth" policy on its annual catch (domestic marine catch of a year cannot be higher than the previous year) in 1999 and a "negative growth" policy in 2000, and such policies have apparently stopped the increasing trend of marine catches [34], although the provided catch in Section 2.1.1 and Fig. 1 does not show a declining trend. Viet Nam has set a goal to reduce its total catch from 2.51 million mt in 2013 to 2.2 million mt in 2020, although this seems not to be in effect [35], given the increasing trend of catches mentioned in Section 2.1.2. The Philippines is establishing biological reference points for the fisheries; harvest control rules will then be developed which will include a target goal for effort and catch reduction.

Viet Nam has set regional catch limits in four regions of their fishing ground, namely the central, the southeast, the southwest regions, and the Bay of Tonkin. Separate zonal catch limits have also been set to the inshore/coastal zone and offshore zone. Thailand implemented an output control program by setting catch limits which were calculated as about 5–7% off the maximum sustainable yield (MSY) that was estimated by the Government. The catch limits were re-expressed as total allowable fishing efforts (TAE) and then allocated to each fishing gear and vessel by size category. Indonesia regulates total allowable catches based on the MSY that estimated and determined by the Government. When the MSY was estimated for a stock, Indonesia set 80% of MSY as the catch allocation to control the fishery output. Taiwan applied species-based catch limits to some of the concerned species such as precious corals and bigeye tuna.

### 3.3. Technical instruments/tools

#### 3.3.1. Fish size

Most of the fishing actors have cod-end mesh size regulations, from 30 mm to 40 mm. Indonesia has banned the usage of bottom trawls all together since 2015, while the others banned gear trawl within a distance from the shore (e.g., inshore areas for the Philippines, within 5 nm for Malaysia, and within 3 nm for Taiwan). Many fishing actors have certain fish size control programs: Viet Nam set allowable fish size limits on sardinella, scads and hairtails, Indonesia on lobsters and swimming crabs, the Philippines on eels and sea cucumbers, and Taiwan on crabs.

#### 3.3.2. Fishing location and season

As indicated in Section 3.1, many fishing actors implemented certain area-based license/agreement control programs; all of them also practiced fishing zone control programs within their EEZs: For Viet Nam, three zones were defined, i.e., inshore zone (0–6 nm), coastal zone (6–24 nm) and offshore zone (24 nm to EEZ); no vessels >90 HP were allowed to fish in inshore and coastal zones, no 20–90 HP vessels were allowed in inshore and high seas, and <20 HP vessels and all non-motorized boats were allowed only inshore. In Thailand, commercial fishing vessels were specified to fish only in one of the two zones mentioned in Section 3.1 and outside of coastal zone. Malaysia defined four zones based on distance from the shore: Zone A, B, C, and C2 for waters between 0–5 nm, 5–12 nm, 12–30 nm from the shore, and 30 nm from shore to EEZ boundary, respectively; the high seas was additionally named as Zone C3. Vessels of specific fishery with specific size category could fish in a specific Zone or above, e.g., only traditional fishermen and traditional anchovy purse seiners (owner operators) could fish in Zone A, but they could also fish in Zone B or above. Tuna longliners and tuna purse seiners of >70 GRT could only fish in the high seas. Indonesia has defined 11 FMAs (zones) and the SCS belongs to the Zone/FMA 711. The Philippines basically defines two zones: within and outside of 15 km from the shore. Only <3 GT vessels are allowed to fish within 15 km, but they can also fish outside of 15 km. Taiwan defines three zones for trawl fishery: 0–3, 3–12 and > 12 nm; no trawling is allowed within 3 nm from the shore and trawlers >50 GRT can only fish in waters of >12 nm.

