

Integrated spatial management of marine fisheries of India for more robust stock assessments and moving towards a quota system

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Abstract

In order to overcome the challenges in administering and regulating marine fisheries in the Indian EEZ under central government administration (area 1.86 million km², which is 92% of the total 2.02 million km²), a zonal management system is proposed. Besides the Territorial Waters (TW) zones regulated by maritime states, the broad marine biogeographic area of the Indian subcontinent were divided into 4, the northwest coast (northeast Arabian Sea - NEAS), southwest coast (southeast Arabian Sea - SEAS), southeast coast (southwest Bay of Bengal - SWBOB) and the northeast coast (northwest Bay of Bengal - NWBOB). There are 13 maritime states based TW zones and 6 regional zones (4 mainland and 2 island) in this proposed plan for fisheries management. The straightening of the coastline through notified baseline points for determining the breadth of TW and EEZ has resulted in 0.11 million km² of internal waters which are not under any regulations. All these zones are planned to be placed under co-management through specific fisheries management councils as advocated by the National Policy on Marine Fisheries 2017. Besides, the catch and effort data reporting, stock assessments and fisheries management under the new regime are highlighted. In fisheries management, a switch to a total allowable catch (TAC) and quota system is recommended. The advantages of zonal management, TAC system and fleet wise quotas are discussed.

Keywords: Marine fisheries, zonal management, TACs, quota system

Introduction

India's newly crafted National Policy for Marine Fisheries (NPMF, 2017) states the need for area specific management of fishery resources. Article 8 and 12 of the policy clearly states the need for species specific and area specific management plans and creation of fisheries management areas to ensure that resource depletion is contained. As per the Constitution of India, 'division of subjects', fishing within the 12 nautical mile (territorial waters) is to be regulated and managed by respective maritime states. The area outside the 12 nautical mile (nmi) zone up to the 200 nautical mile of the Exclusive Economic Zone (EEZ) is mandated to be managed by the Union Government. All maritime states of India have fisheries regulatory acts to govern fishing in their territorial waters. However, the

act to govern the centrally administered area is yet to be put in place. The area of Indian EEZ under the central administration is 1.86 million km² (which is 92% of 2.02 million km² EEZ). The areas which are under maritime state administration are shown in Table 1.

At present the area under central administration is very large and administration and regulation of fisheries in such a large area is a challenging task. Zonal management is a way to delineate areas of the coastal and marine environment to specific allowable or prohibited activities in time or space. Zonal management is very different from the longstanding concept of open access to the seas and oceans. Different forms of zoning have occurred on land for thousands of years, and there have been traditional

and customary marine tenure systems in certain locations throughout history as well. It is only more recently that formally planned zonal management systems are being applied to marine and coastal areas around the world. Some examples are the fisheries management councils and zones in the USA, European Union, Australia and New Zealand among developed countries, and the fisheries management areas in other countries like Indonesia, Thailand and Malaysia. All the Marine Fisheries Regulation Acts (MFRAs) of Indian maritime states allow for specific zones reserved for traditional fishers for protecting their livelihoods and customary rights. The NPMF (2017) encourages maritime states to extend this zone up to the limit of territorial waters (12 nmi), although none of the states have currently done so.

Much earlier, regional fisheries management outputs were recognized as a solution to the country's diverse and vast coastline, multi-species and multi-gear nature of fisheries (Vivekanandan *et al.*, 2003). Consequently,

from 2005 onwards, the ICAR-CMFRI reorganized its fisheries resource assessment projects revolving around each maritime state, with the main objective of developing state-wise Fishery Management Plans (FMPs). This resulted in development of FMPs for the states of Karnataka (Rohit *et al.*, 2016); Andhra Pradesh (Muktha *et al.*, 2018), Tamil Nadu, Maharashtra and Gujarat (all to be published) under the guidance of the Marine Policy Cell of ICAR-CMFRI.

Depending on the resource distribution, abundance and degree of overcapacity, already more than 70% of India's marine fish landings are taken from the centrally administered 12-200 nmi zone by boats operating from all fish landing ports in India (Mohamed *et al.*, 2014; Dineshbabu *et al.*, 2017). It is also a fact that these vessels currently are not given a license to operate in the specific area, although they are all registered with the Department of Fisheries (Ministry of Fisheries, Animal Husbandry and Dairying-MoFAHD). Also, these vessels often land

