For Official Use Only

Report of the Expert Committee for Revalidation of the Potential Yield of Fishery Resources in the Indian EEZ

September 2018

Submitted to

Department of Animal Husbandry, Dairying and Fisheries

Ministry of Agriculture and Farmers Welfare

New Delhi-110 001

सत्यमेव जयते
सचिव
भारत सरकार
Secretary
Government of India

कृषि एवं किसान कल्याण मंत्रालय
पशुपालन,डेयरी, एवं मात्स्यिकी विभाग
कृषि भवन, नई दिल्ली-110001
Ministry of Agriculture & Farmers Welfare
Department of Animal Husbandry, Dairying and Fisheries
Krishi Bhavan, New Delhi-110001

FOREWORD

Marine fisheries plays a significant role in the Indian economy by providing nutritional and food security, generating employment, creating livelihood opportunities and contributing to foreign exchange earnings. The country has a vast maritime area, comprising 2.02 million sq.km. of Exclusive Economic Zone (EEZ), a coastline of 8118 km, and ecologically sensitive ecosystems such as the Sunderbans mangrove forests, Gulf of Mannar, Gulf of Kutch and the waters surrounding the two Island territories, *viz*., Andaman & Nicobar and Lakshadweep. A vibrant and dynamic fishing community spread all along the coastline harvests the fisheries resources of the EEZ.

The management and sustainable harnessing of the resources in the EEZ is vested with both the Department of Animal Husbandry, Dairying and Fisheries (DADF), Ministry of Agriculture and Farmers Welfare and the Department of Fisheries of the coastal States and the Union Territories (UT). While the jurisdiction in the EEZ is divided between the Centre and States/UTs, the larger policies and programmes for exploitation of the resources in the marine waters are taken up in consultation with each other. The conduct of studies to estimate the potential yield from the marine waters of the country is also one such joint initiative of the Centre and the coastal States/UTs to arrive upon estimates that determine the harvestable potential and allow the stock to be fished on a sustainable basis.

The Central Government in association with the fisheries research institutions, Department of Fisheries and development partners has been carrying out stock assessment exercises on a regular basis, the previous exercises carried out during 1991, 2000 and 2011. The present exercise updates the previous assessment of 2011 by utilizing more extensive data collected by the R & D organisations and by using advanced computing methodologies. The Expert Committee constituted to estimate the current Potential Yield has done a commendable job by considering the dynamics of the fishery resources of the Indian EEZ. The Report, besides providing an update on the Potential Yield estimates, also provides an overview of the global and Indian marine fisheries and important suggestions for conservation and management of fishery resources in the EEZ of India.

I hope that this report would be useful for the entire fisheries sector in India and the concerned agencies will be able to make full use of the guidance provided in the Report for sustainable exploitation and management of the fisheries resources within their jurisdictions. I would also like to congratulate the Chairman, members and the experts invited to assist the Committee in completing the task assigned to them and providing this valuable guiding document to the Government.

(Tarun Sridhar)

PREFACE

The ambitious programme of the Government of India to enhance fish production through "Blue Revolution (*Neel Kranti*)" is a significant step towards optimum exploitation of the resources, improving the value chain and enhancing the socio-economic status of the fishers and their families. India, in recent decades, has also created a niche for its seafood in the global market and thus the seafood exports have also contributed substantially towards the achievement of the social and economic goals set in the developmental paradigms of the country's planning process.

India in 2017 formulated the National Policy on Marine Fisheries (NPMF, 2017) based on seven pillars, *viz*., sustainable development, socio-economic upliftment of fishers, principle of subsidiarity, partnership, inter-generational equity, gender justice and precautionary approach. India has also committed itself to the sustainable development of fisheries set in the international agenda, one of the most notable being the Sustainable Development Goals and in particular Goal 14 – Life Below Water.

To meet the objectives of the NPMF, 2017 as also the international agenda, India is moving ahead with the setting up of standards, management protocols and reliable estimates to ensure that the marine fisheries resources are harvested in the most sustainable manner. In this regard, the estimation of Potential Yield (PY) has been an important programme of work ever since the benchmark estimates were made by George *et al*. in 1977.

Since 1977, the Government of India in the Ministry of Agriculture has been routinely carrying out estimates of the PY and 12 such estimates have been carried out so far, with the most recent in the year 2011. The resources considered for estimating the PY as also the methodologies applied have undergone significant changes with the advancements in fishing technologies on one hand and the computing methodologies on the other hand. Some of the recent methodologies also provide good estimates in case of fisheries which are data deficient.

The present Committee was constituted by the Department of Animal Husbandry, Dairying and Fisheries (DADF), Ministry of Agriculture and Farmers Welfare, Government of India in August 2017. The Committee was tasked to revalidate the PY that would also include the additional marine fisheries potential and suggest conservation and management of marine fishery resources within the Indian EEZ. The Committee besides nominated members, also utilized the services of several experts in completing the task.

The Committee convened five meetings to conduct its business. The larger set of data used for estimating the PY was sourced from the Central Marine Fisheries Research Institute, Kochi; Fishery Survey of India, Mumbai; and Centre for Marine Living Resources and Ecology, Kochi. The estimates took into account the data collected through fish landings, exploratory surveys and productivity at different trophic levels. Besides the conventional methodologies used for arriving at the estimates, programmes such as SEA-MICE and CMSY were also used. Wherever required, a precautionary approach was used to arrive at the estimates. Moving ahead from the PY 2011 estimates, the present estimates besides providing aggregate PY, also give state-wise figures. This will allow the coastal States and UTs to plan their harvesting strategies more precisely than what was done earlier.

The Committee is of the view that the revalidated PY estimates will be of use to the government, R & D institutions, development partners and other practitioners of marine fisheries. As estimated in the Report, the Government will also be able to readjust the fishing effort deployed in the marine waters by optimizing the fishing fleet. As the fisheries resources are highly dynamic and also influenced by both man-made and external impacts, in particular climate change, the Committee suggests that the revalidation should be carried out at more regular intervals to ascertain the health and integrity of the resources and the fisheries.

ACKNOWLEDGEMENT

The Committee is grateful to Shri Tarun Sridhar IAS, Secretary, Ministry of Agriculture and Farmers Welfare, Government of India and Dr E. Ramesh Kumar IAS, Joint Secretary (Fisheries), Department of Animal Husbandry, Dairying and Fisheries, Government of India for their constant support and encouragement in carrying out this exercise.

The excellent contributions of each and every member (including co-opted) of this Committee and the Sub Groups in the process of revalidating the fishery potential is highly appreciated. Their active participation in the deliberations, valuable suggestions and constructive criticism has helped in refining the ideas and methodologies adopted in the process.

The Committee is thankful to all the Heads of Institute of CMFRI, FSI and CMLRE for providing the inputs and data sets for various analyses and their respective Sub-Groups for working out the potential estimates presented in the report. The Committee also thanks the Heads of Institute of INCOIS, ZSI, ICAR, NIO, NRSC, NIOT and BOBP-IGO for sparing the services of their Officers to accomplish the task assigned. The Committee also likes to thank Dr. K. Vijayakumaran, Principal Scientist, CMFRI for his contribution in drafting the report.

The task of this Committee was completed on account of the support provided by a large number of officers of the FSI and Central Marine Fisheries Research Institute (CMFRI) and their services are greatly appreciated. The logistical support extended by the FSI, CMFRI and the Bay of Bengal Programme Inter-Governmental Organisation in conduct of the meetings is duly acknowledged.

The Constitution and Terms of Reference

The Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture and Farmers Welfare, Government of India, vide Order No.21001/2/2016-FY (Ind) dated 24 August 2017 constituted the Expert Committee for revalidation of potential fishery resources in the Indian EEZ with the following members and Terms of Reference:

CHAIRMAN

Dr L Ramalingam
Deputy Director General (Fy) / Director General (In-Charge)
Fishery Survey of India, Mumbai

MEMBERS

Dr P Pravin
Additional Director General (Marine)
Indian Council of Agricultural Research
New Delhi

Dr A Gopalakrishnan
Director
Central Marine Fisheries Research Institute
Kochi

Dr A C Anil
Chief Scientist
National Institute of Oceanography
Goa

Dr M Sudhakar
Director
Centre for Marine Living Resources & Ecology, Kochi

Dr Yugraj Singh Yadava
Director
Bay of Bengal Programme
Inter-Governmental Organisation,
Chennai

Dr R Kirubagaran
Scientist G &Head, MBT Division,
National Institute of Ocean Technology
Chennai

Dr Kailash Chandra
Director
Zoological Survey of India
Kolkata

Dr P Paul Pandian (Member Secretary)
Fisheries Development Commissioner
Ministry of Agriculture and Farmers Welfare
Department of Animal Husbandry,
Dairying & Fisheries, New Delhi

Terms of Reference of the Committee:

1. To revalidate the potential yield estimates of marine fishery resources on the basis of research, fisheries resources survey and exploratory work conducted in the Indian EEZ
2. To estimate the additional marine fisheries potential that could be harvested on a sustainable basis from different depth / zones / regions of the Indian EEZ

3. To estimate the number of each category of resource specific vessels / fleet size for sustainable harvest of potential marine fishery resources available in the Indian EEZ for the next five year period, and

4. To give suggestions on conservation, management and sustainable use of marine fishery resources in the Indian EEZ in light of the existing legislation and various global convention(s) / initiatives

Co-option of Members

During the first and second meetings of the Expert Committee, the Members decided to co-opt the following Officials/Experts to provide support in meeting the Terms of Reference.

- The Commissioner/Director of Fisheries of the Govt. of Gujarat (for West coast) and Govt. of Andhra Pradesh (for east coast)
- Dr K Vijayakumaran, Principal Scientist, Central Marine Fisheries Research Institute (CMFRI), Research Centre, Chennai
- Dr K. Sunil Mohamed, Principal Scientist, CMFRI, Kochi
- Dr T V Sathianandan, Principal Scientist, CMFRI, Kochi
- Dr E Vivekanandan**,** Former Principal Scientist, CMFRI, Kochi and presently with BOBP-IGO, Chennai
- Dr V N Sanjeevan, former Director, Centre for Marine Living Resources & Ecology, Kochi,
- Dr S B Choudhury, Scientist-SG, National Remote Sensing Centre, Hyderabad
- M Nagaraja Kumar, Scientist E, Indian National Centre for Ocean Information Services, Hyderabad

Timeline and meetings held

The tenure of the Expert Committee was extended up to 31 August 2018 vide the Ministry's Order No.21001/2/2016-FY (Ind) dated 12 April 2018. Subsequently the tenure was extended upto 30th September 2018 vide Ministry's Order number ……. Dated ……

The Expert Committee met on the following five occasions:

1. 4th November 2017 at FSI HQ, Mumbai
2. 9th March 2018 at CMFRI HQ, Kochi
3. 17th July 2018 at Zonal Base of FSI, Chennai
4. 30th and 31st July 2018 at BOBP-IGO, Chennai
5. 7th September 2018 at Zonal Base of FSI, Chennai

Sub-Groups

The following three Sub-groups were constituted to analyze (a) Commercial fisheries data (CMFRI), (b) Fishing survey data (FSI) and (c) Trophodynamics (CMLRE, INCOIS, NRSC, NIOT and CMFRI) and to provide estimates on the Potential Yield (PY). The composition of the Sub-Groups is given below:

CMFRI Sub-Group

Dr T V Sathianandan, PS (Convener)

Dr K Vijayakumaran, PS (Co-Convener)

Dr Pratibha Rohit, PS&Head I/c, PFD

Dr P U Zacharia, PS&Head I/c, DFD

Dr K Sunil Mohamed, PS& Head I/c, MFD

Dr G Maheshwarudu, PS&Head, CFD

Dr J Jayashankar, PS.

Dr Somy Kuriakose, PS.

Dr Mini KG, PS.

Dr Grinson George, Senior Scientist.

Dr Eldho Varghese, Scientist.

Shri Vivekananda Bharti, Scientist.

Shri Vinaya Kumar Vase, Scientist.

Dr M Sivadas, PS.

Dr U Ganga, PS.

Dr EM Abbdussamad, PS.

Dr S Lakshmi Pillai, PS.

Dr Geetha Sasikumar, PS.

Dr P Kaladharan, PS.

Dr Sobha Joe Kizhakudan, PS.

Dr Sujitha Thomas, PS.

Dr T M Najmudeen, Senior Scientist.

Shri K Mohamed Koya, Scientist.

FSI Sub-Group

Dr L Ramalingam, DDG (Fy)/DG (IC) (Convener)

Shri D K Gulati, Zonal Director

Dr Sijo P Varghese, Sr. Fisheries Scientist

Dr M Vinod Kumar, Sr. Fisheries Scientist

Shri P Chalapati Rao, Statistician

Shri Ashok S Kadam, Fisheries Scientist

Dr Ansuman Das, Fisheries Scientist

Shri Ch Bhaskar, Programmer

Shri Ashish Kumar, Programmer

Shri A. Siva, Senior Scientific Assistant

Shri Rahulkumar B. Tailor, Senior Scientific Assistant

Trophodynamics Sub-Group

Dr V N Sanjeevan, Former Director, CMLRE

Dr B R Smitha, Scientist-D, CMLRE

Dr S B Choudhury, Scientist- SG, NRSC

Shri M Nagaraja Kumar, Scientist E, INCOIS

Dr Sunil Mohamed, PS& Head I/c, MFD, CMFRI

Dr R Kirubagaran, Scientist-G (Rtd), NIOT

Shri N Saravanane, Scientist-E, CMLRE

List of Tables, Figure, Maps

Figures/maps

Acronyms

A&N	Andaman and Nicobar
ADMB	Automatic Differentiation Model Builder
AE	Assimilation Efficiency
ASAP	Age Structured Assessment Program
ASPIC	A Stock-Production model Incorporating Covariates
ASPM	Age Structured Production Model
B	Biomass
BDM	Biomass Dynamic Model
BMSY	Biomass that enables a fish stock to deliver the maximum sustainable yield
BOBP-IGO	Bay of Bengal Programme Inter-Governmental Organisation
BRP	Biological Reference Points
CCRF	Code of Conduct for Responsible Fisheries (of FAO)
Chl –a	Chlorophyll a
CIFT	Central Institute of Fisheries Technology (of ICAR)
CMFRI	Central Marine Fisheries Research Institute (of ICAR)
CMLRE	Centre for Marine Living Resources and Ecology (of MoES)
CMSY	catch-MSY
CPUE	Catch Per Unit Effort
DADF	Department of Animal Husbandry, Dairying and Fisheries
DDG	Deputy Director General (of FSI)
DOD	Department of Ocean Development (Presently MoES)
DSL	Deep Scattering Layer
ECOPATH/ECOSIM	Ecological/ecosystem modelling and simulation software suite
EEZ	Exclusive Economic Zone
FAO	Food and Agriculture Organization (of the United Nations)
FSI	Fishery Survey of India
g	Gram
GLOBEC	Global Ocean Ecosystem Dynamics
GoI	Government of India
HCR	Harvest Control Rules
HP	Horse Power
ICAR	Indian Council of Agricultural Research
IKMT	Isaac-Kidd Midwater Trawl

INCOIS	Indian National Centre for Ocean Information Services
IOTC	Indian Ocean Tuna Commission
IPOA	International Plan of Action
IUCN	International Union for Conservation of Nature
IUU	Illegal, Unreported and Unregulated (fish catch)
Kg	Kilogram
Km	Kilometre
Kt	Knots
LOP	Letter of Permit
M	Metre
M	Natural mortality
MFD	Molluscan Fisheries Division (of CMFRI)
MFRA	Marine Fishing Regulation Act
Mg	Milligram
MICE	Models of intermediate complex ecosystems
MoA&FW	Ministry of Agriculture and Farmers Welfare
MODISAQUA	Moderate Resolution Imaging Spectroradiometer aboard EOSPM1 satellite
MoES	Ministry of Earth Sciences (formerly DOD)
MPEDA	Marine Products Export Development Authority
MSY	Maximum Sustainable Yield
NAIP	National Agricultural Innovation Project (of ICAR)
NIFPHATT	National Institute of Fisheries Post Harvest Technology and Training
NIO	National Institute of Oceanography
NIOT	National Institute of Ocean Technology
NM	Nautical Mile
NMFDC	National Marine Fisheries Data Centre (of CMFRI)
NPMF	National Policy on Marine Fisheries, 2017
NPOA	National Plan of Action
NRSC	National Remote Sensing Centre
OAL	Overall Length (also LOA: Length overall)
PP	Primary Production
PY	Potential Yield
PYE	Potential Yield Estimation
ReALCraft	Registration And Licensing of Fishing Craft

RFMO	Regional Fisheries Management Organisation
SCAA	Statistical catch-at-age
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SP	Secondary Production
SS3	Stock Synthesis III model
SST	Sea Surface Temperature
t	Tonne (= 1000 kg)
TAC	Total Allowable Catch
TOR	Terms of Reference
TY	Target yield
UNCLOS	The United Nations Convention on the Law of the Sea
UT	Union Territory
VGPM	Vertically Generated Production Model
VMS	Vessel Monitoring System
WTO	World Trade Organisation
ZSI	Zoological Survey of India

Contents

Glossary

Certain terms used in this report connote special or restricted meaning and need elaboration for bringing more clarity. Some terms are familiar to Indian readers but may not be so for readers from other countries. Given below is a list of such words/phrases with their meaning in the context of this report. Definitions of standard terms are adapted from FAO Term Portal - www.fao.org/faoterm/en.

Artisanal fisheries - Traditional fisheries involving fishing households (as opposed to commercial companies), using relatively small amount of capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore, mainly for local consumption.

Assimilation efficiency - the proportion of consumed resource biomass that is converted into consumer biomass

Benthic - Associated with the seabed underlying a water body.

Biodiversity - Variety among living organisms, including genetic diversity, diversity within and between species, and diversity within ecosystems.

Biomass - The total weight of the living organisms concerned, whether in a system, a stock, or a fraction of a stock

Biomass at Maximum Sustainable Yield (BMSY) - Average biomass corresponding to maximum sustainable yield. A target reference point estimated using a stock assessment model.

Bivalves – Molluscs with two hinged shells that encase the soft parts of the animal, eg mussels, oysters, clams etc.

Catch per unit effort (CPUE) - The amount of catch that is taken per unit of fishing effort. CPUE can be used as a measure of the economic efficiency of a type of gear, but normally it is used as an index of abundance. Nominal CPUE is simply the measure of CPUE from the fishery. However, it is known that there are many factors (including economics, geographical distributions) which may affect CPUE but do not represent changes in abundance. Therefore, CPUEs are often "standardized" using a variety of statistical techniques to remove the effect of those factors which are known not to be related to abundance.

Catchability – the fraction of a fish stock that is caught by a defined unit of fishing effort

Census - A fisheries census is a survey in which the value of each variable for the survey area is obtained from the values of the variable in all reporting units, that are usually fishing households. The primary objective of fisheries censuses is to provide a detailed classification of the fisheries structure of the country. It provides estimates for each household, and therefore, aggregate data for the smallest administrative, political or statistical subdivisions of the country and for classifications of households by size or other subgroups of interest.

Closed seasons – a period during which fishing, within a specified area, is prohibited

Co-management - A process of management in which government shares power with resource users, with each given specific rights and responsibilities relating to information and decision-making.

Commercial fisheries - Fisheries undertaken for profit and with the objective to sell the harvest on the market, through auction halls, direct contracts, or other forms of trade.

Continental shelf (shelf) - The area of relatively shallow water that fringes a continent from the shoreline to the top of the continental slope. The top of the continental slope is often defined by the 200 m isobath.

Continental slope (slope) - Region of the outer edge of a continent between the relatively shallow continental shelf and the abyssal depths. Often characterised by a relatively steep slope compared to the continental shelf.

Crore - Ten million.

Data - Facts that result from measurements or observations.

Database - A logically structured and consistent set of data that can be used for analysis.

Data-poor fishery – A fishery with little to no existing scientific information on the fishery characteristics relevant for management decisions (e.g. baseline biological data such as size at maturity, fishing mortality and growth rates, stock assessments, fishing effort assessments, and baseline habitat quality assessments)

Dataset - A collection of data and accompanying documentation which relate to a specific theme.