In addition to fishing area control measures, all fishing actors established different types of marine protected area (MPA) with different sizes of no fishing zone.[8] China announced Xi-sha as a MPA; Viet Nam has 16 MPAs in its waters; Thailand claimed to have 25,593 $km^2$ protected areas[9]; Malaysia has 90 MPAs covering 10,400 $km^2$; Indonesia intends to have 200,000 $km^2$ as marine conservation areas by 2020 and has achieved the goal in late 2018 [36]; the Philippines declared numerous small MPAs in the western coast of the Philippines by local governments; Taiwan announced 30,951 $km^2$ MPAs composed of no-entry areas (1.9%), no-take areas (9.6%) and multifunctional areas (including 85.5% of gear-based no-fishing areas) [37].

Most fishing actors have measures of fishing closures by seasons or areas. China has established a summer moratorium of fishing in the Bohai, Yellow, and East China Seas in 1995 and the closure areas were extended to the SCS in 1999 [34]. Viet Nam and Thailand have various spatiotemporal closure measures, and those measures are species-based. Malaysia is taking steps to develop measures of closed area and season on certain small pelagic species. Indonesia has such measures in the adjacent waters of the SCS but not in the SCS. The Philippines has large spatio-temporal fishing closures that are anchored on target species such as small pelagics, including those of Visayan Sea, Zamboanga Peninsula, Davao Gulf and Northern Palawan. In Malaysia, trawl fishery will be banned in zone B (outside of the SCS) by 2020 where the resources have been heavily overexploited; and such measure will gradually be applied toward the SCS fishing areas. Taiwan has both gear-based closure in certain fishing areas and species-based one in certain fishing seasons.

#### 3.3.3. Monitoring and enforcement

Monitoring on fishing efforts and landed catch is a basic procedure to obtain reliable catch statistics. Viet Nam monitors their catches based on logbooks and certain catch certification systems; logbooks are required only for large commercial vessels ≥90 HP, and the rest vessels are required to submit fishing reports. Thailand monitors the catches based on fishers' declarations and independent inspection on all fisheries, as well as logbook system for commercial fisheries. Electronic Reporting System (ERS) is applied to overseas fishing vessels and carriers since 2017 [38]. Thai fisheries agency staff also collects landing information from artisanal and commercial fisheries and conducts a port sampling program for foreign fishing vessels. The landings are validated by Port-In and Port-Out Control Centers [33]. In Malaysia, landing information is collected by staff of the Fisheries Department. Logbooks are required for large commercial vessels ≥70 GRT. Indonesia collects catch information by logbooks (for vessels > 30 GT), port sampling and observer programs. The Philippines has a declaration and port inspection program. Taiwan collects catch information based on regular fishers' declarations and by fisheries agency staff in the market; however, in order to further improve the reliability of the statistics, Taiwan has additionally implemented a strict landing declaration scheme for vessels >10 GRT since 2015. For commercial longline vessels, logbooks are also required.

In general, every SCS fishing actor has a sort of landing monitoring system implemented; some also reported to have "port inspection" and "CDS/certificate" to improve traceability (Table 2), although the criteria of these two items seems different among participants. However, the level of implementation and coverage are crucial to the success of such measures. Although logbooks are required by most fishing actors, such requirement applies only to large commercial vessels. Further explorations are needed on the content and implementation of these statistics collection and monitoring systems in the future.

Most fishing actors have conducted some sort of observer programs, and a majority of them was conducted on a project basis or largely for high seas fisheries. Taiwan has additionally conducted a regular

[8] The information on MPA described here may contain areas outside of the SCS, and the definitions of MPA may also be different by nations.

[9] This includes fisheries reserve areas, environmental protected areas, marine national parks, non-hunting areas and wetland.

observer program for offshore fisheries and routinely dispatches fishery observers onboard of vessels of certain important offshore fisheries.

Regarding the monitoring of vessel geolocation, all SCS fishing actors have specific vessel monitoring tools, such as voyage data recorder (VDR), satellite-based real-time vessel monitoring system (VMS), electronic monitoring system (EMS, consisting of several video or still cameras, coupled with a VMS and installed on fishing vessels), or automatic identification system (AIS) (Table 2). VMS and EMS systems were mostly installed on large vessels, except that Taiwan has required all sized fishing vessels of critical fisheries (e.g., precious coral fishery, those fishing in Taiwan-Japan dispute waters, etc.) to install. The VDR system has largely applied to small vessels due to its low cost and small size. Although VDR is not a real time monitoring system, its information can be used as post evidence for illegal fishing and has been used in solving an international dispute [39]. Taiwan has installed VDRs on more than 5600 coastal and offshore fishing vessels in 2016 [40].