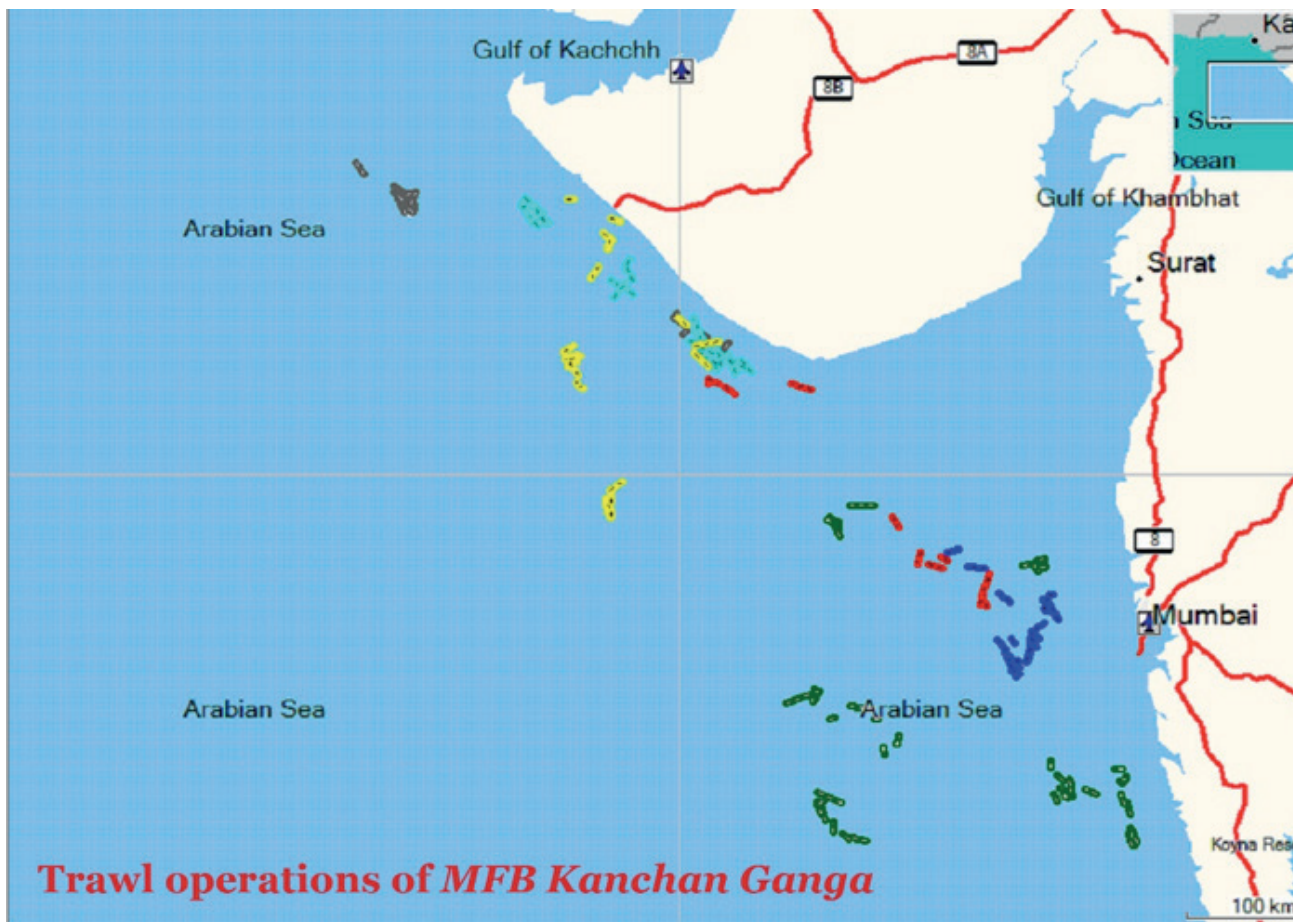


Fig.1. Month wise locations of trawl operations of a Veraval based trawler (MFB Kanchan Ganga) during the 2008-09 fishing season in northwest Arabian Sea. A substantial number of hauls are made off Maharashtra. Map from Mohamed *et al.* (2010).