Deep-sea fishing vessel - fishing crafts, which fish in the deeper parts of the ocean, especially those beyond the edge of the continental shelf

Demersal - Found on or near the benthic habitat (sea bottom).

Detritus - Dead organic matter and the decomposers that live on it; when broken up by decomposers, detritus provides energy to many coastal ecosystems

Discard- Part of the catch, which is not retained and is returned to the sea. Discard typically consists of "non-target" species or undersized specimens.

Ecosystem - A complex system of plant, animal and microorganism communities that, together with the non-living components, interact to maintain a functional ecological unit.

Ecosystem-based fisheries management: a fisheries management approach that takes major ecosystem components and services both structural and functional into account, often with a multispecies or habitat perspective

Effort - A measure of the level of fishing activity used to harvest a fishery's stocks. The measure of effort appropriate for a fishery depends on the methods used and the management arrangements. Common measures include the number of vessels, the number of hooks set, number of trawl tows, the duration of trawl tows and the number of fishing days or nights.

Exclusive Economic Zone (EEZ) - The area adjacent to a coastal state which encompasses all waters between: (a) the seaward boundary of that state, (b) a line on which each point is 200 nautical miles (370.40 km) from the baseline from which the territorial sea of the coastal state is measured (except when other international boundaries need to be accommodated), and (c) the maritime boundaries agreed between that state and the neighboring states.

Fish – Finfish, molluscs, crustaceans and any marine plant or animal that is harvested

Fish meal - Protein-rich meal derived from processing whole fish (usually small pelagic fish, and fishery bycatch) as well as residues and byproducts from fish processing plants (fish offal). Used mainly as feeds for poultry, pigs, and aquaculture feeds for carnivorous aquatic species

Fish refugia - Spatially and geographically defined, marine or coastal areas in which specific management measures are applied to sustain important species [fisheries resources] during critical stages of their life cycle, for their sustainable use.

Fish stock - The living resources in the community or population from which catches are taken in a fishery. Use of the term fish stock usually implies that the particular population is more or less isolated from other stocks of the same species and hence self-sustaining. See: Fishery resource

Fish-aggregating device (FAD) - Buoys or platforms used to attract and aggregate pelagic fishes to increase fishing harvest rates.

Fisherman - A person (male or female) participating in a fishery.

Fisheries Subsidies - Fisheries subsidies are government actions that are specific to the fisheries industry and that modifies -by increasing or decreasing - the potential profits by the industry in the short-, medium- or long-term.

Fishery - The sum (or range) of all fishing activities on a given resource. It may also refer to the activities of a single type or style of fishing (e.g. beach seine fishery or trawl fishery). The fishery can be artisanal, or/and industrial, commercial, subsistence, and recreational, and can be annual or seasonal.

Fishery management - The integrated process of information gathering, analysis, planning, decision-making, allocation of resources and formulation and enforcement of fishery regulations by which the fishery management authority controls the present and future behaviour of interested parties in the fisheries, in order to ensure the continued productivity of the living resources.

Fishery Management Plan (FMP) - Also referred to as a "plan," this is a document that describes a fishery and establishes measures to manage it.

Fishery survey - Sampling, collecting, observing, or surveying the fish or fishery resources, on board scientific research vessels, to increase scientific knowledge of the fishery resources or their environment, or to test a hypothesis as part of a planned, directed investigation or study conducted according to methodologies generally accepted as appropriate for scientific research

Fishing - Any activity, that can reasonably be expected to result in the catching, taking, or harvesting of fish and any operations at sea in support of it.

Fishing capacity - Fishing capacity is the ability of a stock of inputs (eg., boats) used in fisheries to produce output, measured as either effort or catch, over a period of time.

Fishing effort - Amount of fishing taking place, usually described in terms of gear type and the frequency or duration of operations (for example, number of hooks, trawl hours, net length).

Fishing industry - Includes both recreational, subsistence and commercial fishing, and the harvesting, processing, and marketing sectors.

Fishing intensity - Effective fishing effort per unit area. It is proportional to fishing mortality.

Fishing mortality - A mathematical expression of the rate of deaths of fish due to fishing.

Fishing mortality Maximum Sustainable Yield (FMSY) - The fishing mortality rate that at equilibrium is expected to produce the maximum sustainable yield.

Fishing vessel - Any vessel, boat, ship, or other craft that is used for, equipped to be used for, or of a type that is normally used for the exploitation of living aquatic resources or in support of such activity.

Flag State - State having registered a vessel under the national flag.

Fleet - The aggregation of units of any discrete type of fishing activity utilising a specific resource. Hence, for example, a fleet may be all the purse seine vessels in a specific sardine fishery, or all the fishers setting nets from the shore in a tropical multispecies fishery.

Food security - A situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life

Gear - Any tools used to catch fish, such as hook and line, trawls, gill nets, traps, spears, etc.

Geographic Information System (GIS) - An information system that stores and manipulates data which is referenced to locations on the earth's surface, such as digital maps and sample locations.

Geo-referenced data - Data which is connected to a specific location on the earth's surface.

Gill net – curtains of netting that hang vertically in the water, either in a fixed position (eg. surface or seabed) or drifting, that trap fish by their gill covers – operculum – when they try to swim through the net's meshes.

Handline - a hook-and-line method of fishing, ostensibly hauling by hand

Harvest control rules - A rule that describes how harvest is intended to be controlled by management in relation to the state of some indicator of stock status

Herbivory - Consumption of plant material by animals

High seas - waters beyond the areas of national jurisdiction (which can be 200 nm or less)

Illegal, Unreported and Unregulated (IUU) fishing - fishing that is conducted contradictory to legal conservation and management measures currently in place around the world.

Index of abundance - A relative measure of the abundance of a stock; e.g. a time series of catch per unit of effort data.

Jigging – A term most frequently associated with fishing for squid with handlines that are 'jigged' up-and down

Lakh - Hundred thousand.

Landing - The offload or transfer in port of fish from a vessel

License - A license or permit is a document giving the producer the right to operate in a fishery according to the terms established by the regulating authority

Logbook - A record of the fishing activity registered systematically by the fisher, including catch and its species composition, the corresponding effort, and location.

Longline – A method of fishing with large number baited hooks set on branch lines attached to single main line

Macroalgae – Large, multi-celled, photosynthetic algae. Commonly called seaweed.

Macrobenthos - Organisms that live at the bottom of a water column and are visible to the naked eye

Management (of fishery resources) - The integrated process of information gathering, analysis, planning, decision-making, allocation of resources and formulation and enforcement of fishery regulations by which the fishery management authority controls the present and future behaviour of interested parties in the fisheries, in order to ensure the continued productivity of the living resources.

Marine Fishing Regulation Acts (MFRA) – Acts enacted by the maritime states and Union Territories of India to manage the fishery resources within the 12 nautical mile territorial limits

Marine Protected Area (MPA) - Geographic area with discrete boundaries that has been designated to enhance the conservation of marine resources.

Maximum Sustainable Yield (MSY) - The highest theoretical equilibrium yield that can be continuously taken (on average) from a stock under existing (average) environmental conditions without affecting significantly the reproduction process. Also referred to sometimes as Potential yield.

Mechanised vessels – Fishing boats using engines for propulsion and mechanical devices for handling of fishing gear

Meiobenthic fauna - small benthic invertebrates that live in both marine and fresh water environments. The term meiofauna loosely defines a group of organisms by their size, larger than microfauna but smaller than macrofauna.

Mesopelagic - Pelagic zone of intermediate depth, 200-1000m

Migratory (straddling) species – Species that move between distinct geographical areas, especially across the outer limit of the national fisheries waters of coastal States and the adjacent high seas

Minimum landing (legal) size: the smallest length at which it is legal to retain a fish or offer it for sale.

Model - A set of equations and data used to make estimates

Modeling - The construction of physical, conceptual, or mathematical simulations of the real world.

Monitoring, Control and Surveillance (MCS) - Activities undertaken by the fishery enforcement system to ensure compliance with fishery regulations

Mortality - Deaths from all causes, usually expressed as a rate or as the proportion of the stock dying each year.

Motorised fishing boats - Fishing boats using engines for propulsion, but handling of fishing gear is done manually

Motorised mechanical (ReALCraft) - Mechanised boats which could use power for fishing, apart from propulsion.

Motorised non-mechanical (ReALCraft) - Motorised (inboard or outboard) boats using power for propulsion only.

Multispecies fishery - Fishery in which more than one species is caught at the same time.

Natural mortality (M) - Deaths of fish from all natural causes, excluding fishing. Usually expressed as an instantaneous rate or as a percentage of fish dying in a year.

Nautical Mile - Unit of distance (commonly used in navigation) equal to 1,852 meters.

Nominal catch - The sum of the catches that are landed (expressed as live weight equivalent). Nominal catches do not include unreported discards and may differ considerably from the actual catch.

Non-motorised (ReALCraft): Boats not motorised but using human/wind power for propulsion.

North-Eastern Arabian Sea (Trophodynamics) - 15 ^{o} N to 23.5 ^{o} N of Arabian Sea in the Indian EEZ.

North-West Bay of Bengal (Trophodynamics) - 15 ^{o} N to 22 ^{o} N of Bay of Bengal in the Indian EEZ.

Observer - A certified person on board fishing vessels who collects scientific and technical information for the management authority on the fishing operations and the catch.

Oceanic - Open-ocean waters beyond the edge of the continental shelf.

Omnivory – Animals taking food of both plant and animal origin.

Open access - Access to the resource is free to anyone who wants to use or harvest it because there is no ownership of the resource

Others/Miscellaneous/Mixed (Catch) - Resources which could not be classified at finer resolution of nomenclature due to damaged condition, small insignificant quantities, or inability to segregate (trash/by-catch)

Overcapitalisation - Where the amount of fishing capacity (number of boats) in the fishery exceeds the amount needed to harvest the MSY

Pelagic fish - Fish that spend most of their life swimming in the water column with little contact with or dependency on the bottom

Plankton – the animals and plants that float in mid water and drift to-and fro with the tides.

Policy - The course of action for an undertaking adopted by a government, a person or another party.

Potential Yield – See Maximum Sustainable Yield

Precautionary principle (approach) - A set of agreed cost-effective measures and actions, including future courses of action, which ensures prudent foresight, reduces or avoids risk to the resources, the environment, and the people, to the extent possible, taking explicitly into account existing uncertainties and the potential consequences of being wrong.

Primary productivity - A measurement of plant production that is the start of the food chain. Much primary productivity in marine or aquatic systems is made up of phytoplankton, which are one-celled algae that float freely in the water.

Production efficiency (PE) - Amount of biomass stored by consumers relative to the amount of food they successfully absorbed.

Productivity – Production of organic matter by phytoplankton

Protected Areas - A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural values

Protected species - a species of animal or plant which it is forbidden by law to harm or destroy

Purse seine – a deep curtain of netting that is shot in a circle to form an enclosing cylinder around shoals of pelagic fish. A 'pursing wire' attached to the end and lower edges are drawn in to close the bottom of the cylinder. At the same time, the net is progressively hauled aboard to concentrate the fish alongside the boat in the final bight of netting – the 'purse'.

Quota - A share of the Total Allowable Catch (TAC) allocated to an operating unit such as a country, a vessel, a company or an individual fisherman (individual quota) depending on the system of allocation.

ReALCraft (Registration And Licensing of Fishing Craft) - is a work flow based online application system for Vessel Registration under MS Act and License Certificate under MFR Act to the fishing vessels operating along the Indian coast

Reference point - An indicator, typically of the level of stock biomass or fishing mortality rate, used as a benchmark for assessment and as the basis for management objectives set within harvest strategies.

Regional Fisheries Management Organizations (RFMO) - an intergovernmental organization, established by international agreement, with the competence to adopt conservation and management measures.

Resources - Biological resources include genetic resources, organisms or parts thereof, populations or any other biotic component of ecosystems with actual or potential use of value for humanity. Fishery resources are those resources of value to fisheries.

Responsible fishing - Sustainable utilisation of fishery resources in harmony with the environment; the use of capture practices which are not harmful to ecosystems, resources and their quality

Seasonal closure of fishery- Closure of a fishing ground for a defined period. Used as a management tool, often to protect a particular component of the stock at a particular time, such as a spawning aggregation.

Secondary production - any production by organisms which themselves consume primary producers

South-Eastern Arabian Sea (Trophodynamics) - 5^{o} N to 15 ^{o} N of Arabian Sea in the Indian EEZ and Lakshadweep Sea.

South-West Bay of Bengal (Trophodynamics) - 5 ^{o} N to 15 ^{o} N of Bay of Bengal in the Indian EEZ.

Spatial closure - A method of fisheries management that prevents fishing in a defined area.

Spawning stock biomass - The total biomass of fish of reproductive age during the breeding season of a stock

Species group - Group of species considered together, often because they are difficult to differentiate without detailed examination (very similar species) or because data for the separate species are not available (e.g. in fishery statistics or commercial categories).

Stakeholders - A large group of individuals and groups of individuals (including governmental and non-governmental institutions, traditional communities, universities, research institutions, development agencies and banks, donors, etc.) with an interest or claim (whether stated or implied) which has the potential of being impacted by or having an impact on a given project and its objectives.

Standing stock – See biomass

State of the stock - An appreciation of the situation of a stock, usually expressed as: protected, under-exploited, intensively exploited, fully exploited, over-exploited, depleted, extinct or commercially extinct.

Stock assessment - The process of collecting and analysing biological and statistical information to determine the changes in the abundance of fishery stocks in response to fishing, and, to the extent possible, to predict future trends of stock abundance.

Straddling stock - Stock which occurs both within the EEZ and in an area beyond and adjacent to EEZ

Subsistence fishery - A fishery where the fish caught are consumed directly by the families of the fishers rather than being bought by middle-(wo)men and sold at the next larger market.

Sustainable development - Management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment of continued satisfaction of human needs for present and future generations.

Sustainable fishing – Fishing activities that do not cause or lead to undesirable changes in the biological and economic productivity, biological diversity, or ecosystem structure and functioning from one human generation to the next.

Target Reference Point (TRP) - Corresponds to a state of a fishery and/or a resource which is considered desirable. Management action, whether during a fishery development or a stock rebuilding process should aim at bringing and maintaining the fishery system at this level. In most cases a TRP will be expressed in a desired level of output for the fishery (e.g. in terms of catch) or of fishing effort or capacity and will be reflected as an explicit management objective for the fishery.

Target species - Those species that are primarily sought by the fishermen in a particular fishery.

Total Allowable Catch (TAC) - It is the total catch allowed to be taken from a resource in a specified period (usually a year), as defined in the management plan. The TAC may be allocated to the stakeholders in the form of quotas as specific quantities or proportions.

Zooplankton - Plankton consisting of small animals and the immature stages of larger animals

Executive Summary

The Department of Animal Husbandry, Dairying and Fisheries (DADF), Ministry of Agriculture and Farmers Welfare (MoA&FW), Government of India constituted an Expert Committee for revalidation of potential yield of fishery resources in the Indian EEZ vide Order No.21001/2/2016-FY (Ind) dated 24 August 2017. The term of the Committee was extended on two occasions vide Orders of even Nos. dated 12th April 2018 and xxx, respectively. The Committee was tasked to revalidate the PY that would also include the additional marine fisheries potential and suggest conservation and management of marine fishery resources within the Indian EEZ. To fulfill its task, the Committee also invited experts drawn from different institutions.

To estimate the PY, the Committee adopted two approaches, *viz*., (i) direct approach using data from commercial fish landings (for depths up to 200m) and fishing surveys (for 200-500 m depth zone), and (ii) trophodynamic approach using productivity data. The Committee considered the results of the direct approach, which had finer resolution at spatial (State/UT) and species levels to arrive at the PY estimates. With regard to the trophodynamic approach, the Committee agreed to consider it as a support estimate for validation of the PY estimate.

The PYE for 2018 (based on the commercial fish landings during the period 1997-2016), for depths up to 200 m along the mainland has been estimated as 4.9 million tonnes (t) which is 0.8 million t more than the PYE 2011 for the same depth zone. **Adding a PYE of 97,461 t estimated from the 200-500 m depth zone, the total PY for 0-500 m depth zone of the mainland EEZ is estimated as 5.0 million t.**

The oceanic resources potential, based on fishing surveys, has been estimated as 0.23 million t, of which yellowfin tuna constitutes 83,500 t and skipjack tuna 99,500 t. Compared to PYE 2011, there is a marginal increase of the oceanic resources by about 14,000 t. **Thus the total PYE 2018 of the Indian mainland EEZ is estimated at 5.25 million t.**

State-wise distribution of PYE 2018 up to 200 m depth zone shows the highest for Kerala (0.94 million t), followed by Gujarat (0.90 million t) and Tamil Nadu (0.82 million t). With regard to coast-wise PYE 2018 for depths up to 500 m, the west coast recorded 3.17 million t and the east coast 1.85 million t.

Among the species/group, oil sardine recorded the maximum PY with 0.62 million t followed by Indian mackerel (0.32 million t) and ribbonfish (0.30 million t). These three groups account for about a quarter of the overall resource PY. In the demersal category, penaeid prawns (0.29 million t) and croakers (0.23 million t) constitute the major resources.

The marine fisheries resources of Andaman and Nicobar waters have PYE of 47,463 t, while that of Lakshadweep waters harbour a PY of 73,590 t.

The overall PY 2018 of the Indian EEZ (mainland and Island territories) is estimated as 5.31 million t.

Besides the conventional fisheries resources, the PY for non-conventional resources such as oceanic squids (0.63 million t), myctophids (1 million t), jellyfish (0.2 million t) and marine algae (17,775 t) have also been reflected in the Report. The trophodynamic approach for PYE 2018 was considered as a supporting estimate and this has been calculated as 5.12 million t, which corroborates direct PY estimates. Further, the estimate following trophodynamic approach also shows the west coast of India (3.7 million t) to be more productive than the east coast (1.4 million t).

The optimum number of different types of commercial vessels needed for exploiting the PY 2018 has been estimated as 76,967. The fleet size estimates show that the prevailing fishing fleet in India exceeds the optimum number of fishing boats that can harvest the resources sustainably.

The trophodynamic approach for PYE 2018 was considered as a supporting estimate and this has been calculated as 5.12 million t, which is corroborates direct PY estimates. Further, the estimate following trophodynamic approach also shows the west coast of India (3.7 million t) to be more productive than the east coast (1.4 million t).

The NPMF, 2017 provides the guidance for the development of marine fisheries in the country during the next 10 years. Following the policy statements, the marine fisheries sector in India needs to conform to optimization of the fishing fleet, effective monitoring, control and surveillance and improved value chain that reduces post-harvest losses. At the same time, the sector also needs to take necessary action to meet its global commitments, especially with regard to SDG-14 and the resolutions of the Regional Fisheries Management Organisation to which India is a party. The Report in Chapter 6 details such requirements for consideration of the Government.

Summary

Revised Potential Estimate (MSY) from the Indian EEZ (2018)

Sl. No.	(i) Conventional Resources	Revised MSY (in Metric Tonnes - MT)
	Mainland	
1.	0 - 200m deep	4,924,016 MT
2.	200-500m deep	97,461 MT
3.	**Sub Total (1) + (2)**	**5,021,477** MT
4.	**Oceanic** *(excluding Lak. & AN Isl. Oceanic 59,100 MT + 3,669 MT = 62,769 MT)(Oceanic total EEZ =230,832 MT)*	**168,063 MT**
	Island Ecosystem	
5.	Andaman & Nicobar *(incl.Oceanic 43,794 MT)*	47,463 MT
6.	Lakshadweep *(incl.Oceanic 14,490 MT)*	73,590 MT
7.	**Sub Total (5) + (6)**	**121,053** MT
8.	**Conventional Resources Total** (3) + (4)+ (7)	**5,310,593 MT**
	(ii) Non-Conventional Resources	
9.	Deep-sea myctophids	1,000,000 MT
10.	Oceanic squids	630,000 MT
11.	Jellyfish	200,000 MT
12.	Marine macro algae	17,775 MT
13.	**Non-Conventional Resources Total**	**1,847,775** MT
14.	**Conventional & Non-Conventional Resources Grand Total** (8) + (13)	**7,158,368** MT

1. Introduction

1.1. Marine Fisheries- A Global Scenario

The marine fisheries has survived as the only food production sector in the hunter-gatherer mode practiced by civilised human society. World over, fish is being relished as food by the rich and poor alike. Apart from being an important source of nutritious food, marine fishery remains as an important means of income and livelihood for millions of people around the world (FAO, 2016).