#### 3.3.4. Resource enhancement

In addition to setting up MPAs, all SCS fishing actors have established artificial reefs to promote marine life in areas of generally featureless or trawl-damaged sea floor. Establishing artificial reefs is a part of the MPA programs for many fishing actors. All of fishing actors also have fish hatcheries or nurseries that can facilitate the reduction of dependence on wild-caught juveniles as well as the replenishment of natural populations by stock enhancement.

## 4. Experts' opinions on the depletion and recovering of SCS resources

Degradation of the marine resources of the SCS [3–5] was well recognized by the participants. A questionnaire study, entitled "Possible issues that drive the fish stocks to a depleted status or that are needed to be addressed for recovering the resources", was conducted on all the participants (including those were contacted after the Workshop), who are considered as experts on the SCS fisheries. Excluding responses from two participants that seemed doubtable in ranking and from the first author of this work who was the Chair of the Workshop, totally 22 responses were used. Among the respondents, seven were from north of the SCS (NSCS, China and Taiwan) and the rest 15 from the central or the south of the SCS (SSCS); eight were scientists (including one social scientist) and 14 were managers. Issues on the questionnaire were identified and selected according to general literature reviews (many of them were from Ref. [3] and consultations with fisheries researchers). Thirty five (35) issues in total were in the questionnaire (Table 3), which can be categorized into six main subjects (regulation, institution/policy, enforcement/compliance, cooperation, environment impact, and socio-economics), for participants to rank the top 10 most concerned issues to them. Then, the reverse of the rank was used as the score (weighted value) for calculation of the importance of the issues. The unranked items were given a score of 0. Table 3 provides mean and coefficient of variation (CV) of the scores for each individual issue, while Fig. 3 shows the distribution of scores.

The top 25% ranked issues from all participants were "insufficient capacity control", "weak law enforcement" and "insufficient effort control" (see mean scores of Table 3 and score percentage in Table 4), indicating that the levels of controls on fishing capacity and fishing efforts, as well as the enforcement on the designed regulations were the issues with which most participants have concern. The issue of "insufficient capacity control" was strongly emphasized by all participants; while the issue over the number and size of vessels in the SCS was additionally marked as the major target to be controlled by some participants. In addition to these, the top 50% ranked issues included "insufficient enforcement sources", "low policy priority", "insufficient gear regulations", "weak inter-governmental cooperation", "institutional weakness", and "habitat loss"; which have widely covered five subjects.

**Table 3**
List of the issues of the questionnaire titled "Possible issues that drive the fish stocks to a depleted status or that are needed to be addressed for recovering the resources". Last two columns are mean and CV (coefficient of variation) of the scores from respondents (n = 22).