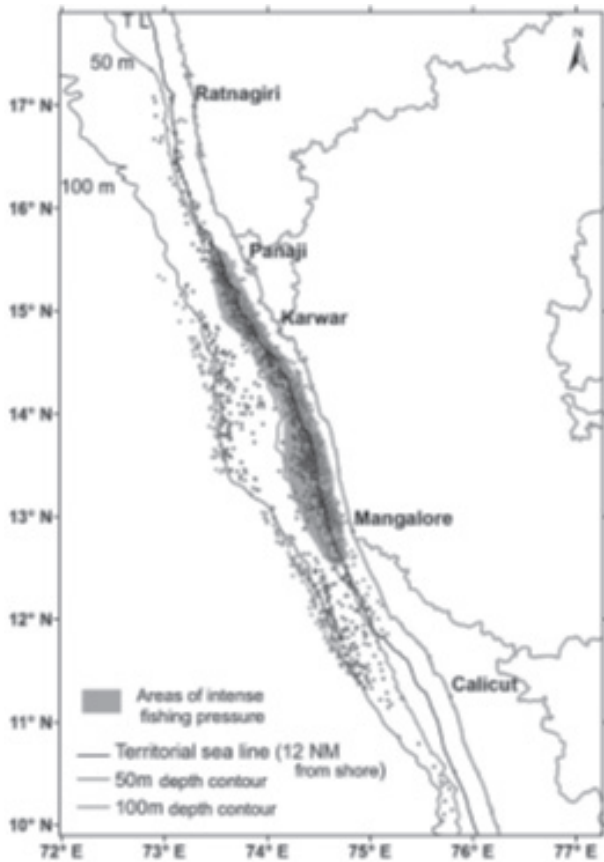


Fig.2. Distribution of trawl fishing effort in Karnataka during 2007-13 fishing seasons (from Dineshbabu *et al.*, 2017). Based from Karnataka fishing operations made off Goa, Maharashtra and Kerala.

catches taken from the 12-200 nmi off one maritime state, in landing centres of another maritime state. For example, a Gujarat based fishing trawler operating off Maharashtra or Goa or even further south will land its catch in a Gujarat fishing port (Fig.1), making state-wise estimate of catches erroneous. Similarly, Karnataka based trawlers operate off Goa, Maharashtra and Kerala (Fig.2) but land their catches in Karnataka fishing ports. This affects the precision of stock assessments as an accurate estimation of catch and effort for each state is an important input for any type of fish stock assessment. The ICAR-CMFRI's catch reporting and stock assessments always use maritime state as a unit in order to help planning and co-ordination. With increasing efficiency and capability of present day fishing vessels such errors are multiplied. Besides, there are reports of clashes between fishermen of neighbouring states (Fig.3) because of competition for resources and lack of clarity regarding who can fish where. Hence, there is an urgent need to rationalize and manage the system within the framework of existing laws and/or new regulations and keeping in view the



Fig.3. News report of clashes between Maharashtra and Gujarat fishermen in the Arabian Sea (Source: *The Times of India*, TNN | Feb 4, 2016).

policy directions in NPMF 2017.

Creation of marine fisheries management zones

The territorial waters (TW) of each maritime state which are administered by respective MFRAs will become the primary coastal zones. They are numbered starting from Zone A1 (Gujarat) to Zone D11 (West Bengal) moving down along the west coast and then proceeding up along the east coast. The broad marine biogeographic area of the Indian subcontinent are generally divided into 4, the northwest coast (northeast Arabian Sea - NEAS), southwest coast (southeast Arabian Sea - SEAS), southeast coast (southwest Bay of Bengal - SWBOB) and the northeast coast (northwest Bay of Bengal - NWBOB). This division is also on the basis of broad oceanographic realms and unique biodiversity of the resources and is mostly aligned with international classifications (Spalding *et al.*, 2007). These zones are named Zone A, B, C and D corresponding to NEAS, SEAS, SWBOB and NWBOB respectively (Fig.4). Since the main island territories of India, Lakshadweep Islands and the Andaman and Nicobar (A & N) Islands are isolated from the mainland, their territorial waters and 12 - 200 nmi area would form 3 separate zones (Table 1).

There are 13 TW zones and 6 regional zones in this proposed plan for fisheries management zones (Table 1 and Fig.4). Among the TW zones, A&N Island has the largest area followed by, Lakshadweep, Tamil Nadu,

Table 1. Classification of marine fisheries management zones of India, its extent and proposed regulatory regime.