The global marine fish production increased from less than 20 million t in early 50s to 79.3 million t in 2016 (FAO, 2018). The catches peaked with a figure of 86.8 million t in 2000, but subsequently leveled off, with average around 80 million t per year till recent years. However, considering the significant unreported and discarded catches, it was suggested that the global catches would be around 120 million t (Zeller *et al*., 2009).

From 1976 to 2006 world seafood trade value increased threefold, from 28.3 billion USD to 86.4 billion USD. During the same period, trade volume increased from 7.9 million t to 31.3 million t, or almost fourfold. Hence, the unit value of seafood has decreased, increasing seafood's competitiveness as a food source (WTO, 2010). However, the recent data tells something different. Of the 171 million tonnes of fish produced globally, capture fisheries accounted for 90.9 million t. The fishery trade peaked at 153.5 billion USD in 2017 recording a growth of 7.8% (FAO- Globefish).

Although marine fishery resources are renewable, they are not inexhaustible. The ever growing demand for seafood, is boosting the prices which in turn is driving the increase in fishing pressure. Continued exertion of fishing pressure on the major fish stocks of the world has resulted in the decline of many important fisheries.

The need for adopting strict management measures has been understood by fishery managers all over the world. Such management measures require scientific information generated by systematic process of data gathering and analysis. For many fisheries, Harvest Control Rules (HCR) have been evolved based on Maximum Sustainable Yield (MSY) and other Biological Reference Points (BRP).

1.2. Indian Scenario

Unlike the stagnating picture of marine fisheries elsewhere in the world, marine fisheries sector in India has been showing an increasing trend for several years. The sector supports more than four million people with employment and source of livelihood. Apart from the nutritional importance of fish in Indian food, the sector also contributes significantly to the export earnings of the country.

The marine fish landings in India show an ever increasing trend over the years. From a meager 0.53 million t in 1950 the landings have increased to 3.83 million t in 2017 (excluding landings from Lakshadweep and A&N Islands) (Annexure 1). The value of the landed catch also has been increasing and currently it is about Rs.78,408 crores at retail level, showing a 7% increase over previous year (CMFRI, 2018).

The export of marine products from the country (including aquaculture) during the year 2017-18 was 13,77,244 t worth Rs.45,107 crore (MPEDA, 2018). The major commodity of

the export basket was frozen shrimp (quantity 41.1%; value 68.46%) and frozen fish (quantity 25.64% and value 10.35%). The growth in shrimp export was contributed mainly by aquaculture production. Trawl fishery also contributes substantially to shrimp export.

According to the ReALCraft registry of DADF, a total of 2,57,898 fishing crafts are registered in the country as on 30 July 2018. Of this 51 are deep-sea fishing vessels, 1,27,575 motorized, 65,064 mechanized and 65,208 non-motorised crafts. While the mechanised fishing vessels account for about 25% of the total fishing fleet in number, they contribute more than 50% to the marine fish landings.

The production breached the 3 million t mark after fluctuating between 2.7 and 2.9 million t, for some years, and there are a few important changes that caused this. First is the expansion of fishing to deeper waters and the second is the expansion of fishing capacity (HP, hold, storage etc.) and endurance.

Fishing activities were confined up to 100m depth (except longliners) a decade ago. Now with enhanced fishing power/capacity the mechanised vessels operate up to 200 m depth or even beyond. The increasing number of units and intensity in the fishing grounds resulted in the decline in Catch Per Unit Effort (CPUE). Increased cost of operation was partially compensated by the change in fishing strategy (single to multi-day operation) and partially by increase in price.

The fishing capacity has been often described in terms of numbers, disregarding fishing power of the units. The traditional crafts of Kerala have become larger in size and have the power to compete with any mechanized fishing units in the State. Moreover when a fishing unit is decommissioned the replaced vessel is often of larger capacity.

The increased duration of stay-fishing by multiday trawlers could obviously result in increasing bycatch and discards of low value fish as the fish hold capacity is reserved for high quality fish. However, the flourishing business of fish feed production without much import of inputs points to the fact that low value fish are mostly converted as fish feed. Moreover, qualitative changes in the landings leading to the phenomenon of ‘fishing down the food web’ in Indian marine fisheries (Vivekanandan et al., 2005) has been established which needs further attention.

1.3. Revalidation of Potential Yield of Marine Fishery Resources in India

The declaration of 200 nautical miles of Exclusive Economic Zone (EEZ) in 1976 endowed India with the right and responsibility to exploit and manage the fishery resources in 2.02 million square km of seas around its peninsula and island territories. Prior to 1976, attempt to assess the potential yield focused on the Indian Ocean as a whole (Prasad *et al*., 1970; Gulland, 1971; Cushing, 1973; Jones and Banerji, 1973; Mitra, 1973) were mostly based on productivity estimate. Notable among them is the estimate by Prasad *et al*., (1970) suggesting a potential of 11-12 million t for Indian Ocean.

It was George *et al*. (1977) who analysed of the exploratory survey data and fish landings data made estimation of the potential yield of the Indian EEZ as 4.5 million t. Subsequently many estimates were made which resulted in a range of potential yield from 3.5 to 5.5 million t. Following an exercise by FSI estimating the potential at 3.92 million t, the Government of India initiated steps to revalidate the potential of the Indian EEZ by constituting Working Groups of Experts periodically from 1990 onwards. Considering the advancements in fisheries as well as in estimation methods, the exercise of revalidation of the potential yield of

the Indian EEZ has become a periodic stock-taking ever since. The subsequent estimates remained within a reasonably narrow range of 3.33 million t and 4.41 million t. A summary of the important attempts made by different authors is provided in Table-1.1.

The Working Group constituted in 1990 estimated the total potential of the EEZ as 3.9 million t comprising of 1.69 million t of demersal 1.92 million t of pelagic stocks and 0.25 million t of oceanic resources. In the year 2000, the estimate was revised as 3.93 million t, adding an estimated 2.05 lakh t of bivalves & gastropods and 1.01 lakh t of deep sea fishes to the previous estimates. Subsequently, the Working Group constituted in 2009, which submitted its Report in 2011, revalidated the potential yield as 4.41 million tonnes, which was higher than the previous estimate by 0.48 million tonnes. In this estimate, the pelagic resources accounted for 2.13 million tonnes, the demersal resources 2.07 million tonnes and the oceanic resources 0.22 million tonnes.

Like the previous exercise of 2011, the current revalidation also uses multipronged approach with different models and databases. The salient feature is that resources and regions left-out in the previous exercise were covered in this exercise. The Committee felt satisfaction on the outcome of the various analyses. The main report contains the summary of the estimates and detailed results and other related information are placed as support documents.

Table-1.1. Summary of Potential Yield Estimates made by different researchers and Government of India.

Author	**Area/Depth zone (m) of EEZ**	**Resource type**	**Resource potential (million tonnes)**	**Method / Approach**
George *et al* (1977)	0-200 & oceanic	Demersal and pelagic	4.46	Primary production; tertiary production
Nair & Gopinathan (1981)	Entire EEZ		5.5	Primary production
Joseph (1985)	0-200	Demersal	2.03	Fish production per unit area
Joseph (1987)	0-500 & oceanic	Demersal and pelagic	4.18	Fish production per unit area
Alagaraja (1989)	0-200	Demersal and pelagic	3.0	Stock assessment model
James *et al* (1987)	Entire EEZ	Demersal and pelagic	4.5	Landing and survey data
Desai *et al*(1989)	Entire EEZ	Demersal and pelagic	3.66	Productivity based
Sudarsan e*t al* (1990)	Entire EEZ	Demersal and pelagic	3.92	Fish production per unit area
Mathew *et al*(1990)	Entire EEZ	Demersal and pelagic	3.74	Primary and secondary production
George *et al* (1991)*	Entire EEZ	Demersal and pelagic	3.90	Landing data and Survey data
Silas *et a l*(2000)**	Entire EEZ	Demersal and pelagic	3.93	Fish production per unit area and landings

Vijayakumaran et al. (2011)***	Entire mainland EEZ	Demersal and pelagic	4.41	Multiple approaches using landings and survey data and trophodynamics

* Cited as GOI, 1991; ** Cited as GOI, 2000; *** Cited as GOI, 2011

2. Methodology and Structure

2.1. Scope

This revalidation exercise is undertaken for the purpose of updating the information needed by the Ministry of Agriculture and Farmers Welfare for revising the policies and plans for exploitation and management of the fishery resources of the Indian EEZ.

The current exercise has used all relevant facts and figures pertaining to the 200 nm EEZ of India. Except for the resource specific vessels targeting oceanic tuna and deep-sea crustaceans, the commercial fishery in the county is presumed to extend up to 200 m depth and the data were segregated and analysed accordingly. The data used in the exercise cover the period from 1997 to 2016.

2.2. Database

Data from diverse sources have been used in the current exercise. The landings data available with National Marine Fisheries Data Centre (NMFDC) of ICAR-Central Marine Fisheries Research Institute (CMFRI) and the survey data generated by Fishery Survey of India (FSI) formed the basis for estimation of potential yield around mainland EEZ. Landing data form NMFDC formed the basis of potential up to 200 m depth, the FSI data formed the basis for estimates of potential from 200-500 m depth zone.

Estimates of oceanic tuna resource potential was made using multiple data sets like hooking rates from longline survey, primary productivity data and nominal catch/MSY from IOTC database.

Data provided by the UT authorities formed the basis of estimation of potential around island territories. Published reports and data generated under various projects in CMFRI formed the basis for estimating potential for other resources.

The trophodynamics Sub-Group used data on primary (including remote sensed data), secondary, tertiary and benthic productivity for estimation of potential of the Indian EEZ. The details of data sets used are provided in the respective scientific documents prepared by the different Sub-Groups.

2.3. Models

The CMFRI sub-group has used three new versions of biomass dynamic models in the line of Models of Intermediate Complexity for Ecosystems (SEA-MICE modified version) for estimation of potential yield up to 200 m depth contour using landing data. Potential yield of islands were estimated by applying Catch MSY (CMSY) methodology recommended for data-poor situations (Martell and Froese, 2013; Zhou *et al*., 2017). The FSI has used ‘Swept area’ method for the estimation of biomass and then the Gulland's formula for virgin stocks was adopted for the estimation of MSY from 200-500 m depth zone. For estimation of oceanic resources the FSI Sub-Group used the approach by Dr M E John in the earlier report (GOI, 2011) and mentioned in John *et al* (2005).

Various other approaches were used for arriving at the potential yield of other resources like myctophids and oceanic squids. The trophodynamics Sub-Group also used the approach similar to the previous exercise but with some changes in the input parameters. The details of methods used are provided in support documents.

2.4. Limitations

While the Sub-Groups have used the best models for their assigned work and made best use of the database at their disposal, there are certain limitations which spring from the underlying assumptions.

First, in a few cases, the landing in a particular state do not necessarily represent the catch taken from the sea off that maritime states. This happens especially when vessels undertake multiday fishing crossing the boundaries of many states, but land the catch in the port of origin. This leads to accounting of landings to the port of origin and the respective maritime state.

Second, there is need for systematic data gathering systems in the Islands, on par with that followed in the mainland.

The term 'oceanic resources' mentioned in this report include resources which straddle beyond the Indian EEZ but are caught within the EEZ. Some of the high-value oceanic, migratory species like the yellowfin tuna are supposed to be from a pan Indian Ocean single stock, implying that separate stock analysis for Indian yellowfin tuna is not necessary. While this aspect needs to be scientifically resolved, considering the importance of the oceanic resources to India the PY of these migratory species has been estimated for the Indian EEZ.

2.5. Structure

The Report is organised in a sequence as in the Terms Of Reference (TOR) as well as logical order of importance without sacrificing the readability. After the preliminary pages of Foreword, Acknowledgement, the next section details Constitution of the Committee, TOR, and working arrangements of the Committee in carrying out the business. Followed by this section is the executive summary which condenses the salient findings of the report in a couple of pages.

The main body of the report is divided into seven chapters. The first chapter gives a brief overview of the world fisheries and Indian fisheries before finally discussing the earlier attempts in revalidation. The second chapter details the scope, databases, models and methods, and limitations before providing an outline of the structure of the report.

The third chapter is perhaps the most important chapter detailing the potential yield estimates of the Indian EEZ. This chapter derives the information from three support documents dealing with resources up to 200 m, 200-500 m, and Oceanic waters. The fourth chapter deals with additional resources such as myctophids, oceanic squids, jellyfish, seaweeds etc.

The fifth chapter is dealing with the number of different types of fishing vessels that are registered under ReALCraft by the respective states for the harvest of fishery resources. These figures obviously is for the resources up to 200 m. The sixth chapter gives a comprehensive list of suggestions for conservation and management on the backdrop of the current provincial, national and global laws and conventions. The seventh chapter shows the way forward for preparation of future Potential Yield reports.

In addition there are support documents provided by the different Sub-Groups of the Expert Committee and other relevant appendices. All citations are consolidated and listed alphabetically at the end under References for the entire report.

3. Revalidation of Potential Yield

3.1. Introduction

As agreed in the first meeting of the Committee, it was decided that the resources potential up to 200 m shall be estimated by CMFRI Sub-Group using fish landing data of appropriate duration available with NMFDC of the Institute. The Sub-Group in Fishery Survey of India (FSI) was entrusted with the responsibility of estimating the resource potential of the 200-500 m depth zone as well as oceanic resources using the survey data. Assessment of potential around island territories and of other new resources shall be carried out by CMFRI team.

It was also agreed that as in the previous exercise, the trophodynamic Sub-Group would workout revised estimates based on productivity at primary, secondary, tertiary and benthic level using appropriate models and conversion factors and present the results as an independent estimate.

3.2. Potential of 0-200 m

The PY estimate for 0-200 m depth zone was based on commercial fish landings. The resource potential up to 200 m depth along the mainland of India was estimated at 4.92 million t. Looking at the previous estimate for the same region (4.08 million t), the current estimate shows an additional potential of about 8.4 lakh t.

A look at the major species/groups contributing to the fishery potential would be of interest. The single most important resource in terms of quantity is Oil sardine with a potential of 6.17 lakh t. The next important resource is the Indian mackerel with more than three lakh t. Ribbonfishes with close to three lakh t comes to third position. The top three contributors account for a quarter of the resource potential and the top six resources account for about 40 percent of the resource potential within 200 m depth contour (Table-3.1).

Table-3.1. Top ten resources contributing to the potential yield of 0-200m zone

Resource	Potential (t)
Oil sardine	617128
Indian mackerel	317049
Ribbon fishes	296724
Penaeid prawns	287293
Croakers	232705
Other sardines	228329
Non-penaeid prawns	197006
Threadfin breams	180975
Bombay duck	167829
Bivalves	160999

3.3. Potential of 200-500 m

As it is not a good choice to delineate the deep water areas to maritime state boundaries, the potential yield estimates of deep water resource were grouped into broader geographical areas, namely, northwest, southwest, southeast and northeast coastal regions.The Southwest coast topped the list with more than 58,000 t followed by northwest coast with more than 25,000 t (Table-3.2).

Table-3.2. Resource potential of 200-500 m of different regions of mainland Indian EEZ

Region	Potential (t)
Northwest coast (Latitude 15-23^{o} N)	25366
Southwest coast* (Latitude 7-15 ^{o} N)	58249
Southeast coast (Latitude 10-15 ^{o} N)	5672
Northeast coast (Latitude 15-23 ^{o} N)	8174
Total	**97461**

*For this analysis, Wadge Bank and Gulf of Mannar are included under the Southwest coast

3.4. Pelagic vs. Demersal

The resource potential for 0-200 and 200-500 m region was divided into pelagic and demersal by adding up the potential for corresponding species/groups (Table-3.3). It could be noticed that up to 200 m there is dominance of pelagic resource. On the other hand, demersal resources were dominant in the 200-500 m zone.

Though pelagic species like sardine, mackerel and ribbonfish contribute substantially to the potential in terms of quantity, generally it is the demersal resources (such as prawns and croakers) that earn more revenue. On this account the importance of trawlers in the Indian fishery cannot be overlooked.

Table-3.3. Potential Yield (t) of the pelagic and demersal resources in 0-200 and 200-500 m depth zones.

Resource	0-200 m	200-500 m	Total
Demersal resources	2209281	89000	2298281
Pelagic resources	2623366	8461	2631827
Mixed resources*	91369	-	91369
Total	**4924016**	**97461**	**5021477**

*Resources that could not be discriminated as Demersal or Pelagic

3.5.Oceanic resources

Oceanic resources are mostly straddling and trans-boundary species which are commercially important. The oceanic resource potential was estimated as 2,30,832 t. Compared to the previous exercise, there is a marginal increase in the estimate by about 14,000 t. This increase was reflected in all the components of oceanic resources, except big-eye tuna (Table-3.4).

One of the important aspects to be considered while planning deployment of resource specific gears targeting important oceanic resources like the yellowfin tuna is that the subsurface component of resources, which may be assumed to be about 25 percent of the total, could be targeted by long-line fishing.

Table 3.4. Resource potential of the oceanic resources

Species	**Potential (t)**
Yellowfin tuna	83500
Skipjack tuna	99500
Bigeye tuna	420
Albacore	112
Swordfish	6500
Sailfish	5200
Marlins	6600
Pelagic sharks	25000
Other species (barracuda, dolphin fish, wahoo, pelagic rays etc.)	4000
Total	**230832**

3.6. State-wise and Region-wise Potential

The state-wise distribution of the potential up to 200 m depth zone is given in Table-3.5. Kerala tops the list with 9.4 lakh t followed by Gujarat with 8.95 lakh tonnes. The Kerala figure includes bivalves which was responsible for elevating the state to first position. Tamil Nadu (8.2 lakh t), Karnataka (6 lakh t) and Maharashtra (4.6 lakh t) are the other states in the order of abundance of resources.

Table-3.5. State-wise and coast-wise resource potential

State/coast	**0-200 m depth**	**200-500 m depth**	**Total**
Gujarat and Daman & Diu	895862		
Maharashtra	457416		
Goa	190146		
Karnataka	604603		
Kerala	940282		
Total for West Coast	**3088309**	**83615**	**3171924**
West Bengal	341894		
Odisha	292568		
Andhra Pradesh	316109		
Tamil Nadu	823834		
Puducherry	61302		
Total for East Coast	**1835707**	**13846**	**1849553**
Grand total	**4924016**	**97461**	**5021477**

In the 0-200 m depth zone, the west coast accounted for nearly 3.1 million t whereas the east coast accounted for 1.8 million t.

It could be seen that the potential for 200-500 m depth zone in the west coast is significantly greater (about 70,000 t) than that of the same depth zone in the east coast. The total resource potential of the east and west coasts of the mainland of Indian EEZ (excluding the oceanic resources and resources around island territories) had a difference of about 1.3 million t.

3.7.Potential of Island Territories

For the two major island groups, the potential of the Lakshadweep waters is estimated as 73,590 t and that of Andaman and Nicobar waters is 47,463 t (Table-3.6). The detailed breakup of the resources could be seen from the appended support document A.

Table 3.6.Potential Yield of Andaman and Nicobar and Lakshadweep Island groups

Island group	**Potential Yield (t)**
Andaman and Nicobar waters	47,463
Lakshadweep	73,590
Total	**1,21,053**

It could be noticed that resources around Lakshadweep islands comprise mainly of tunas which are also estimated as “oceanic resources” in this exercise. This double counting has been rectified in the overall estimate of Indian EEZ resources.