| Subject | Code | Content of the issue | Mean | CV |
|---|---|---|---|---|
| Regulation | 1 | Insufficient gear regulations | 2.32 | 0.63 |
| | 2 | Poor design of fishing zonation (determined by historical patterns of use, rather than resource assemblage patterns) | 1.36 | 0.48 |
| | 3 | Insufficient penalty on violation of regulations | 0.64 | 0.41 |
| | 4 | Insufficient control over fishing capacity leading to over-capacity | 5.95 | 1.29 |
| | 5 | Insufficient fishing effort control | 3.59 | 0.90 |
| | 6 | Mis-management measures (measures designed not corresponding to scientific evidence, e.g., fishing moratorium period is not in the spawning or vulnerable periods of fish stocks) | 1.77 | 0.58 |
| | 7 | Lack of protection on spawning/ nursey areas or seasons | 2.00 | 0.58 |
| | 8 | Management exemption for small-scale fisheries | 0.50 | 0.34 |
| | 9 | Lack of consideration on socio-economic aspects (coastal poverty, community marginalization) | 1.91 | 0.59 |
| | 10 | Inadequate trade governance (no consideration on the effect of market demand on fishing activities) | 0.00 | 0.00 |
| | 11 | Perverse economic incentives (e.g., fuel subsidies) | 0.00 | 0.00 |
| Institution/ Policy | 12 | Institutional weakness (inappropriate management institution design leading to inefficient/ineffective management) | 2.18 | 0.68 |
| | 13 | Insufficient management capacity on the part of local governments (capacity building needed) | 1.41 | 0.52 |
| | 14 | High socio-economic contribution of the South China Sea fisheries to the coastal States leading to national governments' reluctance of limiting their fishing capacity | 1.32 | 0.48 |
| | 15 | Low policy priority given to the fishery due to its limited contribution or small proportion to the GDP | 2.50 | 0.79 |
| | 16 | Rapid industrialization in the South China Sea region inspiring governments to put their policy priority on the economic development over environment protection or preservation | 0.41 | 0.30 |
| Enforcement/ Compliance | 17 | Weak law enforcement due to low political will | 3.77 | 1.01 |
| | 18 | Insufficient enforcement manpower and budget | 2.86 | 0.98 |
| | 19 | Lack of monitoring mechanisms (observer program, port inspection program, vessel monitoring system) | 1.64 | 0.60 |
| | 20 | Inaccurate fishery data or ineffective statistics system | 1.64 | 0.80 |
| | 21 | Lack of supportive enforcement laws or tools to execute the statutory regulations | 0.68 | 0.34 |
| | 22 | Insufficient education on the part of the local fishers | 0.95 | 0.43 |
| Cooperation | 23 | Weak/insufficient inter-governmental cooperation | 2.27 | 0.69 |
| | 24 | Poor inter-agency coordination within government (inter-sectoral conflict) | 0.82 | 0.42 |
| | 25 | Illegal transboundary fishing | 1.59 | 0.62 |
| | 26 | Too many nonbinding instruments in the international institutions | 0.45 | 0.29 |

(continued on next page)

**Table 3** (*continued*)

| Subject | Code | Content of the issue | Mean | CV |
|---|---|---|---|---|
| | 27 | Competing territorial claims between/among South China Sea coastal States | 0.82 | 0.38 |
| | 28 | Maritime boundary delimitation conflicts between/among South China Sea coastal States | 0.27 | 0.32 |
| | 29 | Lack of Regional Fisheries Management Organization (RFMO) in the South China Sea region | 1.59 | 0.50 |
| Environment impact | 30 | Climate change (ocean acidification, increased sea surface temperature) | 0.18 | 0.28 |
| | 31 | Habitat loss by coastal development or destructive fishing methods | 2.09 | 0.77 |
| | 32 | Land-based pollution and/or marine vessel pollution | 0.91 | 0.42 |
| Socio-economics | 33 | Population growth causing increasing demand of protein supply from the sea | 2.05 | 0.67 |
| | 34 | Conflict between commercial and small-scale fisheries (habitat, resources, fishers) (Incursion of industrial fishers into coastal fishing areas and MPAs) | 1.05 | 0.54 |
| | 35 | Coastal poverty | 1.82 | 0.58 |

Participants from the SSCS highly emphasized the issues of insufficient fishing capacity and effort control; that is, although there are capacity control and fishing license/agreement control implemented by all the fishing actors (Table 2), these input controls in the SCS were very insufficient and therefore have driven the resources to their depleted status. In addition, weak law enforcement and associated issue of insufficient enforcement resources (manpower and budget) were also highlighted; and these might be caused by low policy priority given to the fishery due to its limited contribution or small proportion to the GDP. Many of the participants also concerned with the issues of "insufficient gear regulations (on the destructive gears)" and "coastal poverty".