Zone Code	Name of Zone	Internal Waters in km ²	EEZ Area in km ² (TW & outside)	Regulatory Authority	Management Councils
A1	TW Gujarat	26962.89	10873.12	Govt of Gujarat	GJSFMC
A2	TW Daman & Diu	112.09	337.32	UT Daman & Diu	DDSFMC
A3	TW Maharashtra	3173.81	11847.18	Govt of Maharashtra	MHSFMC
B4	TW Goa	834.99	2199.49	Govt of Goa	GOSFMC
B5	TW Karnataka	2110.25	5256.10	Govt of Karnataka	KNSFMC
B6	TW Kerala	1409.05	11529.64	Govt of Kerala	KLSFMC
C7	TW Tamil Nadu	2533.88	18863.83	Govt of Tamil Nadu	TNSFMC
C8	TW Puducherry	98.69	788.37	UT of Puducherry	PUSFMC
C9	TW Andhra Pradesh	8157.96	17436.13	Govt of Andhra Pradesh	APSFMC
D10	TW Odisha	9462.97	7591.32	Govt of Odisha	ODSFMC
D11	TW West Bengal	8129.89	3198.12	Govt of West Bengal	WBSFMC
E12	TW Lakshadweep	44611.57	22965.50	UT of Lakshadweep	LKSFMC
FG13	TW A&N Islands		53683.10	UT of A&N Islands	ANSFMC
A	NEAS		324301.62	Union Govt	NEAS RFMC
B	SEAS		466761.92	Union Govt	SEAS RFMC
C	SWBOB		410099.55	Union Govt	SWBOB RFMC
D	NWBOB		106834.44	Union Govt	NWBOB RFMC
F	EBOB		384565.19	Union Govt	EBOB FMC
G	AN Sea		165654.80	Union Govt	ANS FMC
Total		107598.05	2024786.73		

The area estimates given are indicative. Abbreviations: TW- territorial waters; NEAS - northeast Arabian Sea; SEAS - southeast Arabian Sea; SWBOB - southwest Bay of Bengal; NWBOB - northwest Bay of Bengal; LKS - Lakshadweep Sea; EBOB - eastern Bay of Bengal; ANS - Andaman Sea; SFMC - State Fisheries Management Council; RFMC - Regional Fisheries Management Council; FMC - Fisheries Management Council. Also refer Fig. 4.

Andhra Pradesh and Maharashtra. Together the TW zones, which are the managed areas with enacted laws, account for only 8% of the total EEZ.

Internal Waters: The Government of India has notified the baseline points for measuring seaward the limits of TW and EEZ in 2009 (Ministry of External Affairs - NY/PM/443/1/2009 dated 13 August 2009, *Bulletin No. 71 of the United Nations, Law of the Sea, 2010*). The baseline points are indicated in Fig.4. The creation of the baseline which straightens the coastline, and also takes into account the many small islands off the coast, creates internal waters which is the sea area between the coast and the inner boundary of the TW. Such internal waters are present in all maritime states of India (Table 1) and the total area of internal waters is 0.11 million km² (shown stippled in Fig.4). This is not part of the Indian EEZ. The largest internal waters are in the Lakshadweep Islands (41.5%) as the sea area encircling the TW of these islands are considered as internal waters. The second largest internal water area is in Gujarat where the Gulf of Kutch and Gulf of Kambhat

are included as internal waters. For the purpose of fisheries administration and management, these internal waters have not been accorded proper jurisdiction. It will be appropriate to include the operational control of these waters to the maritime states along with TW when the laws are being amended.

Area wise, the zones managed by the Union Government accounts for 92% of the EEZ (1.86 million km²). The largest among these is the SEAS Zone (B) followed by SWBOB (C), EBOB (F) and NEAS (A). The fisheries in the TW zones are governed by the respective maritime states or UTs through the MFRAs.

Making the zones operational: The regulatory authorities have to notify the zones and the zonal management system through appropriate amendments in the legislation in the case of TW zones as has been done by the Government of Kerala. However, for regional zones appropriate provision has to be made in the proposed new law by the Union Government.