Considering the vastness of the EEZ around the Andaman and Nicobar Islands, the potential estimates for that region seems quite low. An exercise done by FSI in 2005 shows that the potential yield of Andaman & Nicobar Islands as 1,48,000 t. This large difference between the two estimates underlines the importance of implementing an improved data collection system in the Islands similar to one followed in the mainland EEZ.

In the case of Andaman and Nicobar, a combination of landing data and exploratory data becomes inevitable because of the particular underexploited state of the fishery in the A&N waters. An extensive community based system of data collection should work well with the limited species fishery of Lakshadweep.

3.8 Summary of Potential Yield estimates

The total potential yield of the Indian EEZ is revalidated as 5.31 million t by the present Expert Committee (Table 3.7). Of this, the pelagic resources of the mainland account for 2.63 million t, demersal resources of the mainland account for 2.3 million t, potential yield estimated for island groups (excluding oceanic resources) is 58280 t, whereas the potential yield of oceanic resources for the entire Indian EEZ is 2.31 lakh t. Compared to PYE 2011, the current estimate of potential yield of Indian EEZ is higher by 0.9 million t.

Table 3.7. Summary of potential yield estimations for the Indian EEZ

Resource	Potential yield (t)
Demersal resources (mainland)	2298281
Pelagic resources (mainland)	2631827
Lakshadweep (excluding oceanic resources)	14490
A&N Islands (excluding oceanic resources)	43794
Oceanic (for entire EEZ)	230832
Others	91369
Total	**5310593**

The increase in PYE 2018 could be due to the following reasons: (i) Productivity in the Indian seas has probably increased due to climate change; (ii) Use of advanced analytical approach for PYE 2018 estimation, which is different from that used for PYE 2011; (iii) Commercial fisheries has expanded up to 200 m depth in the last 10 years. PYE 2018 has considered commercial fisheries data depth zone up to 200 m unlike PYE 2011, which considered that catches from commercial fisheries had come from depth zone up to 100 m; (iv) Commercial fish landings has increased in the last 10 years, which will have some influence on PY estimates.

Comparison of PYE 2018 (5.31 million t) and annual average fish landings for the years 2015-2017 (3.7083 million t; refer Support Document A on species-wise commercial fish landings) shows that the PYE is higher than the landings. This gives an impression that the status of fishery is quite comfortable and there is scope for increasing production from the current level. However, these estimates mask the following indicators, which do not support taking steps to increase fish catches. (i) The existing fleet size in the country exceeds the actual requirement. (ii) The catch-per-unit effort is reducing for many fisheries. (iii) The quality of fish catches (in terms of size of fish caught and changes in species composition) has changed in the last 10 years.

Considering the above factors, the Expert Committee does not recommend increase in fishing effort, but suggests regulating the fishing activities and diversification of fishing to sustain the catches. Suggestions for managing and conserving fishery resources are given in detail in Chapter 6.

3.9. Estimate by Trophodynamic Approach

From trophodynamic approach, the MSY (=PY) has been estimated as 5.12 million t which is close to the estimate (5.31 million t) using direct approach of estimating from fish landings and fishing survey data. The details of trophodynamic estimate that includes MSY and biomass estimates are available in Support Document D.

Table-3.8: Trophodynamic estimates (Lakh t / year) of MSY from ecosystems within Indian EEZ

Fish Group	Ecosystem				
	SEAS	**NEAS**	**SWBoB**	**NWBoB**	**Total**
Phytoplanktivores	5.793	0.252	1.262	0.504	**7.811**
Pelagic Planktivores	3.895	0.519	1.693	1.192	**7.299**
Pelagic carnivores	9.923	7.548	3.387	1.335	**22.193**
Pelagic omnivores	1.062	1.781	0.374	0.538	**3. 755**
Benthic carnivores	0.335	1.456	0.598	0.498	**2.887**
Benthic scavengers	1.330	2.536	1.810	0.696	**6.372**
Miscellaneous fish	0.389	0.325	0.315	0.041	**1.070**
Grand Total	**22.727**	**14.417**	**9.439**	**4.804**	**51.387**

SEAS: Southeast Arabian Sea; NEAS: Northeast Arabian Sea; SW BoB: Southwest Bay of Bengal; NWBoB: Northwest Bay of Bengal.

Among the two estimates, the direct approach using fish landings and fishing survey data has given better resolution at maritime State and species level. Considering the importance of enhanced resolution that will aid better understanding of status of species in each maritime state and also help developing species and State level management measures, the Expert Committee has chosen 5.31 million t as the final potential yield estimate of the EEZ of India.

4. Additional Potential

As suggested in the TOR, in addition to the conventional resources which are being commercially exploited and routinely recorded in the catch statistics, the Committee looked in to other resources which can form a viable fishery in future. Four such important resources have been identified, which are detailed below:-

4.1. Myctophids

Myctophids are a group of mid-water (columnar) fishes forming a significant part (about 31%) of the Deep Scattering Layer (DSL) in the oceans. Currently this group appears as bycatch in the deep-sea shrimp fishery of south-west coast of India. Though some estimates indicate that Western Arabian Sea has abundant mesopelagic resources to the tune of 94 million t, it would be reasonable to assume that about one million t of myctophids could be harvested by deploying appropriate vessels (Table 4.1).

Being a low value fish, myctophids are not directly used for human consumption. Whatever is landed goes for fishmeal production. Developing appropriate processing technologies for myctophids as well as creating good markets for mass produced myctophid products can open up an avenue for target harvesting and utilization of this untapped resource.

4.2. Oceanic squids

Commonly known as oceanic squids, the purpleback flying squid, *Sthenoteuthis oualaniensis* is an oceanic cephalopod of the family Ommastrephidae. This warm water species of the Indo-Pacific waters has been commercially harvested by Japan, and Taiwan/the Chinese distant water fishing fleet. The Arabian Sea is one of the richest regions for these oceanic squids in the Indian Ocean and is the most promising region for developing a large-scale fishery.

Under an NAIP project, CMFRI, CIFT, FSI and NIFPHATT joined hands to address the various issues of harvest and post-harvest of oceanic flying squids using a value chain approach. The vessel based studies under this project indicated highest abundance during December and January around the Lakshadweep Islands. The project estimated the MSY as 0.63 million t.

Since there is sufficient fishable biomass to support a new targeted squid fishery using jigging, seining or gillnetting from the western seaboard of India (Kochi, Mangalore and Goa), incentives to entrepreneurs to start pilot projects may be given priority.

4.3. Jellyfish

Jellyfish is becoming an important fishery, with a potential of earning foreign exchange. It has been estimated by the 'Sea-Around-Us' project that India's jellyfish catches were more than 100,000 tonnes, particularly during the period 2002 to 2006. The NMFDC database of CMFRI shows much lower catches from 1980s onwards in the states of Gujarat, Karnataka, Kerala, Tamil Nadu and Andhra Pradesh.

The increased abundances of jellyfish have been attributed to changes in the marine system, especially seawater warming. The landings are sporadic and with large inter-annual variability in time and space. As a consequence, establishment of permanent processing facilities is not considered to be economically feasible. Small-scale opportunistic processors export salted and dried jellyfishes to Southeast Asian countries, Korea, Japan and China.

The important species harvested are *Crambionella stuhlmanni*, *C. annandalei*, *C. orsini*, *Catostylus perezi*, *Rhopilema hispidum*, *Lychnorhiza malayensis*, *Lobonema smithi* and *Rhizostoma pulmo*. It is reasonable to assume the potential of jellyfishes from Indian seas as around 2,00,000 t. However, a lot of knowledge gap exists on population dynamics and other aspects of jellyfish, which need attention.

4.4.Marine macro algae

Marine macro algae or seaweeds are exploited for commercial production of phycocolloids such as agar, algin and carrageenan. Important harvested species include: red seaweeds such as *Gelidiella acerosa, Gracilaria edulis* and *Gracilaria crassa* for agar production and brown seaweeds *Sargassum* spp. and *Turbinaria* spp. for algin production.

More than 5000 fishers (mostly women) in the Gulf of Mannar, Palk Bay and Gulf of Kutch are involved in collection of seaweed (*Gelidiella acerosa*, *Gracilaria edulis*, *Sargassum* spp. and *Turbinaria* spp.) for their livelihood. For carrageenan production, red seaweed *Kappaphycus alvarezii* is being cultivated in the Palk Bay region. From Tamil Nadu coast, alone the MSY of the exploited seaweeds is estimated to be 17,775 t.

Table 4.1 – Resource potential of other resources

Resource	Potential (t)
Deepsea myctophids	10,00,000
Oceanic squids	6,30,000
Jellyfish	2,00,000
Marine macro algae	17,775
Total	**18,47,775**

5. Different types of fishing craft for Sustainable Fishery

Mandatory registration of fishing vessels and issuance of fishing license

Previously, registration of fishing vessels was done by the Coastal States/UTs under their respective Marine Fisheries Regulation Act (MFRA). However, some States like Karnataka and Gujarat were doing registration under the Merchant Shipping (MS) Act. After the 2008, it was decided to have a uniform registration system for registration of all types of fishing vessels irrespective of their size and tonnage. This registration is now done under the Merchant Shipping Act, 1958 (MS Act) and the Coastal State Fisheries Departments have been presently empowered to do the registration of fishing vessels. The Ministry of Shipping (MoS) had on 24th June, 2009 notified a format for uniform registration of fishing vessels and also the State-wise registrars as identified by the States/UTs.

The Department of Animal husbandry, Dairying and Fisheries (DADF) through the National Informatics Centre (NIC) has developed a uniform web based registration regime (***ReALCraft***) for online registration of fishing vessels. *ReALCraft* is a work-flow based online application system for registration of all category of fishing vessels under the MS Act and issuance of fishing license under the Marine Fisheries Regulation Act (MFRAs) to the fishing vessels operating in the Indian waters. Registration under the ReAL*Craft* is being done by the notified registrars of the Department of Fisheries of all Coastal States and Union Territories (Registrars are notified by the Ministry of Shipping).

Progress

As on 30th July, 2018, a total of 2,57,898 fishing vessels have been registered under ReALCraft system and State-wise details are furnished at Table 5.1. The security agencies, Central Government agencies and Coastal State Governments/UTs are provided need based access to this system to access the database.

Table-5.1. Number of different types of crafts in the ReALCraft Registry of DADF as on 30th July 2018

Name of State	Deep-sea fishing vessel	Motorised non Mechanical	Motorised Mechanical	Non-motorised	Total
Andaman & Nicobar		1894	109	1383	3386
Andhra Pradesh		21642	2073	15869	39584
Daman & Diu		305	1855		2160
Goa		1	2493	291	2785
Gujarat		11406	16410	76	27892
Karnataka		8575	4449	9016	22040
Kerala	51	30538	5760	2664	39013
Lakshadweep		1360	33	375	1768
Maharashtra			20046	7458	27504
Odisha		10629	1881	14588	27098
Puducherry		1863	1062	1798	4723
Tamil Nadu		33262	5791	5926	44979
West Bengal		6100	3102	5764	14966
Total	**51**	**127575**	**65064**	**65208**	**257898**

6. Suggestions on conservation, management and sustainable use of marine fishery resources in the Indian EEZ in light of the existing legislation and various global convention(s)/initiatives

The foregoing Chapters in this Report on Estimation of Potential Yield and fleet size have already shown that the existing fleet size is in excess for harnessing the full potential of fish stocks in the Indian EEZ. In addition to the increase in number of vessels, combined effect of increase in size, technical efficiency, and fishing time of each vessel in a year or season has substantially increased the overall fishing capacity.

Considering the importance of fish products as a source of nutrition, the importance of preserving the marine environment, that offshore fisheries have expanded over the last decade, that the adoption, monitoring and enforcement of effective conservation measures, is inadequate in many areas and that many coastal resources are over-utilized, the need to regulate fishing practices and fisheries management to avoid over-exploitation of fisheries resources or loss of biodiversity has been recognised.

The Government of India and State Governments have adopted various measures for sustainability of fisheries, and to achieve a better relationship between fishing activities and conservation of environment and resources. The Potential Yield revalidation committee reviewed a large number of documents on the existing legislation in India and their outcomes. This review also included perusal of various binding and non-binding international instruments relevant to the fisheries and environmental (especially biodiversity) sectors and India's position with respect to the implementation of the provisions contained in such instruments. The reviews on fisheries governance structure in India, national laws governing marine fisheries, existing legislations related to fisheries in India, global conventions and commitments, and regional instruments and regional cooperation have been placed as Support Document E.

The Committee has taken the view that National Policy on Marine Fisheries 2017 (NPMF 2017) is the overarching instrument for conservation, management and sustainable use of marine fishery resources in the Indian EEZ. The following Sections have highlighted/elaborated some of the Policies outlined in NPMF 2017 into actionable points.

6.1.0 Improving management regime

6.1.1 Regulation for sustainable use of resources beyond territorial waters: Keeping in view the developments in exploitation of the resources in waters beyond 12 nautical miles, there is an urgent need to enact a comprehensive legislation for regulation of Indian fishing fleet in the EEZ. The Central Government, on a priority, may consider an Act / guidelines for regulation of fisheries and related matters in waters between 12 and 200 nm.

6.1.2 Expanding and revising the scope of Marine Fishing Regulation Acts (MFRAs): The existing MFRAs were framed about three decades ago. In the last 30 years, the marine fisheries in the country has undergone several changes and new issues and challenges have emerged. The current issues facing fisheries are far more complex than before making fisheries management more difficult and challenging. Government of India may guide the maritime States/UTs for revising the MFRA by enlarging its scope.

6.1.3 Fishery Management Regions (FMRs):Many species of marine fishes are mobile and their movements are not restricted by political boundaries. Their distribution and movements

are determined by ecological and environmental boundaries. However, fisheries management remains bounded by historical jurisdictions rather than ecological ones. In this context, the EEZ of India could be divided into the following six ecological and environmental zones for fishery management purpose:

(i) Northwest coast consisting of Gujarat and Maharashtra
(ii) Southwest coast consisting of Goa, Karnataka and Kerala
(iii) Southeast coast consisting of Tamil Nadu, Andhra Pradesh and Puducherry
(iv) Northeast coast consisting of Odisha and West Bengal
(v) Andaman & Nicobar Islands
(vi) Lakshadweep Islands.

The ecosystem types, distribution of fish species and type of fisheries are similar within each of the six regions; and there may be little difference between the six regions. It is suggested that six Regional Councils may be established for implementation of fisheries management by coordinating the activities of maritime states within each Region. The Establishment of FMRs may be linked to licensing of fishing boats, issuing guidelines on fishing areas and landings the catches within each region.

6.1.4 Fisheries management in Andaman & Nicobar and Lakshadweep group of islands:

It is suggested that the following approach may be adopted:

(i) Fisheries data including landings and fishing effort of different craft and gear may be collected following the methodology adopted in the mainland.
(ii) As a precautionary approach, the number of fishing boats may not be increased, but the efficiency of existing fishing practices may be improved.
(iii) Improvement in shore-based infrastructure facilities, such as ice plants, cold storages and transportation will encourage fishers to venture into multi-day fishing.
(iv) Infrastructure facilities and logistics for improving markets and marketing of products from the islands need to be considered.

***6.1.5 Ecosystem Approach to Fisheries Management (EAFM)*:** EAFM offers a practical and effective means to manage fisheries more holistically. The management strategies in India so far have concentrated on fishing practices and have not addressed all the threats facing fisheries like climate change, pollution, habitat degradation. It has been realized that a broader and more inclusive approach is needed that expands on existing management. EAFM is an extension of the conventional principles for sustainable development in general, and sustainable fisheries development in particular, to cover the ecosystem as a whole. The key features of an EAFM include: consideration of ecological, social, and governance processes over broad spatial and temporal scales; a focus on resilience; adaptive management, co-management, institutional cooperation and coordination, and a precautionary approach. EAFM represents a move away from conventional fisheries management and focuses on target species and towards decision making processes that balance ecological and human well-being with improved governance frameworks. This concept, which is relatively new to India, needs to be adopted by the fisheries and develop management plans that not only work locally, but also fit into broader fishery/ecosystem strategies.

6.1.6 Increasing the Marine Conservation Areas: Marine conservation areas are globally recognized as an important regulatory tool for protecting and conserving coastal and marine biodiversity. The conservation areas can improve ecosystem functions and services through maintaining ecological structure and processes that support economic and social uses of marine resources. Sustainable Development Goal 14 (SDG 14) and Aichi Target have emphasised the importance of increasing the areas of conservation to 10%. It is necessary to designate new conservation areas, fish refugia and, fish sanctuaries; and expand the current conservation areas with specific objective of protecting aquatic resources. The designated areas should have clear fisheries and ecosystem objectives.

6.1.7 Fishery Management Plans (FMPs):In marine fisheries of India, there are a few iconic species in terms of volume of landings, life history traits and vulnerability to fishing and environmental factors. These species need special attention for sustenance under dedicated management plans, which are existing only for a few species in the country now. For example, FMPs may be developed for oceanic tuna fisheries, shark fisheries (under National Plan of Action – Sharks) and oil sardine fisheries. Specific fishing areas such as Wadge Bank and Palk Bay also could be considered for FMPs in addition to gear-based, or ecosystem-based or resource-based FMPs. Considering the availability of species-and-region-based PY estimates, Harvest Control Rules (HCR) may be introduced within the FMPs.

6.1.8 Implementing catch quotas: In India, output control measures such as limitation of total catch or catch quotas does not exist. In the absence of output control measures, the input control measures alone will not be effective. Output control, which is recognized as better management option, is being followed by many countries. As estimates on PY are available for all the major fished stocks, it is possible to adopt effective output control measures by fixing catch quotas and introducing Total Allowable Catch (TAC).

6.1.9 Adapting marine fisheries to climate change

Fisheries is directly affected by climate change. Fishing and climate change are strongly interrelated pressures on fish production and need to be addressed jointly. Reducing fishing mortality in the majority of fisheries, which are currently fully exploited or overexploited, is the principal means of reducing the impacts of climate change. As the Marine Fishing Regulation Act (MFRA) is the key instrument for regulating fishing in the State, it is necessary to mainstream climate change adaptation into the Act. The MFRA may integrate considerations of climate change adaptation into budgeting, implementation and monitoring processes at state level. Integrating and proper implementation of sea safety and MCS mechanism into the MFRA; and developing capacity and awareness programmes are important.

As part of India's International commitments on climate change, the concept of green fisheries by reducing Green House Gases (GHG) emissions from fishing and fishing related activities also need to be encouraged.

6.1.10 Monitoring, Control and Surveillance: The DADF has made remarkable progress in (i) registering of all types of fishing craft, (ii) geo-referencing fishing harbours and fish

landing centres; (iii) issue of biometric card to fishermen, and (iv) using colour code to fishing boats to identify the maritime state they belong to. Further to this progress, the following measures are suggested:

(i) Licensing all fishing boats may be made mandatory and strictly implemented.
(ii) Fishing licenses should clearly specify the gear to be operated in mechanized and motorised craft.
(iii) Regular reporting of fish catches, position of fishing operation, submission of voyage report, crew compliance etc. need to be introduced.
(iv) Vessel Monitoring System (VMS) should be put in place for better monitoring of the fishing vessels. Better communication devices such as radio transmitters, Automatic Identification System (AIS) may be installed in all the mechanised boats. This will also improve sea safety of the fishermen.
(v) Adequate number of on-shore High Frequency stations need to be established.

There is a need to strengthen enforcement by establishing Enforcement Wing in the Department of Fisheries of each maritime State.

6.1.11 Promoting co-management: Fisheries co-management is "A partnership arrangement between government and local community of resource users and other stakeholders, to share the responsibility and authority for management of the fishery" (Source: FAO). The management could be on a single fishery, gear type, fleet, geographical area; or multi-resource, multi-stakeholder integrated management. Many success stories are emerging globally on fisheries co-management. In India, the Governments of Tamil Nadu and Puducherry have initiated the process of co-management by forming three-tier co-management committees at Village, District and State level. Government of Kerala has amended the Kerala Marine Fishing Regulation Act (KMFRA) to include co-management. Co-management process is already in place for management of short-neck clam fishery in Ashtamudi Lake. It is recommended that co-management process may be encouraged by the Governments of other maritime State Governments by identifying specific fisheries and establishing and co-management committees.