On the other hand, those from the NSCS emphasized the issues of "lack of protection on spawning/nursey areas or seasons" and "habitat loss by coastal development or destructive fishing methods". Such emphases were different from those of the SSCS, and such difference may be resulted from the fact that over half of the NSCS participants were fisheries scientists who were more concerned with the resources than policy instruments or tools. However, they also highlighted the issues of "weak/insufficient inter-governmental cooperation" and "lack of RFMO"; both fall into the subject of cooperation. Another important set of highlighted issues included "weak law enforcement due to low political will" and "insufficient capacity control" which might be associated with the issue of "high socio-economic contribution of the SCS fisheries to the coastal States leading to Governments' reluctance of limiting their fishing capacity". Political will and government determination were considered to be important drivers to the conservation of the SCS resources by the NSCS.

While issues coded 14 and 15 generated similar results (low political will) but they were based on different considerations: Issue 14 considered high contribution of the fisheries to coastal states but issue 15 limited contribution. Both were emphasized, however, the SSCS mostly chose issue 15 (six of the 15 participants chose issue 15 with score sum of 41 and only one chose issue 14 with score of 8) while the NSCS slightly prefer issue 14 (four of the seven chose issue 14 with score sum of 21 and four, with duplication with the former four, chose issue 15 with score sum of 14) (Table 4); they had different evaluation about the socio-economic contribution of the SCS fisheries to the coastal stats for not yet known reason.

In terms of issue subjects, regulation, enforcement/compliance and institution/policy were considered as the most influential factors contributing to the current depletion or future recovery of the SCS resources (Table 5). The issue subject of socio-economics (population growth caused increasing food demand, conflicts between fisheries, and coastal poverty) was also highlighted (mainly from SSCS) which was different from the reading of Table 4 because the issues within this subject had all been recognized, even not been highly recognized. All issues except for socio-economics were recognized to be important by the NSCS, with slightly higher scores on the subjects of regulation and environment impact. Nevertheless, the SSCS highly emphasized the

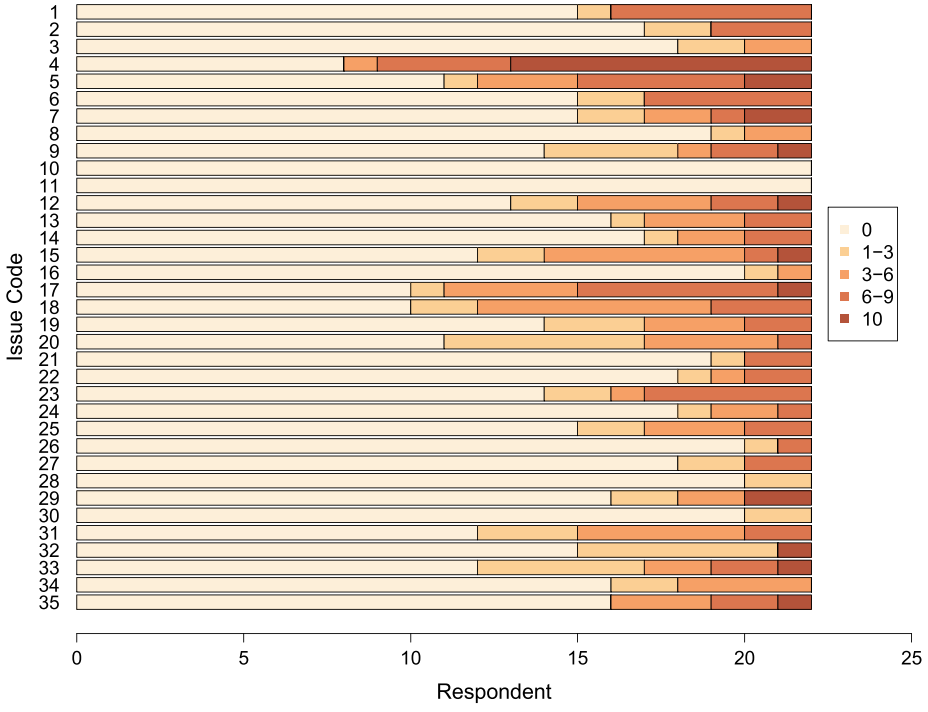


**Fig. 3.** Score distribution for each issue of the questionnaire (total number of respondents = 22).

**Table 4**
List of issues with sum of scores in order from highest to lowest, by all respondents (ALL), respondents from southern SCS (SSCS), and from northern SCS (NSCS). The "%" is the accumulated percentage of the summed score of an issue over the total scores, and only the first 80% issues are shown. The first 25% scored issues are marked with orange color, and those up to 50% are marked with green color with dash line. The issues are listed in brief; please use the Code to cross-reference the full name of the issue in Table 3.