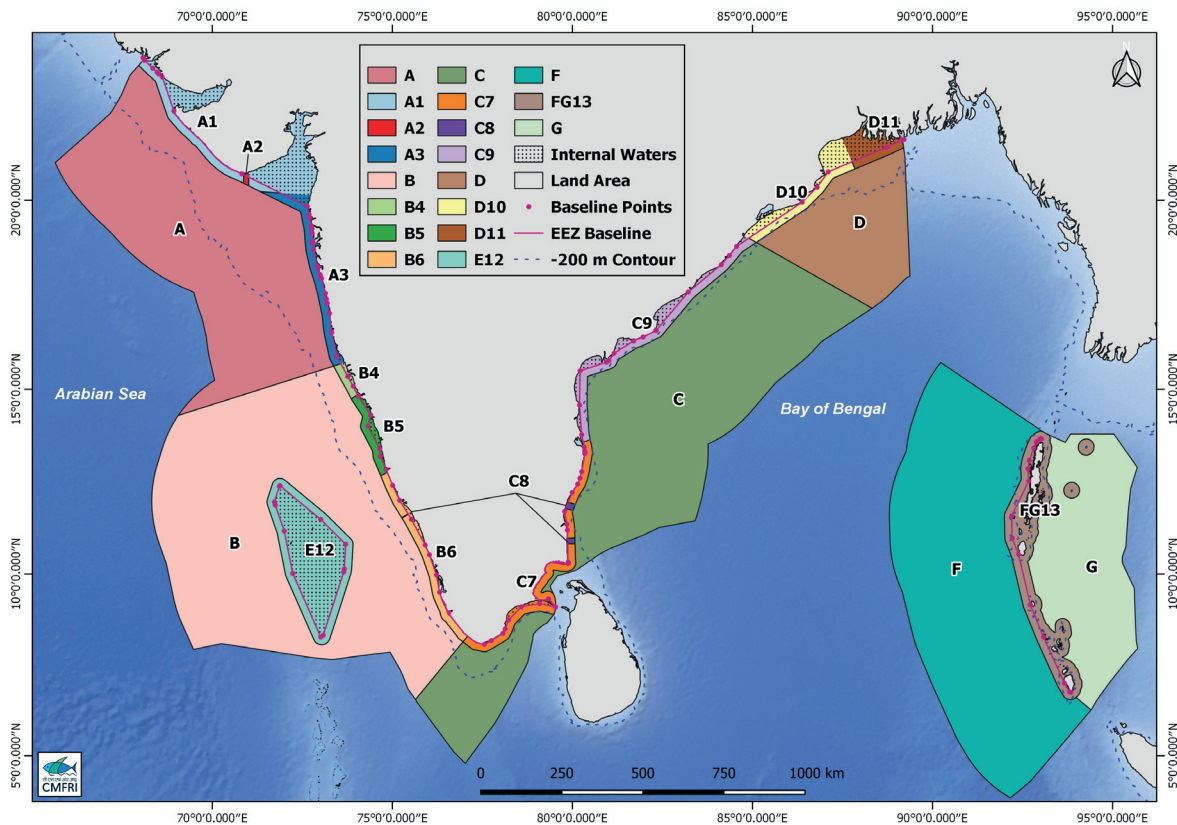


Fig. 4. Map showing proposed fishing zones in Indian EEZ. The map is only for the purpose of geographic information reference and the area estimates are indicative. Map source: Flanders Marine Institute (2014), Union of the ESRI Country shapefile and the Exclusive Economic Zones (version 2).

Reporting catch and effort under the new regime

The ICAR - CMFRI which estimates all India marine fish catch and effort follows a maritime state based reporting from 1950 onwards. Finer spatial resolution data (district/fishing harbours etc.) are also available in its database (NMFDC - National Marine Fisheries Data Centre). Following the initiation of electronic tablet based field data collection from 2018, spatial data reporting through passive geo-referencing has become possible. Since vessel-gear combinations which fish inside and outside the TW are well known, it is possible to categorize the reporting to reflect this spatial information in all parts of the country. Once the zonal fisheries management system becomes formal, the data reporting to the states/UT and centre would be for TW of each maritime state/UT and for the 6 RFMC areas. ICAR - CMFRI should also make concerted efforts to split the historical data from 2007 (year in which complete species reporting was enabled) to enable long-term comparisons and for model fitting.

Stock assessments under the new regime

One of the aims of introducing area based zonal fisheries management is to bring in more robust and accurate stock assessments. For coastal, shallow water species the catch and effort data generated for state-wise TW zones would be used for doing stock assessments. Most of the species/stocks in the regional zones exploited by trawls have limited latitude-wise movements. Therefore, for the outside TW regional zones, the catch and effort data for the regional zones would be used for stock assessments. This would result in species/stock MSYs (Maximum Sustainable Yields) for state-wise TW zones and regional zones leading to better management of fish stocks. The derived MSY figures for each major stock (forming more than 5% of total catch in a fleet) in different zones can then be used to fix zone based precautionary total allowable catch (TAC) quotas at 80% of the MSY. With advent of electronic tablet based data collection and reporting system, the catch

estimates have only a lag of one month at present as compared to the 3 - 4 months period earlier. This means that management agencies can quickly act to caution a fisheries when a quota is approached or completed based on advisories from ICAR - CMFRI.

The highly migratory fish stocks such as tunas would need a different approach since their distribution transgresses several management zones. It would be advisable to derive estimates of MSY separately for the Arabian Sea and Bay of Bengal for such fish stocks and then allocate quotas for each zone based on the relative fishing intensity.