6.1.12 Capacity building: The management measures suggested in this Report requires specialist human resources. The skills and expertise required for fisheries managers, scientists and fishermen can come only from proper training. It is suggested that training courses are tailor-made for specific purpose and stakeholders. The purpose of capacity building in fisheries and environment in India is enhancing the skill in (1) resource assessment; (2) ecosystem assessment; and (3) management system implementation and governance enhancement. The levels of capacity building are individuals, institutions, societies and trainees' trainers. It is also important that fisheries managers acquire adequate skills on conflict resolution and communication techniques. Training need assessment has to be done to identify knowledge, skills and attitudes required.

6.2 Regulating fishing practices

6.2.1 Regulation on fishing vessel construction: Presently, there is no system of registration of boat building yards meant for construction of fishing vessels. This practice has led to unregulated construction of fishing vessels and also invites national maritime security issues.

As a part of general management plan for regulating fishing capacity, the design and construction of fishing vessels are to be monitored and regulated by complying with standard norms. The owner of the boat yard and the owner of fishing vessel may obtain prior approval of the Department of Fisheries, before construction of fishing vessels of more than 12 m length.

6.2.2 Regulation of fishing gear: Fishing licenses should clearly specify the gear that may be operated in mechanized craft. At present, minimum mesh size of fishing gear is not prescribed in MFRA other than for cod end of trawl. Consequently, nets with small mesh size are used, leading to capture of juvenile fish. Minimum mesh size and gear dimension regulation are required for all major gears like gillnet, trawl net, seine nets etc. It is also important to specify the maximum size of fishing net, specifically gillnets and seines. Regulation on fishing gear may be done by bringing all fishing net manufacturers and dealers under a system of registration and licensing. Manufacture/selling of fishing gear below permitted mesh size may be prohibited.

6.2.3 Regulation of fishing methods: Destructive fishing practices have a devastating effect on fish stocks and on the marine environment. For example, (i) pair trawling or bull trawling is a modified practice in trawling where two or more vessels join together to drag one large trawl net. The efficiency of pair trawling is 3 to 4 times more as compared to conventional trawling, leading to rapid depletion of resources. (ii) In Gujarat, a fleet of trawlers operate side-by-side simultaneously, not allowing any fish to escape. (iii) Fishing practices like mini trawling carried out near the shore often creates law and order problems. The practice leads to substantial destruction of juvenile fish and should be banned for the long term sustainability of resources. The above mentioned as well as similar types of destructive fishing methods need to be prohibited.

The ringseine has been prohibited by a few maritime states, but it is being operated illegally. The ring seine is the predominant gear for catching small pelagics, particularly the oil sardine. Considering that the (a) ringseine is an efficient gear to catch small pelagics, (b) total ban on the gear will be a lost opportunity to harvest these short-lived resources, and (c) livelihood of a large number of fishermen will be affected by total ban on the gear, it is suggested that the ringseine fishery may be regulated (instead of total ban) to avoid excess fishing pressure and prevent growth overfishing.

6.2.4 Regulation of minimum legal size of fish caught: Indiscriminate exploitation of large amount of juvenile fish along with low value biota occurs all along the coasts. These fish are landed and transported to fish meal plants. As the demand for fish meal is growing, there is deliberate capture of juveniles, affecting fish stocks. Exploitation of juvenile fish results in considerable economic loss, growth overfishing causing serious damage to the fish stock in terms of long-term sustainability of the resources. Minimum legal size (MLS) may be prescribed for different species to maintain spawning stock biomass.

***6.2.5 Designation of fishing area*s:** At present, fishing areas for three different categories of craft have been allotted based on the distance from the shore. The area ranging from 3 to 5 nautical miles (nm) from the shore has been allotted by the maritime states for non-motorised and motorised craft. A few states have incorporated the depth criteria also for the allotment. The area beyond the designated area for non-motorised and motorised craft has been allotted for all the boats, including the mechanised craft. In the last one decade, the mechanised boats have ventured into offshore fishing grounds and it has been estimated by CMFRI that

majority of the catch by the mechanised craft is from areas beyond the territorial waters of 12 nm. This indicates that the fishing effort of a large majority of mechanised boats is distributed in areas beyond 12 nm. Considering this development and reducing the fishing intensity within the territorial waters, the following measures are suggested:

(i) The fishing area of within territorial waters of 12 nm may be allotted exclusively to non-motorised and motorised boats of overall length (OAL) <12m. Among the motorised boats, only those navigating with a single motor may be permitted within this area.
(ii) Fishing by all mechanised boats and motorised boats >12 m OAL as well as all the motorised boats navigating with twin outboard motors may be prohibited from fishing within the territorial waters.

6.2.6 Closure of fishing season:The present closure of fishing for 61 days synchronising with fish spawning activity and monsoon (April 15 – June 14 along the east coast; June 1 – July 31 along the west coast) is yielding beneficial results in terms of improving the catches. This measure may be continued with the following modification:

(i) In addition to closure of fishing by all mechanised boats during the two-month ban, fishing by all motorised boats may be prohibited from fishing during the two-month ban period. This means that only non-motorised crafts will be permitted to operate during the ban period.
(ii) To protect pelagic spawning stocks, operation of all types of seine nets may be prohibited during the seasonal closure.

It is suggested that change of months and duration of closure may be considered based on improved information from time-to-time on spawning and other vital characteristics of the fisheries.

6.2.7 Safety-at-Sea: At present fishing vessels are not carrying basic navigational lights, other signals and safety equipment, often resulting in accidents, loss of life and property at sea. It is mandatory that all fishing vessels be fitted with appropriate lights and flags for signalling as per international maritime norms. They should also possess Life Saving Appliances (LSA) and Fire Fighting Appliances (FFA) as per sea safety norms. The fishing vessels also need to possess adequate communication facilities. Fitment of Distress Alert Transmitters (DAT), GPS and other safety devices for tracking and regulating fishing vessels are necessary.

6.2.8 Prevent, Deter and Eliminate Illegal, Unreported and Unregulated (IUU) fishing: The FAO's Committee on Fisheries adopted International Plan of Action (IPOA) to prevent, deter and eliminate illegal, unreported and unregulated fishing (IPOA-IUU) in 2001. IUU fishing is a major impediment towards sustainability of the marine fisheries sector. In Indian context, IUU Fishing remains a contentious issue. Incidences such as violation of zonation norms under Marine Fishing Regulation Acts, use of prohibited gear, fishing in the waters of other countries, etc. have damaged the health of the fish stocks and even resulted in social tension. In addition, there is global concern and urgency to curb IUU fishing. Successfully curbing IUU fishing can improve livelihoods of fishers and increased flow of revenue from fishing activities while protecting the fish stocks from further damage. It is necessary for India to prepare National Plan of Action to prevent, deter and eliminate illegal, unreported and unregulated fishing (NPOA-IUU).

***6.2.9 Subsidies*:** Some States in India are providing subsidies for fuel and purchase of outboard motors for very long time. These subsidies encourage entry of fishing vessels into the fishery, thereby exerting pressure on living resources and ecosystems. Global pressure is also mounting to dispense with these subsidies. It is recommended that the Government may consider gradually phasing out these subsidies, and replace them with subsidies that will encourage fishers to adopt sea safety measures and establishing communication facilities in fishing boats. To incentivise adoption of closed fishing for 61 days, the compensation that is being paid to the fishers may be increased. Further to improve seafood quality and safety, subsidies may be provided for establishing on-board preservation facilities and on-shore mini and micro processing plants near the fishing harbours, fish landing centres. Improving the quality of fishes will fetch higher economic value to the fishers and traders for the same amount of fish caught/traded as well as ensure safe seafood to the consumers.

6.2.10Regulating fish meal plants: Fish meal plants have proliferated in the country in the last five years. For raw material, the plants use small pelagics such as oil sardine and anchovies, which otherwise could have been used for direct human consumption. This is a matter of concern as (i) the demand leads to overfishing of such species; (ii) undermines the integrity of marine ecosystem, and (iii) leads to wastage of wealth. The Government may address this issue by taking steps to control and regulate proliferation of fish meal plants.

6.3Improving infrastructure

***6.3.1 Improving facilities*:** Provision of adequate infrastructure facilities is critical to marine fisheries value chain, and also for many MCS functions. Based on a comprehensive reassessment of the requirements and ensuring minimal impacts on the coastal ecosystems, the Government may create additional facilities, including harbour-based fish dressing centres and fish processing estates. It is also important to maintain hygiene and sanitary aspects of the infrastructure facilities, such as fishing harbours, fish landings centres and fish markets in the country and raise them to international standards.

6.3.2 Living conditions on fishing boats: Presently, mechanised multiday fishing vessels do not have basic sanitary facilities such as toilets, kitchen (galley) space and sleeping (berthing) arrangement. Space for all these basic facilities are now used for increasing fish hold capacity. These basic human necessities are to be provided on board for the crew as per the provisions of ILO Convention 188 of the International Labour Organization (ILO). The basic human necessities are to be provided for the crew on board mechanised multiday fishing vessels as per provisions of the Articles 25-28 of ILO C188. A model boat of standard size with ideal living conditions, communication equipment and sea safety devices may be designed, constructed and exhibited by the Government.

***6.3.2 Improving trade*:** In spite of growth of marine products export, Indian seafood is yet to realise its optimum value, mainly due to low levels of value addition and poor product branding. The Government may take steps to promote product diversification, improve value addition and product branding to reach new markets. Considering the growing domestic demand, the Government may improve the existing infrastructure for domestic markets and value chain to ensure maximum value for fishery products and supply of high quality fish to consumers. It is also important to integrate fishery products with Food Safety Standards Authority of India (FSSAI) benchmarks to improve seafood safety. The Government may create an enabling environment for promoting traceability and eco-labelling of highly valued fishes, which will benefit seafood industry and sustainability of fish stocks.

6.4 Fostering international/regional cooperation

***6.4.1 International agreements/arrangements*:** As mentioned in this Chapter, India is a signatory to a number of international instruments and agreements. These obligations need to be implemented to make fisheries sustainable as well as to ensure compliance. FAO's Code of Conduct for Responsible Fisheries (CCRF), Voluntary Guidelines on Sustainable Small-scale Fisheries (VG-SSF) and SDG 14 are some of the instruments that directly address marine fisheries sustainability. It is essential that the Government makes all efforts to implement the provisions in these instruments keeping in view the complexities and by engaging the stakeholders and fisheries organisations for better implementation.

***6.4.2 Regional cooperation*:** The migratory and straddling fish stocks such as tunas, tuna-like species and sharks are shared by neighbouring countries. Engaging these countries to develop a strong regional cooperation in management and sustainable utilisation as well as conservation of transboundary resources is necessary. Cooperation with neighbouring countries to ensure safety and security of fishermen is also necessary as the Bay of Bengal and Arabian Sea witness increasing events of storms and cyclones.

7. The Way Forward

The PY 2018 has been estimated based on improved analytical methods compared to the earlier estimates. However, considering the limitations listed in Sub Section 2.4 and potential for improvement of the analysis, the following suggestions are made by the Committee:

(i) With enhanced sea endurance, the mechanized fishing fleet often ventures into multiday voyages and fish in areas away from their port of origin. However, the fish are landed in the port of origin. Hence, the landings data (which is used for estimation of PY for 0 – 200 m depth zone) may not represent the catch off that State. To overcome this problem, it is necessary to collect information on fishing areas of multiday mechanized boats so that the catch data could be assigned to the respective States.

(ii) Data collection in the two Island groups needs improvement. The data collection system followed in the mainland may be followed for the Islands.

(iii) For pan-oceanic stocks like the yellowfin tuna, stock analysis needs to be carried out using molecular markers. This will provide answer to the question whether the species is a single stock across the Indian Ocean or the stock in the India seas are different from that of Indian Ocean.

(iv) While the Committee has used improved analytical methods for PY estimation, it is important that future estimates are made by applying scientifically advanced analytical methods that are likely to be developed in future.

(v) Stock assessment exercises are to be carried out periodically for important commercial species. The periodicity may be three years for short-lived species and six years for long-lived species.

(vi) The research institutes that are mandated to perform fish stock assessment, namely Central Marine Fisheries Research Institute and Fishery Survey of India, may incorporate specific data requirements for estimation of PY and other BRPs in their research projects and fishing surveys.

(vii) In the future committees, the DADF may consider inclusion of representatives from Central Institute of Fisheries Technology (CIFT) and two Fisheries Universities and ensure effective participation of Department of Fisheries.

(viii) A Standing Committee may be established by the DADF to periodically review the data requirements and methodology of future estimates.

Appendices

Support Document –A

Estimates of potential yield for the depth zone up to 200 m and the fleet size

CMFRI Sub-group

1. Introduction

Marine fish production in India has increased from 2.95 million t in 1998 to an all-time high of 3.94 million t in 2012. The average growth rate during the period 1998 to 2017 is 2.03 % per annum. As per the ReALCraft registry of DADF, Ministry of Agriculture and Farmers' Welfare, there are about 2,57,898 fishing crafts in the country for exploitation of marine fishery resources. Out of this about 65,064 are mechanized, 1,27,575 are motorized, and 65,208 are non-motorised. There are 51 vessels designated as deep-sea fishing vessels. Trawlers dominate the mechanised fleet. The traditional non-motorised crafts (70%) and motorized crafts (59%) are concentrated on the east coast whereas the mechanized vessels (78%) are more along the west coast.

Fishing by these crafts, especially the trawlers, was concentrated in the depth zone up to 100 m till a decade back. With the expansion of size of the craft and power of the engine, they started venturing up to 200 m in recent years. Therefore in the current analysis the exploited stock was assumed to be coming from within 200 m depth zone of the EEZ.

2. CMFRI Sub-Group

In accordance with the resolutions made in the first meeting of the Committee held at Mumbai on 4th November 2017, the CMFRI formed an elaborate sub-group to work out the deliverables from the Institute. The following are the outputs expected from CMFRI sub-group:

- Resource-wise and state-wise potential yield (MSY) up to 200 m depth contour based on landing data.
- Potential yield estimates for Island territories (Lakshadweep and Andaman & Nicobar Islands)
- Estimates of Potential for other exploited and unexploited resources such as seaweeds bivalves etc.

3. Database

The major database for the exercise of estimating potential yield estimates around mainland was the data available with National Marine Fishery Resources Data Centre (NMFRDC) of CMFRI. Statistics provided by UTs of Lakshadweep and Andaman & Nicobar Islands as well as information available within the Institute were used for estimating the fishery potential around the Island territories. Information generated under various projects within the institute was the basis for providing the estimates of potentials of other exploited and unexploited resources.

4. Methodology

A number of models were used for estimating the resource potential of the Indian EEZ. Compared to the previous exercise, there is a significant improvement in the understanding and application of models.

4.1. Basic Assumptions

Any modelling exercise inevitably has to make a number of assumptions which may often be a little different from reality. Landing of fish by a boat is mostly decided by its base of operation or port of registration, while fishing operation is not confined to the area of sea bounded by the extended line of state boundaries into the sea.

Recent landings data formed the input for estimation of the resource potential. While landings is a function of effort, considering the complex techno economic variables. The analysis was done by taking catch as an indicator of the available resources.

4.2.Potential Yield Estimates

The methodology adopted for estimation of potential yield from the portion of the Indian EEZ up to 200m depth is based on three new versions of biomass dynamic models in the line of MICE (Models of Intermediate Complexity for Ecosystems) (Plaganyi et al., 2014). The MICE model has the following expression for calculation of successive years' biomass known as the process equation.

$$B_{t+1} = B_t + rB_t\left(1 - \frac{B_t}{K}\right) - \sum_{i=1}^{g}(q_i E_{i,t})B_t$$

Where,

B_t is the biomass of the resource being modelled in year t

$E_{i,t}$ is the fishing effort in hours by fleet type i in year t

R is the intrinsic annual growth rate of the biomass

q_i is the catchability coefficient for the fleet type i

K Is the carrying capacity for the resource being modeled

For relating the biomass to the observable quantities namely fish catch and fishing effort the observation equation having the following expression is used.

$$C_t = \sum_{i=1}^{g}(q_i E_{i,t})B_t$$

Where,

C_t is the catch/landing of the resource being modelled in year t

The following three modified versions of the MICE models to suite the complex multi-gear fishery situation prevailing in our country were used for modelling individual fish resources for each of the maritime states in order to arrive at sustainable harvest levels (MSY). For most of the resources the first model was found suitable followed by the second model. The last model could be used only in one case.

1. $B_{s,t+1} = B_{s,t} + r_s B_{s,t}\left[1 - \left(\frac{B_{s,t}}{K_s}\right)\right] - \sum_{i=1}^{g}\left(\lambda_{s,i} p_{s,i} E_{i,t}\right) q_s B_{s,t}$
2. $B_{s,t+1} = B_{s,t} + r_s B_{s,t}\left[1 - \left(\frac{B_{s,t}}{K_s}\right)^{\mu_s}\right] - \sum_{i=1}^{g}\left(\lambda_{s,i} p_{s,i,t} E_{i,t}\right) q_s B_{s,t}$
3. $B_{s,t+1} = B_{s,t} + r_s B_{s,t}\left[1 - \left(\frac{B_{s,t}}{K_s}\right)^{\mu_s}\right] - mB_{s,t} - \sum_{i=1}^{g}\left(\lambda_{s,i} p_{s,i} E_{i,t}\right) q_s B_{s,t}$

The symbols used in the model mean:

$B_{s,t}$ is the biomass of the species ***s*** corresponding to year **t**

r_s is the intrinsic growth rate for species ***s***

K_s is the carrying capacity for species ***s***

μ_s is the exponent parameter in the model for species ***s***

$\lambda_{s,i}$ is the effort standardization parameter for species ***s*** corresponding to gear type ***i***

q_s is the catchability coefficient of gears for species ***s***

$p_{s,i,t}$ is the proportion of the species ***s*** in the catch by gear ***i*** in year **t** (calculated from catch data)

For estimation of parameters of the models as well as sustainable harvest levels computer software developed under ADMB environment (Automatic Differentiation Model Builder) was used. The input data used for modelling were time series on resource-wise fish catch and fishing gear-wise effort (hours of fishing operation) available in the National Marine Fishery Resource Database of CMFRI for each maritime state.

5. Results

5.1.Resource potential of the EEZ

The present exercise of revalidation estimated the resource potential of the Indian EEZ up to 200 m as 49,24,016 t. This estimate excludes the potential for island territories which is given separately. The Oil sardine emerged as the single largest resource of the Indian EEZ with a potential of more than 6 lakh tonnes. Indian mackerel (3.17 lakh t) ribbonfish (2.97 lakh t) and penaeid prawns (2.87 lakh t) were the other important resources in the order of abundance. Together with other sardines, oil sardine and mackerel accounted for nearly a quarter of the estimated resource potential (Table-A-1).

5.2.Group-wise Potential

A look at the resources from the two important realms, namely pelagic and demersal, is useful to understand their relative importance in the resource basket. Pelagic resources dominated the potential estimates with 2.62 million tonnes while demersal resources closely trailed with 2.2 million tonnes (Table-A-2). Considering the relative higher value, demersal resources could be termed as the major contributor to the fishery revenue. Except in the sea off Gujarat, Maharashtra and Odisha where demersal potential was more, in all other states pelagic resource potential was prominent.

5.3.State-wise Potential

State-wise estimates of the potential almost reflected the pattern and order of marine fish landings in the country. Kerala topped with 9.4 lakh t of resources (by virtue of the bivalve resources added to the potential) followed by Gujarat (including Daman and Diu) with (8.9 lakh t) Tamil Nadu (8.2 lakh t), and Karnataka (6 lakh t). Puducherry (0.6 lakh t) and Goa (1.9 lakh t) had a respectable share in tune with the extent of their coast, Andhra Pradesh (3.2 lakh t) was surprisingly pushed behind West Bengal (3.4 lakh t). The details of the potential resources is depicted in Table- A-1.