| Code | Issue in brief | Sum | % | Code | Issue in brief | Sum | % | Code | Issue in brief | Sum | % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALL | | | | SSCS | | | | NSCS | | | |
| 4 | Insufficient capacity control | 131 | 11% | 4 | Insufficient capacity control | 107 | 13% | 7 | Lack protection for spawning | 32 | 8% |
| 17 | Weak law enforcement | 83 | 18% | 5 | Insufficient effort control | 71 | 22% | 23 | Weak inter-govt. coop. | 30 | 16% |
| 5 | Insufficient effort control | 79 | 24% | 17 | Weak law enforcement | 57 | 29% | 17 | Weak law enforcement | 26 | 22% |
| 18 | Insufficient enforce. sources | 63 | 29% | 18 | Insufficient enforce. sources | 51 | 35% | 31 | Habitat loss | 25 | 29% |
| 15 | Low policy priority | 55 | 34% | 1 | Insufficient gear regulations | 42 | 40% | 4 | Insufficient capacity control | 24 | 35% |
| 1 | Insufficient gear regulations | 51 | 38% | 15 | Low policy priority | 41 | 45% | 29 | Lack of RFMO | 24 | 41% |
| 23 | Weak inter-govt. coop. | 50 | 42% | 35 | Coastal poverty | 40 | 50% | 14 | Govt's reluctance of control | 21 | 46% |
| 12 | Institutional weakness | 48 | 46% | 12 | Institutional weakness | 38 | 54% | 2 | Poor fishing zonation design | 19 | 51% |
| 31 | Habitat loss | 46 | 50% | 6 | Mis-management measures | 37 | 59% | 9 | Lack of SE considerations | 16 | 55% |
| 33 | Population growth | 45 | 53% | 33 | Population growth | 34 | 63% | 27 | Competing territorial claims | 15 | 59% |
| 7 | Lack protection for spawning | 44 | 57% | 25 | Illegal transboundary fishing | 28 | 66% | 15 | Low policy priority | 14 | 62% |
| 9 | Lack of SE considerations | 42 | 61% | 20 | Inaccurate fishery data | 27 | 70% | 21 | Lack of enforce. laws/tools | 14 | 66% |
| 35 | Coastal poverty | 40 | 64% | 9 | Lack of SE considerations | 26 | 73% | 19 | Lack of monitoring mech. | 13 | 69% |
| 6 | Mis-management measures | 39 | 67% | 13 | Insufficient mgmt capacity | 26 | 76% | 32 | Pollutions | 13 | 73% |
| 19 | Lack of monitoring mech. | 36 | 70% | 19 | Lack of monitoring mech. | 23 | 79% | 18 | Insufficient enforce. sources | 12 | 76% |
| 20 | Inaccurate fishery data | 36 | 73% | | | | | 33 | Population growth | 11 | 78% |
| 25 | Illegal transboundary fishing | 35 | 76% | | | | | | | | |
| 29 | Lack of RFMO | 35 | 79% | | | | | | | | |

subjects of regulation, enforcement and socio-economics (Table 5, Fig. 4).