Method of allocation of quota

Once a TAC has been determined, allocation of this quota for different resource users becomes imperative. In a multispecies and multigear scenario, this becomes a complex and difficult exercise, and we can only learn as we move forward. Several objective criteria have been used elsewhere in the world including provision for resource rents and management costs with regional variations (Morgan, 1997). In the TW zones which are under the control of maritime states, we envisage a property rights based allocation to traditional fishers. Here, the multitude of gears and high diversity in the resources have to be taken into account. In the regional zones, there is the additional dimension of multiple state vessels besides the multispecies and multigear nature of the fisheries. Another important facet in quota allocation is the consideration for social and economic status of the fishers, which needs factorization after initial trials. Besides, as tropical ecosystems have high turnover and high fluctuations in biomass, we recommend a variable (not fixed) quota system based on the frequency of the

stock assessment for each stock. Currently, we present one example each from TW zone (oil sardine, Kerala) and regional zone (SWBOB, threadfin bream, states of Tamil Nadu, Puducherry and Andhra Pradesh).

The first example of oil sardine is worked out by taking 0.8MSY as a precautionary annual catch quota, and by giving more weightage to (p1) those fishing fleets which harvest oil sardine in high proportions (targeted fishery, oil sardine catch by the fishing fleet divided by total oil sardine catch) and (p2) weightage to those fleets in which oil sardine forms a major proportion (oil sardine catch by the fishing fleet divided by total catch by the fishing fleet). By this rule those fishing fleets having high values for both p1 and p2 will have the maximum allocation. This is illustrated in Table 2.

One way of limiting the harvest to allotted quota of the fishing fleets can be by controlling the number of trips by each fishing fleets. Using information on fishing effort in terms of number of trips as well as hours of fishing available in NMFDC and information on fishing crafts in the fishery available from Marine Fisheries Census 2016, the allowable number of trips can be calculated.

In the second example, we take the case of the trawl fishery for threadfin breams (*Nemipterus japonicus*) in SWBOB zone comprising the states of Tamil Nadu, Puducherry and Andhra Pradesh. Using the same proportions (p1, p2 and its product) as applied above for oil sardine, we first apportion the quota for different fleets, and then applying this proportion in the total proportion of all states to the fleet quota, the state-wise fleet-wise quota can be determined (Table 3).

Table 2. Gear-wise annual quota allocation for oil sardine stock in TW of Kerala. Proportion of the species caught by each gear (p1) and proportion of the species in total catch by the gear (p2) and its product (p1*p2) are used to apportion the quota.

Gear ID	p1	p2	p1*p2	Quota (tonnes)
MRS	0.481	0.726	0.349	121814.4
IBRS	0.046	0.725	0.033	11633.2
MPS	0.002	0.164	0.000	127.3
OBRS	0.403	0.597	0.240	83959.2
OBGN	0.046	0.238	0.011	3796.5
NM	0.022	0.343	0.008	2677.4
Total/0.8MSY				224008.0

MRS - Mechanized raing seine; IBRS - Inboard ring seine; MPS - Mechanized purse seine; OBRS - Outboard ring seine; OBGN - Outboard gillnet; NM - Non-mechanized gears.

Table 3. Gear-wise and state-wise annual quota allocation for *Nemipterus japonicus* stock in SWBOB. Proportion of the species caught by each gear (p1) and proportion of the species in total catch by the gear (p2) and its product (p1*p2) are used to apportion the quota first, and then this proportion is applied the fleet-wise quota for determining the state-wise quota.

Gear ID	AP	PU	TN	Total Quota (tonnes)
MMT	0.2	2575.2	1005.1	3580.5
MST	0.0	3591.2	9238.8	12830.0
OBGN	35.3	0.1	0.1	35.5
Total/0.8MSY	36	6166	10244	16446

MMT - Mechanized multiday trawl; MST - Mechanized singleday trawl; OBGN - Outboard gillnet;
 AP - Andhra Pradesh; PU - Puducherry; TN - Tamil Nadu

Marine fisheries management under the new regime

A systemic plan has to be developed for ushering in a healthy marine fisheries management system for the country. Since the TWs are under the regulatory control of respective maritime states through their MFRAs, this is fairly straightforward. The main action would be to amend or update the MFRAs in tune with modern fisheries management principles with proper vision, mission and objectives. As advised by the NPMF (2017), this may be done by drafting a model bill by the Union Ministry of Fisheries to be enacted by all maritime states. It is important to have new legislation for zonation by both the maritime states and the Centre.