5.4.Potential of Island Waters

The estimates for islands were derived by applying a new estimation methodology recommended for data-poor situations namely, Catch MSY (CMSY) (Martell and Froese, 2013;Zhou et al., 2017). The potential estimated for Andaman and Nicobar waters is 47,463 t comprising more than forty different species/groups (Table-A-3). Perches, sardines, silver bellies and anchovies, were significant in the estimated potential. These estimates are based on catch landed alone and may not reflect the actual potential which could be assessed only by comprehensive exploratory surveys. It is reasonable to look at the figures arrived at by FSI in 2005 to get an idea of the possible range of potential estimate in Andaman & Nicobar waters (John et al., 2005).

The potential for Lakshadweep was estimated to be 39292 t of tuna species (Table-A-4). Skipjack formed the bulk of the potential (26,100 t) followed by yellow fin (9,100 t). *Euthynnus affinis* (3,220 t) and *Auxis*spp. (872 t) were the other species included in the potential. An estimate of the baitfish potential, though important in pole and line dominated fishery, could not be arrived at due to various constraints.

5.5.Other Resources

5.5.1. Deepsea myctophids

Studies in the Arabian Sea have indicated that, the areas rich in the midwater fish stocks are dominated by myctophids. The total abundance of mesopelagic fishes in the Northern and Western Arabian Sea is estimated at about 94 million t (GLOBEC, 1993; Gjosaeter, 1984). Raman and James (1990) have conducted studies on distribution and abundance of myctophids in the EEZ of India, using IKMT (Isaac-Kidd Midwater Trawl) as sampling gear. According to their studies, myctophids formed 31% of the total fish biomass of the deep scattering layer (DSL) in the Eastern Arabian Sea. Peak abundance of myctophids was in waters along 69°30'E longitude between 18°30'N and 21°30'N latitudes and in the waters north of 15°N between 68° and 73°E longitudes. The share of myctophids (32%) in bycatch discards of deep sea shrimp trawlers operating off southwest coast of India, indicate the potential of these species for future expansion, adopting a precautionary approach (Vipin *et al*., 2012).

Though there are no precise estimates of the stock of myctophids in the Indian EEZ, the availability of fishable quantities of myctophids is beyond doubt. Directed midwater trawling in the Arabian Sea can bring in substantial quantities (>1,000,000 tonnes) of myctophids. Though not suitable for direct human consumption, this resource can be used for fish meal and fish oil.

5.5.2. Oceanic squids

The purpleback flying squid, *Sthenoteuthis oualaniensis* is an oceanic cephalopod of the family Ommastrephidae, distributed in the warm waters of the Indo-Pacific region. The species has been commercially harvested only in Okinawa (Japan), Taiwan and, recently, in the central Arabian Sea by the Chinese distant water fishing fleet. The Arabian Sea is considered one of the richest regions for these oceanic squids in the Indian Ocean and is also considered a most promising region for developing a large-scale fishery (Zuyev et al. 2002). As part of India's strategic outlook towards exploitation of deep sea resources, a World Bank aided ICAR-National Agricultural Innovation Project (NAIP) operated by CMFRI, CIFT, FSI and NIFPHATT addressed the exploitation of these oceanic flying squids using a value chain approach and vessel based surveys. These studies (Mohamed et al., 2018) indicated that highest abundances were observed during December and January within 10 and 13°N and 71 and 72°E around the Lakshadweep Islands. The mean abundance in the area was 4.21 t/km^2 and the maximum sustainable yield (MSY) was estimated as 0.63 million t.

The distribution and abundance of *S. oualaniensis* in the Arabian Sea is apparently highly influenced by environmental variables. The key variables driving the daily vertical movement may be food and temperature. There is sufficient fishable biomass in the area to launch a new targeted squid fishery using jigging, seining or gillnetting from the western seaboard of India (Kochi, Mangalore and Goa), adopting a precautionary approach (Mohamed et al., 2018).

5.5.3. Jellyfish

According to the 'Sea-Around-Us' project, global catches (reconstructed) of jellyfishes have increased to touch nearly one million tonnes making jellyfish the largest zooplankton fishery on the planet (Brotz, 2016). India's jellyfish catches have been pegged at more than 100,000 tonnes particularly during the period 2002 to 2006 by the Sea-Around-Us project. The CMFRI's NMFDC database also indicates catches from 1980s onwards at much lower levels, particularly in the states of Gujarat, Karnataka, Kerala, Tamil Nadu and Andhra Pradesh, caught by diverse gears.

While jellyfish are often perceived as a nuisance by fishers, they can also be a valuable commodity and are savoured as a delicacy in many places in the world. Their increased abundances maybe due to ecosystem and climate change, and there are many small-scale processors in India who export salted and dried jellyfishes to Southeast Asian countries, Korea, Japan and China. Reports indicate several species of non-venomous and edible jellyfishes in Indian seas, of which *Crambionella stuhlmanni*, *C. annandalei*, *C. orsini*, *Catostylus perezi*, *Rhopilema hispidum*, *Lychnorhiza malayensis*, *Lobonema smithi* and *Rhizostoma pulmo* are the major species being exploited. Jellyfish swarms are common during May-August in Bay of Bengal and July-September in the Arabian Sea with high inter annual variability. Considering the above facts, it is reasonable to consider the potential in tapping jellyfishes from Indian seas would be around 2,00,000 t. As there is dearth of knowledge on population dynamics of jelly fish, using a precautionary approach in fishery management is inevitable.

5.5.4. Marine macro algae

Potential yield or the MSY of marine macro algae or seaweeds exploited for the commercial production of polysaccharides also known as phycocolloids such as agar, align and carrageenan from Tamil Nadu coast was estimated from the datasets available from 1980 to 2003 and 2013-2017. The MSY of these exploited seaweeds was 17,775 t.

Important species include: red seaweeds such as *Gelidiella acerosa*, *Gracilaria edulis* and *Gracilaria crassa* for agar production and brown seaweeds *Sargassum* spp. and *Turbinaria* spp for align production. The ideal season for exploitation are February-September for *Gelidiella acerosa* and September-December as well as February-March for *Gracilaria* spp. With regards to align yielding seaweeds, September-May is the season of abundance for *Sargassum* spp. and January-July for *Turbinaria* spp. Around 5000 fisherfolk (both men and women) in the Gulf of Mannar and Palk Bay region, especially in the Ramanathapuram district of Tamil Nadu, depend on collection of seaweed (*Gelidiella acerosa*, *Gracilaria edulis*, *Sargassum* spp. and *Turbinaria* spp.) for their livelihoods. Among the seaweed collectors majority are women. For carrageenan production, red seaweed *Kappaphycus alvarezii* is being cultivated in the Palk Bay region and the production details are shown in the fig.A-1.

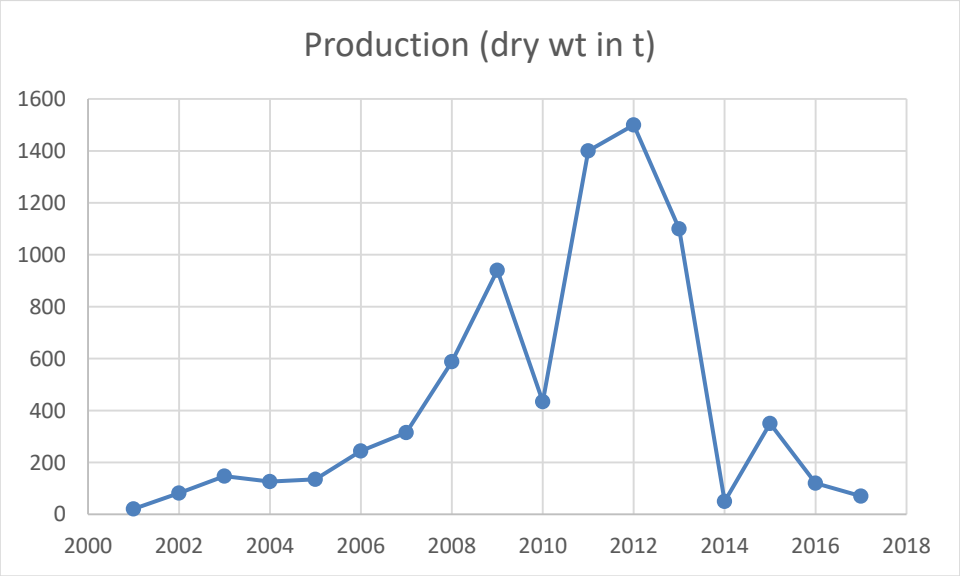

Fig. A.1. The trend of production of red seaweed *Kappaphycus alvarezii* in Palk Bay, Tamil Nadu

6. Conclusion

The exercise done by the CMFRI sub-group is very extensive as it covered the mainland as well as the island territories. In addition, the Sub-Group also provided a comprehensive picture of other resources such as oceanic squid, jellyfish, myctophids, seaweeds etc. This information would provoke planners to think about exploitation strategies to tap these underutilized resources.

Table-A-1. The state-wise estimated potential of different resources up to 200 m depth contour along the Indian mainland

Resource	AP	GDD	GO	KA	KL	MH	OD	PU	TN	WB	Total
Sharks	4929	12861	81	1293	4207	12604	2226	115	6728	2784	47828
Skates/Guitarfish	197	1914	10	118	330	96	0	11	527	225	3428
Rays	7103	1908	40	608	1509	1058	1705	2039	13642	1766	31378
Eels	1798	5806	4	982	842	1591	1717	26	678	861	14305
Catfishes	6154	38794	2947	1068	353	15532	12653	1321	4103	15466	98391
Wolf herring	786	6948	5	1041	379	1637	954	72	3443	10532	25797
Oil sardine	12796	1783	79009	115384	224008	19941	957	7992	155082	176	617128
Other sardines	31742	1045	13564	11520	28975	2903	15648	8565	109573	4794	228329
Hilsa shad	5	1125	0	0	0	451	2264	0	612	51101	55558
Other shads	7083	1171	25	323	166	1231	477	2	6802	0	17280
Coilia	510	19798	0	13	115	14492	3115	0	1352	13102	52497
Setipinna	0	0	0	0	21	0	6328	2	264	6879	13494
Stolephorus	7072	232	109	8303	36581	115	5441	960	11153	3262	73228
Thryssa	4289	9750	1875	9150	4289	1662	3045	1129	11125	7720	54034
Other clupeids	7072	7071	2430	7072	11153	6382	18078	2463	17289	16952	95962
Bombay duck	2365	89637	0	0	0	36256	4967	0	0	34604	167829
Lizard fishes	5564	19212	1490	33143	11153	2042	3872	989	9722	261	87448
Half beaks & full beaks	299	819	141	1830	1711	424	139	8	2422	261	8054
Flying fishes	314	84	0	14	41	0	0	423	1923	0	2799
Rock cods	609	9094	572	12631	7833	4183	266	396	2903	67	38554
Snappers	629	1341	0	195	3618	418	541	168	5785	16	12711
Pig-face breams	2	1116	0	21	783	4	0	242	17392	0	19560
Threadfin breams	3617	39517	1901	59122	44058	17945	603	1668	11161	1383	180975
Other perches	7072	25668	2739	20961	12730	1093	4103	1427	25737	3234	104764
Goatfishes	4289	4976	0	72	957	596	8356	1014	12730	734	33724

Resource	AP	GDD	GO	KA	KL	MH	OD	PU	TN	WB	Total
Threadfins	957	6631	4	0	43	1572	299	116	839	1862	12323
Croakers	11153	79521	1758	4289	13356	34585	45885	1723	15608	24827	232705
Ribbon fishes	26978	125412	4336	29015	37022	19077	28575	1018	14310	10981	296724
Horse Mackerel	6491	7764	3385	6768	6927	8645	4289	503	1778	5896	52446
Scads	6632	6961	3050	32622	56437	1401	1093	807	22405	235	131643
Leather-jackets	737	6802	421	2319	602	1690	3040	80	2732	3111	21534
Other carangids	7072	12480	19828	7072	23588	8246	7890	2417	26409	933	115935
Silver bellies	4289	149	415	6436	7340	715	5763	8256	94061	14009	141433
Big-jawed jumper	200	622	326	3863	2193	1090	105	0	142	0	8541
Black pomfret	9115	2627	980	2550	2824	2303	2264	160	1747	656	25226
Silver pomfret	5847	11561	393	917	2339	7524	4630	268	4085	13545	51109
Indian mackerel	41375	5743	26283	79044	82089	36894	12736	1007	21210	10668	317049
Other mackerels	38	0	0	0	0	65	275	6	134	8	526
S. commerson	4786	8107	456	7721	10674	7126	2789	1126	24938	237	67960
S. guttatus	4089	6533	108	921	411	6461	1509	36	963	8203	29234
S. lineolatus	0	0	0	0	1	0	26	0	0	0	27
Acanthocybium sp.	0	1	0	1	515	22	0	6	67	0	612
E. affinis	9248	3809	4728	5989	12730	3600	1108	538	9765	51	51566
Auxis spp.	741	11625	3668	1422	7721	4657	1	683	7072	60	37650
K. pelamis	4100	1245	0	47	1256	1	27	64	3616	0	10356
T. tonggol	0	0	0	0	0	0	0	0	0	6	6
Other tunnies	2387	0	9	0	0	0	12	0	0	0	2408
Billfishes	1602	1188	0	264	13762	372	30	61	4240	50	21569
Barracudas	2079	6845	250	7856	6874	1023	248	1804	17822	131	44932
Mullets	181	2334	12	703	230	309	464	59	3490	1135	8917
Unicorn cod	0	13	0	0	0	270	0	0	0	0	283
Halibut	550	1528	0	306	15	138	1	39	275	29	2881
Flounders	79	0	0	0	17	0	0	0	5	0	101

Resource	AP	GDD	GO	KA	KL	MH	OD	PU	TN	WB	Total
Soles	2255	11070	1390	14955	26450	4041	6660	208	1364	8038	76431
Penaeid prawns	28106	43303	5347	19825	30296	39900	49328	3509	31492	36187	287293
Non-penaeid prawns	5329	79521	0	0	4289	78285	8301	0	4554	16727	197006
Lobsters	52	1172	0	8	170	506	43	89	808	169	3017
Crabs	7072	23660	630	3980	7230	1352	3734	957	20347	2193	71155
Stomatopods	268	3551	643	14845	2801	3307	136	8	60	1	25620
Bivalves	0	0	2784	24075	125318	6495	0	0	2327	0	160999
Gastropods	0	0	0	0	2590	1	0	17	1215	0	3823
Squids	975	40690	928	16949	19047	21123	516	1174	15256	288	116947
Cuttle fishes	2035	46606	851	11672	18603	8206	1448	2308	14373	2826	108928
Octopus	0	637	0	1301	4651	303	0	460	3325	0	10677
Miscellaneous	2995	34481	221	12004	14058	3455	1888	763	18852	2652	91369
Total	**316109**	**895862**	**190146**	**604603**	**940282**	**457416**	**292568**	**61302**	**823834**	**341894**	**4924016**

AP – Andhra Pradesh; GDD – Gujarat and Daman & Diu; GO – Goa; KA – Karnataka; KL – Kerala; MH – Maharashtra; OD – Odisha; PU – Puducherry; TN – Tamil Nadu; WB – West Bengal

Table-A-2. The state-wise breakup of potential yield with respect to pelagic and demersal resources up to 200 m depth zone.

Resource	AP	GDD	GO	KA	KL	MH	OD	PU	TN	WB	Total
Demersal	120245	515056	26233	256185	357946	268608	165155	28708	322991	148154	**2209281**
Pelagic	192869	346325	163692	336414	568278	185353	125525	31831	481991	191088	**2623366**
Mixed	2995	34481	221	12004	14058	3455	1888	763	18852	2652	**91369**
Total	**316109**	**895862**	**190146**	**604603**	**940282**	**457416**	**292568**	**61302**	**823834**	**341894**	**4924016**

Table-A.3. The estimated potential of different resources for the EEZ of Andaman and Nicobar Islands

No.	Species	CMSY
1	Anchovies	3730
2	Barracuda	664
3	Bigeye tuna	6
4	Billfishes	1480
5	Catfish	185
6	Croakers	961
7	Flatfish	18
8	Goatfishes	16
9	Hilsa shad	367
10	Lizardfish	12
11	Mackerel	2660
12	Mullet	997
13	Pelagic sharks	1900
14	Pomfrets	455
15	Ribbonfish	190
16	Round scads	214
17	Sardines	4780
18	Seerfish	1000
19	Silver grunt	23
20	Silverbellies	3910
21	Skipjack tuna	81
22	Threadfin breams	275
23	Threadfins	38
24	Wolf herring	91
25	Yellowfin tuna	95
26	Cephalopods	43
27	Crabs	899
28	Deepsea lobster	40
29	Elasmobranchs	2790
30	Gerrids	208
31	Halfbeaks & fullbeaks	231
32	Neritic Tunas	2500
33	Oceanic squids	32
34	Other carangids	2850
35	Penaeid shrimps	874
36	Perches	8650
37	Barracuda oceanic	46
38	Other demersal	3670
39	Other pelagic	421
40	Others oceanic	60
	Total	**47463**

Table-A-4. The estimated potential of different resources for the Lakshadweep waters

No.	Species	Catch	CMSY	BMSY
1	Skipjack tuna	9979	26100	43800
2	Yellowfin tuna	2759	9100	15300
3	Kawakawa	417	3220	11400
4	*Auxis* spp.	529	872	3090
	Total	**13684**	**39292**	**73590**

Support Document - B

Demersal Fishery Potential in 200-500 m depth zone of the Indian EEZ

FSI Sub-Group

1. Introduction

Fishery Survey of India (FSI) carries out demersal trawl surveys in the EEZ round the year using different types of trawl gear. The surveys were conducted using standard gear by adopting stratified random sampling with reference to depth and area.

The *Expert Committee for Revalidation of Potential Fishery Resources in the Indian EEZ,* in its first meeting came to an understanding that the current fishery exploitation by commercial vessels extended upto 200 m depth contour. This is well reflected in the landing data collected by the Fishery Resources Assessment Division (FRAD) of Central Marine Fisheries Research Institute (CMFRI). Therefore, it was decided that FSI analyse the trawl data from the depth strata 200-500m for four regions of Indian EEZ namely, northwest, southwest, northeast and southeast (Figure 2).