## 5. Conclusions and suggestions for further cooperation

Degradation of the fisheries resources in the SCS has been frequently reported, and calls for international cooperation through establishing a formal international or multilateral RFMO in the region or some sorts of MPAs or peace parks were frequently made in recent years [3–5,7,9]. However, little progress was observed in formulating such a formal cooperative mechanism, or current-existing similar cooperative mechanisms have already been demonstrated to have certain deficiencies [41]; so that most resources in the region are still not subject to any management in a cooperative manner mainly due to the disputes of sovereign rights on the SCS. In order to bypass such disputes and to make a practical step forward so as to reach the goal of joint management, a bottom-up approach was then undertaken through holding a SCS Fisheries Resources and Management Workshop in 2017. Such Workshop was intended to function as a platform or forum for the seven key fishing actors of the SCS to get together and to provide basic information on their respective fisheries without specifically referring to the sources and without political concerns. The Workshop and its consequent efforts, for the first time, have successfully compiled and presented basic information on (1) the fisheries statistics from the seven key fishing actors of the region and (2) the management measures implemented by each fishing actor, and, at the same time, have collected and reviewed (3) subjective evaluations from managers or scientists on the causes of the stock depletion or the key issues that should be addressed for any potential stock recovery.

**Table 5**
Average scores by issue subjects for all respondents (ALL), respondents from southern SCS (SSCS) and from northern SCS (NSCS). Figure in the parenthesis is the number of respondents. Issues of codes 10 and 11 were removed before calculation of mean for subject Regulation since these two have not been selected by any respondent.

| | ALL (22) | SSCS (15) | NSCS (7) |
|---|---|---|---|
| Regulation | 2.23 | 2.36 | 1.95 |
| Institution/Policy | 1.56 | 1.51 | 1.69 |
| Enforcement/Compliance | 1.92 | 2.00 | 1.76 |
| Cooperation | 1.12 | 0.91 | 1.55 |
| Environment impact | 1.06 | 0.64 | 1.95 |
| Socio-Economics | 1.64 | 1.93 | 1.00 |

Most fishing actors do not possess specific SCS catch statistics. Accordingly, participants were invited to work out a set of national estimates (Fig. 1) and to examine the major fishery elements and their outputs (Fig. 2). Such estimates might be different from reports of previous literature; however, they are believed to be the best estimates obtained from the participants who are supposed to know better their own actual catch figures. As a first step, the compilation of catch and relevant fisheries data has depicted a general picture of the fisheries in the SCS which is valuable for understanding the fishing activities in the SCS. Comparing the statistics provided by the participants and those estimated by the *Sea Around Us* (Fig. 1) has shown a range of discrepancies in between. In view of its potential contribution to the common understanding over the SCS fisheries and to the regional cooperation on the conservation and management of the SCS fisheries resources, continuation of such Workshop is thus strongly recommended while reviewing and clarifying the various statistical systems of all SCS fishing actors is also suggested as the urgent need and a major topic for the next meeting. In this regard, inputs from fisheries statistics experts are expected to contribute to the improvement of the statistics and the statistical systems.

The study has compiled and summarized the management measures that currently implemented by each fishing actor, by category of input control, output control and technical instruments or tools (Table 2). Lack of awareness of the management measures implemented by other or even neighboring fishing actors was observed in the meeting, further