The Indian Marine Fisheries Code (IMFC) advises adopting a participatory or co-management approach for the entire country (Mohamed *et al.*, 2017) by creating fisheries management councils with adequate representation for fishers and other stakeholders. In this bottom-up tiered system the consensus decisions taken in the lower councils with scientific support are ratified by the upper councils, finally enabling equitable decisions and rule making. The National Marine Fisheries Management Council (NMFMC) will be the apex council under the Union Ministry of Fisheries which will have oversight of all councils. In a maritime state, the Village FMC is at the lowest rung, which reports to the District FMC which in turn reports to the State FMC (Fig.5). The management councils

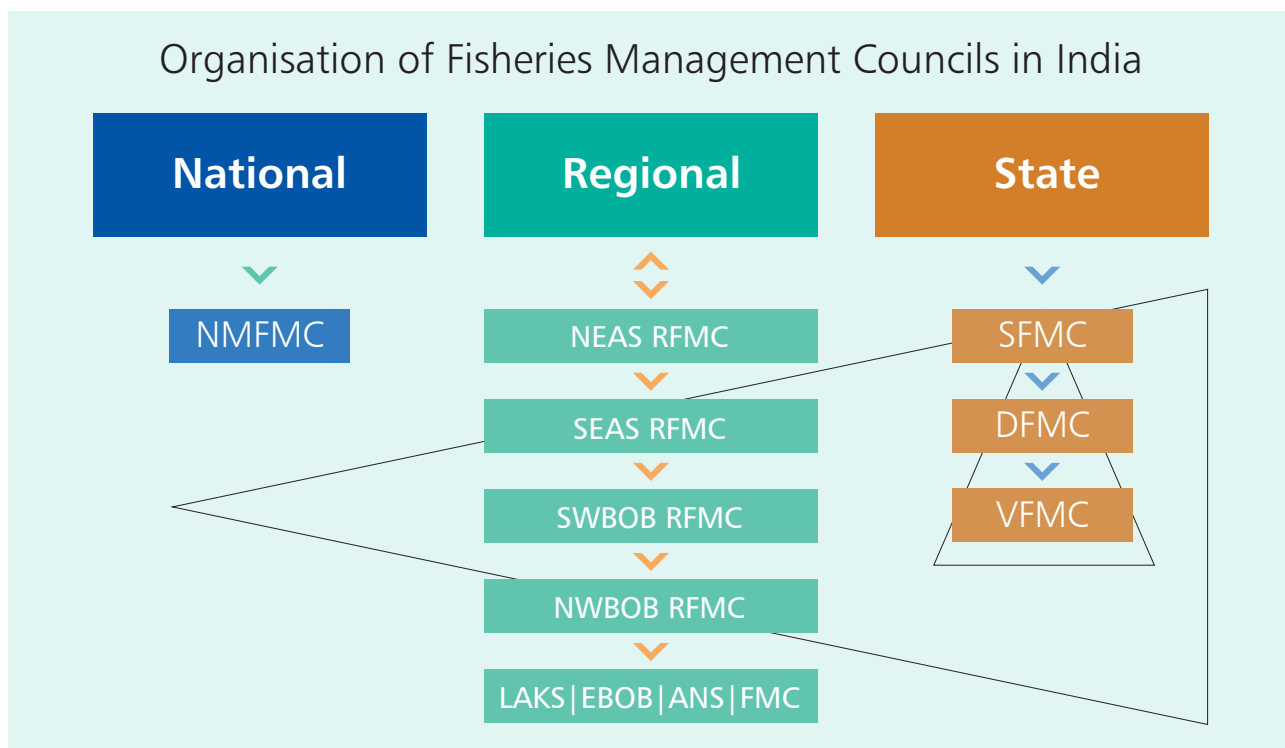


Fig. 5. Infographic of the proposed council based fisheries management for India (adapted from Mohamed *et al.*, 2017). Triangle apices shows the top of hierarchy within the system.

proposed for managing the fisheries in the respective zones are shown in Table 1. The Kerala MFRA has been amended in 2017 to accommodate this system, and the Kerala SFMC has already made terms of reference for the FMCs and the SFMC has had its first meeting. The regional FMC (RFMCs) have representations from multiple maritime states as per Table 1 and Fig.5.

Fishing licenses as a means of regulatory control

It is necessary to ensure that vessels licensed to fish in a particular zone fish in this zone only (through implementation of VMS/AIS systems) and land their catches in fishing ports lying within the zone. This would lead to more accurate zone-wise catch and effort estimate, and in turn, more meaningful and robust stock assessments. According to the FAO CCRF (Code of Conduct for Responsible Fisheries), Article 8.1.2, every country should maintain records on all vessels which are authorized (licensed) to fish and Article 7.6.2 states

that no vessel be allowed to fish unless so authorized. Further, Article 8.1.1 also states that fishing operations allowed by them are conducted within waters under their jurisdiction, indicating area specific licensing of fishing vessels. These clauses are crucial to implement the zonal fisheries management plan.