2. Database

Though the previous committee has used data from 1997 to 2008, the current exercise has taken data from January 2002 to December 2016 to ensure representative coverage of EEZ. FSI deployed ten survey vessels for demersal resources surveys during the period and operated around 16647 hauls in the depth range 200-500 m. About 7% of total operated hauls (1200 hauls) available in the depth range 200-500 m were used for the present analysis. The data segregated and processed for the depth zone 200-500 m for the four regions separately. The regions followed are:

North-west Coast: Latitude 15°– 23° N

South-west Coast: Latitude 07°– 15° N

South-east Coast: Latitude 10°– 15° N

North-east Coast: Latitude 15°– 22°N

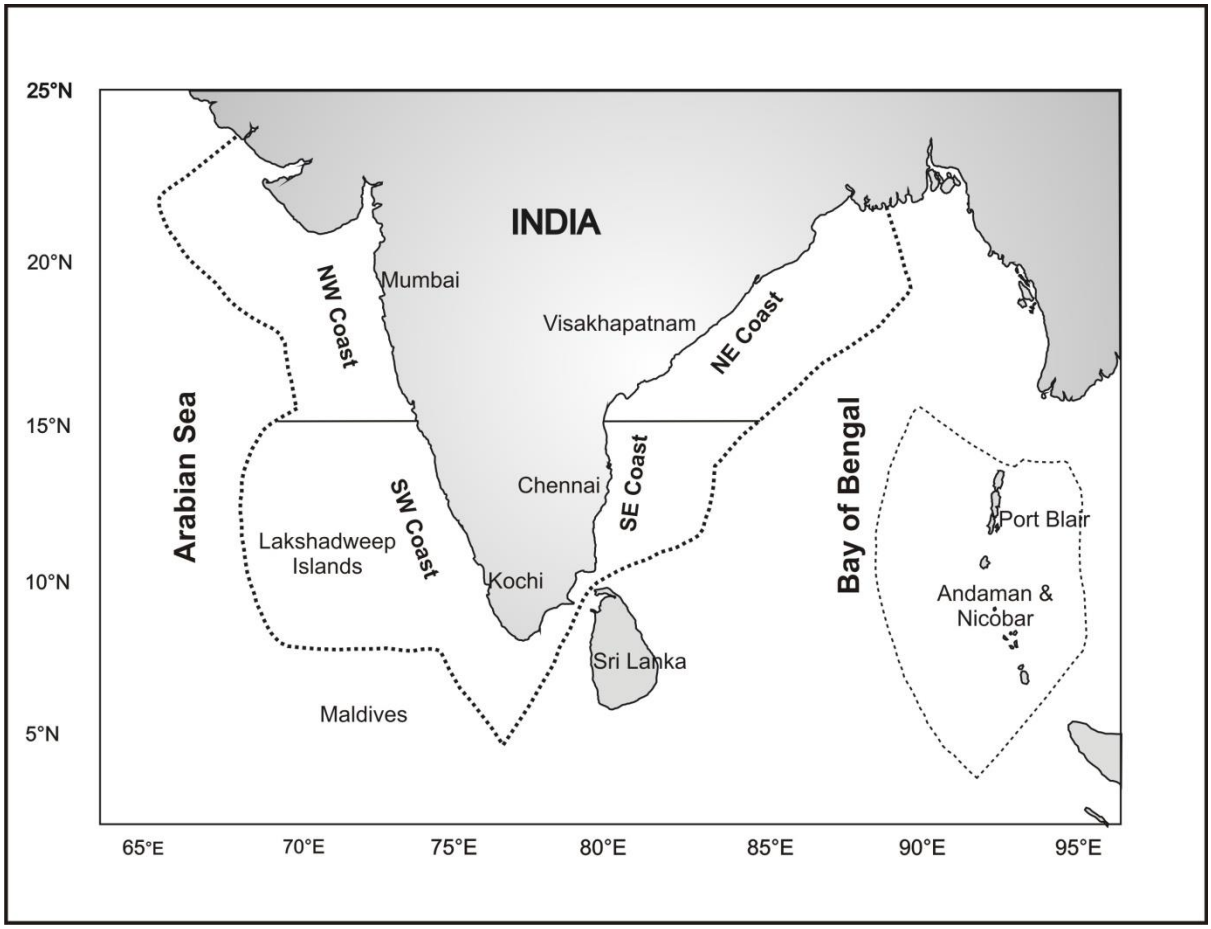

Fig. B1. Map of Indian EEZ showing different regions considered for estimation of potential yield

3. Method

The fishing hauls made using fish trawl, shrimp trawland cephalopod trawl were grouped together for respective region /depth stratum and processed for species-wise CPUE. The *swept area method* as detailed below was used in estimation of biomass (B) of the resources.

$$\boldsymbol{B = \left\{\frac{CPUE}{(a \times X_1)}\right\} \times A}$$

Where, $\boldsymbol{A}$ is the area of given depth / region in square km,

$\boldsymbol{a}$ is swept area, and

$\boldsymbol{X_1}$is the proportion of the fish caught in the net which is assumed as 0.50

Swept area **a** is calculated using the following equation:

$$\boldsymbol{a = t \times v \times h \times X_2}$$

Where, $\boldsymbol{t}$ is the duration of trawling (h)

$\boldsymbol{v}$ is trawling speed (km per h)

$\boldsymbol{h}$ is the length (m) of the head rope (for multiple gears operated in the given depth region the same is arrived by combined mean of head rope lengths)

$\boldsymbol{X_2}$ is the ratio representing the effective opening of the head rope length, assumed as 40%

Note: The trawling speed was worked out using actual distance from shooting and hauling positions and the haul duration. The average trawl speed was 2 knot for 200-500 m depth.

On arriving at the biomass (B), Maximum sustainable yield (MSY) is calculated by using the following formula:

$$\boldsymbol{MSY = 0.5 \times M \times B}$$ (for virgin stock)

Where, M is the natural mortality rate of the species and

B is biomass of the species

Note: Natural mortality (M) is adapted from published literature wherever available; otherwise M is taken as 1.

4. Results

The density of fish and MSY estimated for 200-500m depth zone for four regions are depicted in Table B2

The total maximum sustainable yield for 200-500m depth zone, combining all the four regions was estimated at 97461t. South-west region is having 59.77% of the potential in 200-500m depth because of vast area with good stock density. Bull's eye (Family Priacanthidae) is the prominent resource with 16,991t followed by black ruff (12,182t) and decapterids (10,599t). Resources like snake mackerels, green eyes and deepsea shrimps are some of the other prominent resources that occurred in the 200-500m depth.

Table-B-1. The details of survey (number of hauls, effort and area) in different regions in the depth 200-500 m depth zone by FSI vessels

Region	**North-west**	**South-west**	**South-east**	**North-east**	**Total**
Lat range °N	**15°– 23° N**	**7°– 15° N**	**10°– 15° N**	**15°– 22° N**	
Area (km^2)	7690	11795	1765	3875	25125
Hauls	29	399	610	162	1200
Effort (h)	27	539	884	238	1688

Table-B-2. Stock density (t per sq km) and MSY (t) for depth zone 200-500m

Region	North-west	South-west	South-east	North-east	Total
Latitude	15°-23°	7°-15°	10°-15°	15°-22°	
Density (t per sq km)	3.38	5.5	3.38	2.52	
MSY (t)	25366	58249	5672	8174	97461

Table-B-3. The MSY (t) estimated for different demersal resources in 200-500m depth zone

Sl. No	Resource	NW (15-23)	SW (7-15)	SE (10-15)	NE (15-22)	Total
1	Trigger fishes		118			118
2	Cat fishes	185		1		186
3	Black ruff		9396	1958	828	12182
4	Crabs		4596	636	490	5722
5	Cuttlefish	112	8			120
6	Decapterids	10459	7	133		10599
7	Deep sea lobster		137	9		146
8	Deep sea shrimp	196	6075	488	1687	8445
9	Deep sea shark		784	83	4	872
10	Sciaenids	46		6	13	65
11	Eel		97	3	3	104
12	Cobia	7				7
13	Snake mackerel		8108	20	36	8164
14	Flat fishes		6	18	21	45
15	Green eyes		6504	529	4	7037
16	Jellyfish		74	21	17	112
17	Groupers	86	13			98
18	Lantern fishes		726			726
19	Pony fishes	39		1		40
20	Lesser sardines			2		2
21	Lizardfishes	450	218	7	3	678
22	Lobsters		1			1
23	Molluscan shells			7	44	51
24	Moonfish		3	0		3
25	Threadfin breams	464	3	3	6	476
26	Octopus		257	9		265
27	Other deepsea fishes	77	7198	493	1598	9366
28	Other perches		1360			1360
29	Other scombroids		36	1		37
30	Other demersal fishes	77	251	2	5	335
31	Monocle bream	85				85

32	Shrimps		727	1		728
33	Bulls eye (Priacanthids)	11953	629	1148	3261	16991
34	Indian driftfish		404	1		404
35	Rat tail		57			57
36	Rays		295	1		296
37	Shark	43	373	2		418
38	Skate		3			3
39	Squids	562	1981	6	11	2559
40	Cusk eels			3	13	17
41	Goat fishes (Upeneids)	80				80
42	Emperor fish			1		1
	Demersals total	24921	50444	5592	8043	89000
	Pelagic resources					
1	Anchovies	54				54
2	Barracuda	45	29	2	2	78
3	*Caranx* sp.			2		2
4	Mackerel	277		3		280
5	Misc. fishes	69	3200	65	129	3463
6	Ribbon fishes		4577	7		4584
7	Wolf herrings			1		1
	Pelagics total	445	7805	80	131	8461
	Grand total	25366	58249	5672	8174	97461

Support Document-C

Assessment of oceanic tunas and allied resources in the Indian EEZ

P. Chalapati Rao and Deepak K Gulati (with inputs from various sources)

1. Introduction

While making assessment for oceanic tunas and allied resources for Indian EEZ the methodology /assumptions proposed by Dr M E John in the earlier revalidation report is adopted. The four important oceanic tuna species occurring in the Indian EEZ are yellowfin tuna (*Thunnus albacares*), skipjack tuna (*Katsuwonus pelamis*) bigeye tuna (*Thunnus obesus*) and albacore tuna (*Thunnus alalunga*). Besides, billfishes and oceanic sharks are the other important large pelagics caught in our waters. The oceanic tunas are highly migratory, with their distribution covering the entire Indian Ocean except the southern latitudes. As the oceanic tunas exhibit large-scale migratory behaviour, estimation of Maximum Sustainable Yield of these stocks from the EEZ of any coastal nation may not be realistic compared to regional estimates. However, to enable policy formulation and development planning in the country, some approximation of a target yield from the Indian EEZ is necessary to be worked out with reference to the overall potential / production in the Indian Ocean.

The tuna fishery in the Indian Ocean is fully developed, with several coastal countries as well as distant water fishing nations participating in the fishery. The Scientific Committee of the Indian Ocean Tuna Commission (IOTC,2017(a)) in its recent session (November 2017) has stated about the stock status of the tropical tunas and billfishes as follows:

- Yellowfin tuna: The increase in effort from multiple gears and associated catches in recent years has substantially increased the pressure on the Indian Ocean stock. As no stock assessment was conducted in 2017, the stock status determination has not changed since 2016 .

- Skipjack tuna: It is a highly productive species. Catches have increased with increasing fishing pressure and it would be expected that the stock would fluctuate around the target level. The trend of some indicators suggests that the stock status should be closely monitored. Stock size and fishing pressure are considered to be within acceptable limits.

- Bigeye tuna: Declines in longline effort since 2007, have lowered the pressure on the Indian Ocean bigeye tuna stock, indicating that current fishing mortality would not reduce the population to an overfished state in the near future. Catches should not exceed the MSY level (104,000 t).

- Swordfish: The decrease in longline catch and effort from 2005 to 2011 lowered the pressure on the Indian Ocean stock as a whole, and despite the recent increase in total recorded catches, current fishing mortality is not expected to reduce the population to an overfished state over the next decade.However, the catches should not exceed MSY levels (31590 t).

- Sailfish: The estimated increase in coastal gillnet catch and effort in recent years is a cause of concern for Indo-Pacific sail fish. However as a whole,the stock is determined to be still not overfished but subject to overfishing and the catch should be maintained at MSY levels (25000 t)

- Marlins: All marlins are subject to over fishing or over fished. They are exploited beyond MSY levels. The maximum catch should be lower than MSY.

2. Database

Data from the following three sources are used in the estimation process.

a) Nominal catch of oceanic tunas and allied species from the Indian Ocean during the last 10 years (2007-2016) obtained from the IOTC database and the latest assessment of MSY by the Scientific Committee of the IOTC (Table-C1).

b) Satellite derived data on primary production from the Indian EEZ and the Indian Ocean during the period 2013 - 2014 obtained from the Centre For Marine Living Resources & Ecology (CMLRE), Kochi (Table-C2).

c) CPUE obtained in tuna longline survey conducted by FSI vessels in the Indian EEZ including Andaman & Nicobar waters during 2007 – 2016 (Table-C3). The survey deployed altogether 2 million hooks in both multifilament as well as monofilament longline. The geo locations of tuna stations are depicted in the figure C-1

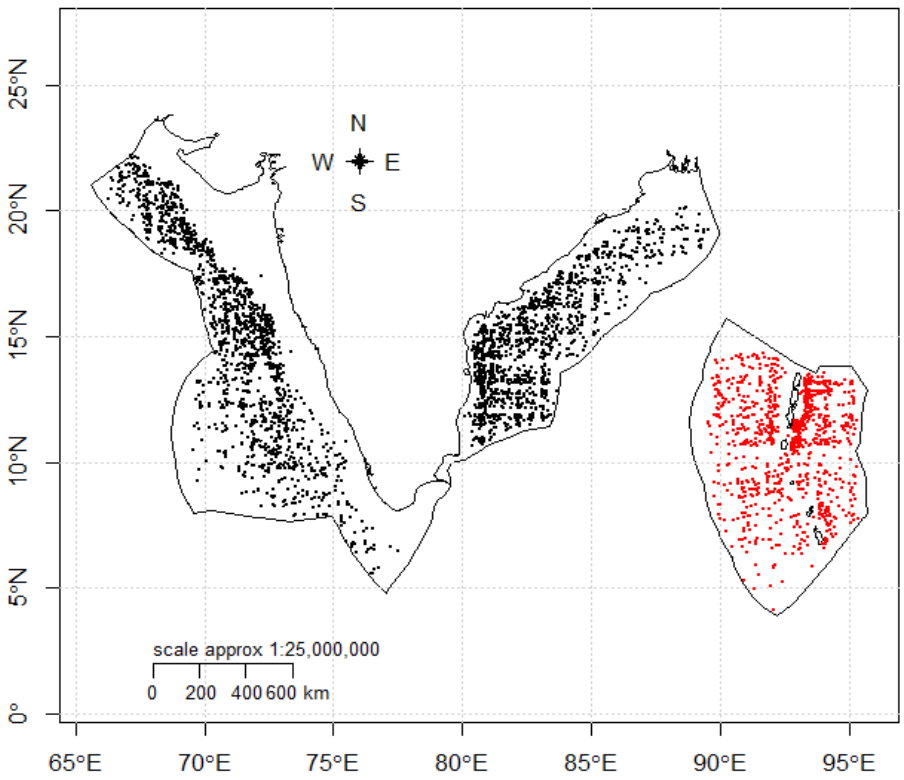

Figure C1 : Longline survey stations operated by FSI survey vessels in the Indian EEZ

3. Methodology and assumptions

1.On the basis of the production / MSY from the Indian Ocean, an estimate of Management Yield (MY), defined as a reference point at which restrictive management function may have to be put in place in the Indian Ocean, is assumed as follows.

- Yellowfin tuna: The MSY of 422,000 t assessed by the IOTC for its area of competence in the year 2016 is based on two models such as Biomass Dynamic Model (BDM) and Stock Synthesis III (SS3) model, which gave qualitatively similar results.As no stock assessment was conducted in 2017, the stock status determination has not changed since 2016, and gives a somewhat more optimistic estimate of stock status than the 2015 assessment as a result of the use of more reliable information on catch rates of longline fisheries and catches updated to 2016. Hence the same figure is taken as management yield.

- Bigeye tuna: No new stock assessment was carried out for bigeye tuna in 2017, thus, stock status is determined on the basis of the 2016 assessment and other indicators presented in 2017.The MSY estimate of 104,000 t by the IOTC in the year 2016 was carried out with six analytical models, namely Age Structured Assessment Program (ASAP), Biomass Dynamic Model (BDM), A Stock-Production Model Incorporating Covariates (ASPIC), Statistical catch-at-age (SCAA), Age structured production model (ASPM) and Stock Synthesis III (SS3)which gave more or less consistent values. Hence the same figure is taken as the management yield**.**

- Skipjack tuna: Considering the shorter life span, 5-year average seems to be reasonable.
  As the stock is highly productive and the fishing pressure is assumed to be within acceptable limits, the precautionary reduction may not be necessary. Hence 4,08,000t is considered as the management yield.

- Sword fish: The MSY estimate of 31590t was based on a new assessment undertaken in 2017 using stock synthesis with fisheries data up to 2015. Hence 31,590t is considered as management yield.

- Sailfish: MSY estimate 25,000t considered as Management yield.

- Marlins: Five years average of 36,000t of blue marlin, black marlin and striped marlin is taken as the management yield.

2) From the management yield suggested for the Indian Ocean, the target yield from the EEZ is apportioned taking into account of three factors, *viz*., primary production (Table-C2), extent of distributional area of the stock and CPUE obtained in longline fishing (Table-C3), using the following expression,

$$\boldsymbol{TY_{eez} = MY_{io} \times \frac{P_{eez}}{P_{io}} \times \frac{A_{eez}}{A_{io}} \times \frac{CPUE_{eez}}{CPUE_{io}}}$$

where,

$\boldsymbol{TY_{eez}}$ is target yield for Indian EEZ
$\boldsymbol{MY_{io}}$ is management yield considered for Indian Ocean
$\boldsymbol{P_{eez}}$ is primary production per unit area in Indian EEZ

P_{io} is primary production per unit area in Indian Ocean

A_{eez} is extent of the area of Indian EEZ

A_{eez} is extent of the area of distribution of the stock in the Indian Ocean

$CPUE_{eez}$ is catch per unit effort (Hooking rate = No. of fish / 100 hooks) obtained in longline fishing from the Indian EEZ and

$CPUE_{io}$ is catch per unit effort (Hooking rate = No. of fish / 100 hooks) obtained in longline fishing from the Indian Ocean.

3) The distribution of yellowfin tuna and skipjack in the Indian Ocean is mainly north of 20°S whereas bigeye tuna and billfishes occur in areas north of lat. 30°S. While the former two species are available throughout the EEZ, the occurrence of bigeye tuna is mostly in south of lat. 10° N (Sudarsan *et al*., 1988).

4) The hooking rate of yellowfin tuna obtained in longline survey in the EEZ is 0.52% (Table-C3).

5) The average hooking rate of yellowfin tuna by the Taiwanese longline fleet in the Indian Ocean hovers around 0.5% for the last two decades (IOTC, 2009). The hooking rate by the Indonesian longline vessels is also about 0.5% (Uktolseja, 1998).

6) As the commercial fishery always tends to concentrate in areas and seasons of high CPUE, in contrast to the survey objective involving systematic coverage of areas / seasons, the CPUE from the commercial fishery can be expected to be 2-3 times the CPUE obtained in the survey. The CPUE realized by 9 converted vessels (20-24 m OAL) during 2005-2007 was more than 2%.

7) In the Indian Ocean the proportion of yellowfin tuna occurring in longline and other gears targeting the surface swimming component is 23:77 (last 10 years). The same proportion is considered to be valid for the Indian EEZ. (IOTC, 2017b)

8) The relative proportion of yellowfin and skipjack in the Indian Ocean is 1:1.19 (last 10 years). The same ratio is considered to be valid for the EEZ.

9) The ratio in the catch rate of yellowfin tuna and bigeye tuna recorded in the survey was 1:0.005. While bigeye tuna inhabits the deeper layers of thermocline, the gear used in the survey was targeting yellowfin tuna occurring in the shallower layers of thermocline. It is assumed that by deploying deep longline and by concentrating effort in areas south of lat. 10°N, the catch rate of bigeye tuna can be increased 2-3 times.

10) The ratio of the catch rate of yellowfin tuna and sharks recorded in the survey was 1:0.51, based on which the target yield of pelagic sharks was estimated. Nevertheless, considering the sharp decline reported in the CPUE of sharks in longline surveys (John and Varghese, 2009) and further considering the biological characteristics, namely, low natural mortality, long lifespan and low fecundity of sharks and in view of the FAO's International Plan of Action for Conservation and Management of Shark Fisheries (IPOA – Sharks), as a precautionary approach, only 60% of the estimate is considered as the target yield.

11) The relative proportion of catch of yellowfin tuna and billfishes in the Indian Ocean is 1:0.22 (last 10 years). The same ratio is considered to be valid for the EEZ. (IOTC, 2017c)

12)Though there was not much catch reported for Albacore in survey vessels, an average annual catch of 28 tonnes reported by LOP vessels during last ten years. However, Albacore inhibits still deeper layers of thermocline to big eye tuna and concentrating in areas south of lat. 10^{o}N, the target yield of albacore could be assumed as 4 times of the average annual catch reported.

4. Target yield estimates

The target yield of the tunas and other larger pelagics from the Indian EEZ estimated on the basis of the above methodology is 230720t (Table-C-4).

In the case of yellowfin tuna, out of the projected yield of 83,500 t, the sub-surface component that can be targeted by longlining is estimated to be 19,200 t. Planners may make note of this figure while suggesting further fleet development.

5. Comparison with earlier estimates

A comparison of the output of various earlier exercises with current one would be interesting as given in Table-C-5. As regards bigeye tuna, the assumption in the earlier revalidation (2000) that the proportion of catch of the species in the Indian Ocean is valid for the Indian EEZ is erroneous as the main area of occurrence of the stock is south of lat.5^{o}N.