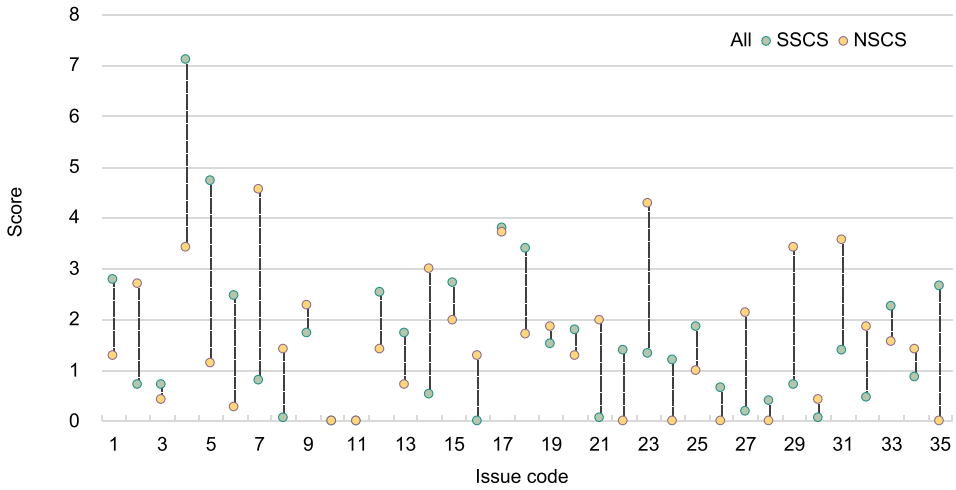


**Fig. 4.** Mean scores of the issues for all participants (ALL), as well as for participants from southern SCS (SSCS) and from northern SCS (NSCS). Refer to Table 3 for full name of the issue code.

indicating the need for a platform or forum to communicate and understand the management measures designed for the fisheries in general and/or for the fisheries in the region by other fishing actors. Such communication and mutual understanding are crucial for the future construction of any regional collaborative management scheme.

Again, as a first step, the summary table (Table 2) shows a picture of management measures that have been designed for and implemented in the region. However, it does not provide details on the scale of the measures (e.g., coverage of logbook or observer programs) or on the level of enforcement or effectiveness. Further exploration on this topic is thus needed for examining the adequacy of those measures and for designing a general collaborative regional management scheme as mentioned above. In addition, definitions of certain management measures seemed to be different in the minds of different participating parties (e.g., fishing license control and MPA) and clarification for definition consistency is thus needed.

The questionnaire study has indicated general views of participating parties on the causes leading to stock depletion, which may in turn be interpreted as the key issues for the recovery of the SCS fisheries resources. The priority issues emphasized by the participants include insufficient control on fishing capacity and fishing efforts as well as weak law enforcement; which may relate to the issues of insufficient enforcement resources, low policy priority and institutional weakness. Many essential management measures (e.g., input controls) have been implemented by the participating parties and/or in the region (Table 2), however, the scale and enforcement on those measures might be of concern which have resulted in ineffectiveness of the implementation. Solutions to such predicament apparently are not straightforward, considering the complicated causes derived from the questionnaire.

Issues that were highlighted by the SSCS were apparently different from those by the NSCS (Table 4 and Fig. 4). The attribution of this difference is yet to be explored and renders for further study. High percentage of the views from fisheries scientists, rather than managers, of the NSCS (5 over 7) in the current questionnaire study could have significant effect and such unevenness should be mitigated in the future study. Once again, such difference of perception between or among different fishing actors (or even between scientists and managers) revealed from the questionnaires manifests the need of mutual understanding through a suitable platform or forum.

The questionnaire study was conducted within a short session of the Workshop along with some responses obtained from participants through emails. It might be possible that this practice has prevented the participants from fully understanding the issues on the questionnaire. Participants were encouraged to add in new issues; however, this was also limited by the short time frame. A thorough design of the questionnaire and a deeper degree of participation by the participants in the process of answering the questionnaire are expected to be able to secure better insight on the issues that are considered to be needed for the recovery of the SCS marine or fisheries resources.

In general, the Workshop has demonstrated its value by the results as presented in this paper and has made an important and practical step forward to the joint management of the SCS resources. The Workshop functions as a platform or forum for scientists and managers who are associated with the SCS fisheries, rather than politicians, to get together and to exchange fisheries information and to build mutual trust. Compilation, presenting and sharing the fisheries statistical data and management information gathered in this paper could provide a base for understanding the current fishery status in the SCS. For those management gaps and needed statistics improvement identified in this paper, the Workshop is expected by the participating parties to continuously function as a useful platform or forum, or even a 'clearing-house mechanism' [19,20], in which and through which intraregional parties could find ways and solutions by themselves while extraregional professional inputs are also helpful. Hopefully, through such a bottom-up, second track approach, and such a non-political, depoliticized and non-State driven forum, the participating parties could develop a commonly agreed regional fisheries resources conservation and management scheme or arrangement to be undertaken by all the fishing actors of the SCS.

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