Currently there is lack of clarity in the system of registration and licensing for vessels fishing in the 12 - 200 nmi zone. The DoF (MoFAHD) currently registers the vessels allowing fishing operations throughout the Indian EEZ (12 - 200 nmi). The State Department of Fisheries (DoF) gives a license for the same vessel to fish in the TW of the respective state. When zone based management is introduced this system has to be radically changed. A license is the authorization to fish in a particular area using a particular gear, and registration of a vessel is only to ensure that the vessel is seaworthy and complying with all sea safety requirements. Under the new regime licenses to fish should be given on a zonal basis by each maritime state for TWs and for the 6 regional zones by the Union Government. Since many of the regional zones

Table 2. Comparison of current fisheries management system and the proposed changes.

No.	Current regime	Proposed change
1	<p>TW fisheries management</p> <ul style="list-style-type: none"> Done by all maritime states under their respective MFRA's. Limited area based (within TW) exclusive right to traditional small-scale fishers in all maritime states. Mechanized fishing is also done in this zone. Catch reported on maritime state basis without delineating inshore and offshore resources 	<ul style="list-style-type: none"> Change in name of zone. Include Internal Waters within this management regime. Introduction of council management system (already done by Kerala State through amendments in KMFR Act). Gear-wise quotas for major coastal stocks and stock managed on the basis of this. Assuring exclusive rights to traditional and modified traditional fishing methods. No mechanized or industrial fishing in this zone. Catch and effort data reporting only for inshore resource in TW zones to facilitate stock assessments.
2	<p>Outside TW fisheries management</p> <ul style="list-style-type: none"> Entire outside TW area, up to 200 nm considered as one large fishing area The DoF (MoFAHD) registers the vessel and the DoF (maritime state) issues the license (legally valid only in TW). Vessels permitted to operate in any area outside of State TWs. Vessels can land their catch in any fishing port if respective state allows it by paying user fee. Temporal closure during monsoon along west coast and during summer along east coast is the only management practiced. 	<ul style="list-style-type: none"> Outside TW area split into 4 regional and 2 island zones Zone based licenses issued for fishing, allowing licensee to fish only in that zone. Vessels can land their catches only in ports of respective zones. Introduction of regional council management system. Gear-wise quotas for major offshore fish stocks Quota allocation based on an objective criteria Temporal closures reworked based on breeding period of major offshore stocks. Catch and effort data reporting based on offshore zones to facilitate stock assessments.

are shared between States, it would be appropriate if this authority is given to respective maritime states based on current fleet sizes. The number of licenses forms a point for input control by the respective RFMCs based on TACs.

Advantages of spatial management and TACs

Changing over to a spatial fisheries management is a profound change from the present system of functioning and a big challenge (Table 2). However, the advantages outweigh the hard work by a big margin in our journey towards putting India's marine fisheries on a sound sustainable footing. Some of the advantages are listed below:

- More organized and systematic fishing operations and its regulation.
- By bringing in council based management, introduce co-management into the system ensuring equity among all participants and comply with EAFM (Ecosystem Approach to Fisheries Management) principles.
- Reduce inter-state conflicts among fishermen arising out of competition for resources.
- More accurate and meaningful stock assessments leading to practical harvest control rules.
- Introduce quota management system based on TACs which leads to assured incomes and sustainable fish stocks.
- More effective science based management of key resources leading to sustainability.
- Traditional fishers get exclusive rights and zone exclusivity assures conflict reduction.

- Favours price stabilization by avoiding boom and bust situations in fish catches.

Endnote

The spatial management and TAC proposal given above represents a radical change in the manner in which marine fisheries in India is governed. It is quite possible that there may not be sufficient backing from decision makers in effecting these changes immediately considering the effort involved and also due to the perception that business-as-usual is a safer option. But, in the long-term interest of safeguarding the country's resources and ensuring equity and sustainability it is necessary to make these changes. Managing the tuna and allied fisheries based on quotas is already a requirement for India as per IOTC (Indian Ocean Tuna Commission) obligations. Many developing countries have already put similar systems in place.

Acknowledgements

Authors thank the Director, ICAR - CMFRI for facilities, Dr. V. Kripa for critical reading and Mr. Sebastian Mathew, ICSF, Chennai for critical insights and documents on internal waters.

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