Table-C-1. Nominal catch and MSY of oceanic tunas and allied species in the Indian Ocean; values are in thousand tones (source: IOTC)

Species	Highest Catch	10-yr average (2007-16)	5-yr average (2012-16)	Highest moving average (5-year)	Latest year (2016)	MSY (IOTC, 2017)
Bigeye tuna	138 (2007)	106	101	112 (2007-11)	87	104
Yellowfin tuna	422 (2016)	358	407	407 (2012-16)	412	422
Skipjack tuna	466 (2007)	419	408	430 (2007-11)	446	564
Swordfish	40 (2016)	30	35	35 (2012-16)	17	32
Black marlin	19 (2015)	14	16	16 (2012-16)	17	10
Blue marlin	17 (2012)	12	15	15 (2012-16)	16	12
Striped marlin	6 (2012)	4	5	5 (2012-16)	5	NA
Sail fish	29 (2013)	26	28	28 (2012-16)	28	25

(Source: IOTC)

Table-C-2. Estimated Primary Production in the Indian EEZ and Indian Ocean (Source: CMLRE)

Region / latitude	**Area (10^6km^2)**	**Total PP (10^6t.C/yr)**	**PP (t C/yr/km^2)**
Indian EEZ	2.02	229.7	113.7129
Indian Ocean (20^{o}S-24^{o}N)	23.21	2317.41	99.8453
Indian Ocean (30^{o}S-24^{o}N)	32.82	3199.016	97.4715

Table-C-3. Hooking rate recorded in longline survey by FSI fleet (2007-2016)

Species	Hooking rate (No./ 100 hooks)	Catch rate (Kg/ 100 hooks)
Overall	2.03	32.59
Yellowfin tuna	0.52	14.30
Bigeye tuna	0.002	0.07
Skipjack tuna	0.09	0.36
Swordfish	0.41	5.54
Sailfish	0.11	3.01
Marlin	0.05	1.70
Shark	0.8	7.33
Others*	0.05	0.34

*Includes barracuda, dolphinfish, wahoo, pelagic rays etc.

Table-C-4. Target yield of oceanic tunas and allied species from the Indian EEZ

Sl. No.	Species	Target yield (t)
1	Yellowfin tuna	83,500
2	Skipjack tuna	99,500
3	Bigeye tuna	420
4	Albacore	112
5	Swordfish	6,500
6	Sailfish	5,200
7	Marlins	6,600
8	Pelagic sharks	25,000
9	Other species*	4,000
	TOTAL	**2,30,832**

*Includes barracuda, dolphinfish, wahoo, pelagic rays etc.

Table-C-5. Comparison of the Potential yield estimates made in earlier assessments

Sl. No	Species	Revalidation 1991	Revalidation 2000	Revalidation 2011	Revalidation 2018
1	Yellowfin tuna	1,08,900	1,14,800	80,000	83,500
2	Skipjack tuna	1,00,200	85,200	99,000	99,500
3	Bigeye tuna	300	12,500	500	420
4	Albacore	-	-	-	112
5	Billfishes	3,800	5,100	14,400	18,300
6	Pelagic sharks	31,600	26,200	20,800	25,000
7	Other species	1,200	-	1,800	4,000
	TOTAL	**2,46,000**	**2,43,800**	**2,16,500**	**2,30,832**

Support Document-D

Ecosystem based assessment of Potential Fish Yield from Indian EEZ
A trophodynamic approach

Sanjeevan V N[1], Smitha B R[2], Sunil Mohamed[3], Saravanae N[2]& Sudhakar,M[2].

[1.] Kerala University of Fisheries and Ocean Studies, Kochi ; [2.] Centre for Marine Living Resources & Ecology, Kochi ; [3.] Central Marine Fisheries Research Institute, Kochi.

1. Introduction

Fish occupying diverse trophic levels in an ecosystem, depend directly (herbivory) or indirectly (omnivory, carnivory, scavengivory etc.) on primary production (PP) to meet their energy needs for growth and metabolism. At each trophic level, there is considerable loss of energy proportional to the consumption efficiency (CE), production efficiency (PE) and assimilation efficiency (AE) of organisms. Though, energy flow between successive trophic levels of an ecosystem (transfer efficiency; TE) is generalized to be approximately 10% (Ryther, 1969) recent studies have documented that the TEs vary with ecosystems and seasons (Pauly & Christansen, 1995). In the trophodynamical approach TEs estimated for different seasons and ecosystems are used to quantify possible fish biomass that can be supported at different trophic levels of an ecosystem.

Six discrete ecosystems have been delineated within the Indian EEZ, each of which has distinct physical, chemical and biological attributes (Sanjeevan *et al*., 2009). These are the North-eastern Arabian Sea (NEAS) extending from 23.5^0N to 15^0 N, the South-eastern Arabian Sea (SEAS) from 15^0N to 5^0N, the Lakshadweep Sea (LS), the South-west Bay of Bengal (SWBoB) from 5^0N to 15^0N, the North-west Bay of Bengal (NWBoB) from 15^0N to 22^0N latitudes and the Andaman Sea (AS). In the present study the two island ecosystems (LS & AS) are not considered. Each ecosystem was divided into shelf/coastal area (shore to 200 m isobath) and slope/offshore area (from 200 m isobath to the boundary of the EEZ). Coastal waters for ecosystems with narrow shelf (SWBoB & NWBoB) are considered as 1.25 times the area of the coast for NWBoB and 1.5 times the area for SWBoB. Primary, secondary and benthic productions are estimated separately for Summer Monsoon (SM) season extending from June to September, Fall Inter-Monsoon (FIM) in October, Winter Monsoon (WM) from November to February and spring Inter-Monsoon (SIM) from March to May.

2. Methodology

Production patterns in the four marine ecosystems of peninsular India are estimated separately for coastal and offshore waters, covering all the seasons of the years 2012 to 2017. Vertically Generated Production Model (VGPM) of Beherenfield and Falkowski (1997) was used to describe the relationship between the surface chlorophyll from satellite data and depth integrated PP. Depth integrated monthly composite chlorophyll-a data were generated on 9 X 9 km^2 resolution using ocean colour data (Chl-a) from SeaWiFS and MODIS AQUA. The derived values were validated using *in-situ* Chl-a data from *FORV Sagar Sampada* for SM, FIM, WM & SIM seasons. For an ecosystem, the sum of seasonal PP is taken as the annual PP.

For estimation of secondary production, the zooplankton data of *FORV Sagar Sampada* (2012 to 2017) were utilized. Biovolume (Bv) of zooplankton is estimated as Bv = DV/VWF where DV is the displacement volume in ml and VWF is the volume of water filtered. Bv for each season and ecosystem were converted to standing stock of zooplankton (SSz) by multiplying with the number of generations of zooplankton (τ/n) represented by 62% copepods. The generation time (τ) for copepods is estimated from the equation of Harris *et al*., 2000 ($\tau = 128.8\ n\ e^{-0.120T}$) where T is the sea surface temperature (SST) and n represent the number of days in a season. Estimated SSz is converted to carbon by multiplying the dry weight (1ml SSz = 0.075 g) with the factor 0.342 (Madhupratap *et al*., 1990).

Benthic production was estimated from the cumulative average biomass values of macrobenthos and meiobenthos obtained from *FORV Sagar Sampda* data centre. Macrobenthic biomass for each ecosystem covering the major seasons was estimated by integrating the average production from the depth strata's 0 to 50 m; 50 to 100 m; 100 to 200 m and 200 to 500 m taking two generations per year, as suggested by Robertson (1979). These biomass values were converted to organic carbon using the conversion factor of Parulekar *et al*. (1980) where dry weight is 22% of wet weight and carbon content is 34.5% of dry weight. Biomass of meiobenthic fauna from the depth strata's mentioned above was integrated to estimate the total biomass per season for each of the ecosystems. From this, total standing stock was estimated by multiplying with 18.25, the average of the number of generations of nematodes (16.9 days) as given by Zaika *etal*(1979), foraminifera (20 days) as given by Mikael & Kjell (1999), and harpacticoid copepods (21.6 days) as given by Ugo & Mistri (1991). Standing stock was then converted to gram carbon following Gerlach (1978), where dry weight is 25% of wet weight and carbon content is 50% dry weight.

Detritus production in ecosystems was estimated from the average detritus flow of 2005.5 ton/ km^2/ y^{-1} estimated for Karnataka waters through an ECOPATH model (Mohamed et al., 2008) multiplied by the total area of the ecosystem. The ratio derived from PP to detritus was used as a proxy to an approximate detritus load in ecosystems. Extensive blooms of microalgae dominated by *Noctiluca scintillans* are prevalent in the coastal and offshore waters of NEAS during the WM and early SIM seasons which ultimately sink to the bottom increasing the load of particulate organic matter in this system. Therefore the detritus load of NEAS is considered 50% higher than other ecosystems. Detritus load was converted to carbon terms by dividing the wet weight by 10.

Secondary production of herbivores was estimated directly from the PP applying the TEs between PP and SP ranging from 3.78 to 23.98 and applying a factor of 0.1 to the SP to derive fish biomass. For omniplanktivorus fish, consumption of phytoplankton and zooplankton was considered in equal proportions and accordingly 50% of biomass was derived using the TEs for PP to SP and the rest 50% using the TE of 10%. For pelagic carnivores 10% of the SP was considered as the TE. Pelagic omnivores were considered to undertake carnivory and detritivory in equal proportions and therefore TEs of 10% SP and 10% detritus were applied to derive their biomass. Mohamed *etal*(2008) had worked out the TE for detritivory to be 9.1. For benthic carnivores TE of 10% of Benthic Production (BP) is applied for the estimation of biomass. Benthic scavengers were considered to consume detritus and dead organisms in equal proportions. From the detritus in the water column 10% is expected to reach the sea bottom using which biomass is estimated at the TE of 10%. For miscellaneous fish TE of 10% SP is applied. Fish biomass in carbon terms is derived by multiplying the total biomass at each trophic level with a factor of 0.1 except for benthic carnivores (BC) where it is considered as the proportion of BC in the total benthic biomass. The estimated BC values were 0.123 for SEAS, 0.606 for NEAS, 0.239 for SWBoB and

0.846 for NWBoB. Biomass in carbon value is portioned amongst the stocks in an ecosystem using an Ecological Preference Index (EPI) derived from percentage abundance. Carbon values were multiplied by 10 to derive wet weight (biomass). From the biomass, Maximum Sustainable Yield (MSY) of fish is estimated using Gulland (1971) formula MSY = B x M x e where B is the fish biomass, M is the natural mortality coefficient (0.85 for coastal waters and 1 for offshore waters) and e is the escapement factor (0.5).

3. Results

Production potential for coastal and offshore areas of SEAS, NEAS, SWBoB & NWBoB with regard to primary production (PP), secondary production (SP), detritus production (DP) and benthic production (BP) are given in Table-1. TEs from PP to SP are also included in the table. Values except TE are in million tons carbon per year ($mtC.y^{-1}$).

Potential fishery yield at different trophic levels of SEAS, NEAS, SW BoB and NW BoB are given in Table-2. Fish yield is represented in lakh ton per year (LTY^{-1}). The sharp increase in biomass and MSY of oil-sardine in our estimates is attributed to the increase in phytoplankton production in recent years (2012 to 2017), the increase in PP carbon values being 20.6% for SEAS, 18.22% for SW BoB and 8.87% for NW BoB compared to the PP values for the years 2002 – 2009 (last revalidation report). However the PP of NEAS coastal waters has shown 24.08% dip in recent years as compared to the previous estimate.

4. Conclusion

The revalidated annual potential yield from the fishery resources of Indian EEZ except the two island ecosystems (Lakshadweep and Andaman & Nicobar) is 51.15 lakh ton or 5.2 million ton of which 23.397 LT is contributed by the SEAS, 13.660 LT by NEAS, 9.370 LT by SW BoB and 4.723 LT by NW BoB.

Table-D-1: Production potential ($mtC.y^{-1}$) and Transfer Efficiencies.

Ecosystem	Zones	PP	SP	TE	DP	BP
SEAS	Coastal	32.61	5.79	17.70	20.55	0.62
	Offshore	96.64	23.12	23.98	96.64	0.18
NEAS	Coastal	43.36	2.89	7.17	35.72	0.52
	Offshore	24.43	3.76	12.69	20.35	0.95
SW BoB	Coastal	7.83	0.31	3.78	5.45	0.08
	Offshore	32.32	1.97	5.00	36.04	0.32
NW BoB	Coastal	18.94	1.01	5.00	12.74	0.10
	Offshore	42.88	3.95	8.58	41.07	0.13.

PP: primary Production; SP: Secondary Production; TE: Transfer Efficiency; DP: Detritus production; BP: Benthic Production

Table-D-2: Trophodynamic estimations of MSY from ecosystems within Indian EEZ; values are in lakh t per year

No	Fish Group	Zone	SEAS	NEAS	SWBoB	NWBoB	Total
A.	**Phytoplanktivores**						
1.	Oil Sardine	Coastal	13.630	0.550	2.971	0.020	17.171
2.	Hilsa	Coastal	-	0.040	-	1.165	1.205
	Biomass		13.630	0.590	2.971	1.185	18.376
	MSY		**5.793**	**0.252**	**1.262**	**0.504**	**7.811**
B.	**Pelagic Planktivores**						
1	Indian mackerel	Coastal	3.290	0.267	0.780	0.534	4.871
2	Scads	Coastal	2.249	0.087	0.264	0.004	2.604
3	Anchovies	Coastal	1.194	0.274	0.241	0.613	2.322
4	Rays	Coastal	0.092	0.059	0.192	0.086	0.429
5	Other PP*[1]	Coastal	2.344	0.534	2.503	1.570	6.951
	Biomass		9.169	1.221	3.980	2.807	17.177
	MSY		**3.895**	**0.519**	**1.693**	**1.192**	**7.299**
C	**Pelagic carnivores**						
1	Sharks	coastal	0.237	0.356	0.051	0.054	0.698
		offshore	0.159	0.025	0.005	0.022	0.211
2	Eels	coastal	0.060	0.119	0.057	0.089	0.325
		offshore	0.007	0.009	0.010	0.037	0.063
3	Bombay duck	coastal	-	5.003	0.018	1.294	6.315
4	Lizard fish	coastal	1.841	0.540	0.320	0.010	2.711
		offshore	2.073	0.039	0.319	0.004	2.435
5	Perches[@]	coastal	7.058	2.731	1.686	0.216	11.691
6	Ribbon fish	coastal	2.096	3.376	0.622	0.446	6.540
		offshore	0.236	0.242	0.113	0.184	0.775
7	Leather jackets	coastal	0.081	0.185	0.119	0.105	0.490
8	Seer fish	coastal	0.643	0.509	0.336	0.118	1.606
9	Tuna	coastal	1.627	0.514	0.791	0.010	2.942
		offshore	0.183	0.037	0.081	0.004	0.305
10	Barracuda	coastal	0.382	0.139	0.345	0.006	0.872
		offshore	0.043	0.021	0.035	0.002	0.101
11	Wolf herring	coastal	0.058	0.214	0.139	0.110	0.521
12	Cephalopods	coastal	3.549	2.231	0.983	0.109	6.872
		offshore	0.399	0.160	0.100	0.045	0.704
13.	Other PC*[2]		2.617	1.332	1.860	0.271	6.080
	Biomass		23.349	17.782	7.990	3.136	52.257
	MSY		**9.923**	**7.548**	**3.387**	**1.335**	**22.193**
D	**Pelagic omnivores**						
1	Pomfrets	coastal	0.185	0.488	0.180	0.232	1.085
2	Horse mackerel	coastal	0.335	0.347	0.155	0.385	1.222
		offshore	0.005	0.026	0.025	0.133	0.189
3	Threadfin bream	coastal	3.075	1.443	0.308	0.075	4.901
		offshore	0.479	0.107	0.049	0.257	0.892
4	Mullets	Coastal	0.025	0.064	0.074	0.034	0.197
	Biomass		4.104	2.475	0.791	1.116	8.486
	MSY		**1.062**	**1.781**	**0.374**	**0.538**	**3.755**

E	**Benthic carnivores**						
1	Catfish	coastal	0.144	1.075	0.209	0.259	1.687
		offshore	0.004	0.198	0.084	0.084	0.370
2	Goat fish	coastal	0.045	0.089	0.325	0.033	0.492
		offshore	0.002	0.016	0.130	0.010	0.158
3	Croakers	coastal	0.574	1.991	0.421	0.555	3.541
		offshore	0.016	0.016	0.170	0.182	0.384
	Biomass		0.785	3.385	1.339	1.123	6.632
	MSY		**0.335**	**1.456**	**0.598**	**0.498**	**2.887**
F	**Benthic scavengers**						
1	Prawns	coastal	0.941	4.494	1.296	0.889	7.620
		offshore	0.520	0.260	0.084	0.288	1.152
2	Flat fish	coastal	0.353	0.353	0.111	0.068	0.885
		offshore	0.200	0.020	0.008	0.002	0.230
3	Silver bellies	coastal	0.400	0.009	2.005	0.209	2.623
4	Other BS*[3]	Coastal	0.353	0.471	0.687	0.094	1.605
		offshore	0.200	0.264	0.044	0.030	0.538
	Biomass		2.967	5.871	4.235	1.580	14.653
	MSY		**1.330**	**2.536**	**1.810**	**0.696**	**6.372**
G	**Miscellaneous fish**						
	Biomass		0.915	0.766	0.740	0.096	2.517
1	MSY		**0.389**	**0.325**	**0.315**	**0.041**	**1.070**
	Total Biomass		**54.919**	**32.090**	**22.046**	**11.043**	**120.098**
	Total		**22.727**	**14.417**	**9.439**	**4.804**	**51.387**

PP[1]- Other pelagic Planktivores include other sardines, other shads, other mackerel etc. Perches[@] include Rock cods, Snappers, Pig-faced breams, Threadfin breams and other perches. PC*[2]- Other Pelagic Carnivores include skates, half-beak and full-beaks, flying fish, thread fin, other carangids, bill fishes, unicorn cod etc. BS*[3] – Other benthic scavengers include lobsters and crabs. Miscellaneous fish include bivalves & gastropods.*

Support Document – E

Existing national and global legislation and convention(s)/initiatives

1.0 Fisheries Governance structure in India

Mandate and authority: Entry 57 of List 1 of Seventh Schedule of the Constitution of India specifies *Fishing and Fisheries beyond Territorial Waters* as Union Subject, whereas Entry 21 of List II speaks of Fisheries as a State Subject. Reading both the Entries together, it follows that control and regulation of fishing and fisheries within territorial waters is the exclusive province of the State, whereas beyond the territorial waters, it is the exclusive domain of the Union. The Union Government acts as a facilitator and coordinator responsible for policy formulation, carrying out fishery research and channeling funding support to the states in line with the national priorities and the commitments made to the State/UT Governments. The Ministry of Agriculture (DADF) within the purview of its allocated business helps the coastal States and the UTs in development of fisheries within the territorial waters, besides attending to the requirements of the sector in the EEZ. Therefore, management of fishery exploitation in the EEZ requires close coordination between the Union and the States (Table E.1).

1.1 Allocation of business between Union and the States:

As defined by the Indian constitution, both the Union and the State Government agencies manage fisheries activities. While at the Union-level, the DADF in the Ministry of Agriculture is the focal point, in the State/UTs, it is the Department of Fisheries (DoF). Other Union Ministries/ Departments like the Ministry of Commerce and Industry (MoCI), Ministry of Earth Sciences (MoES), Ministry of Food Processing Industries (MoFPI), Ministry of Environment and Forests (MoEF) play important role in various aspect of fisheries resources management. At the national level, the Ministry of Defence (MoD) through the Coast Guard (ICG) is also associated with the management of fisheries in the EEZ.

1.2 Role of Union Government: The Fisheries Division in the DADF acts as the focal point for fisheries development and management in the country. It formulates strategies for national development plans for the sector and issues policy guidelines for fisheries development and management. It also provides technical and financial assistance for fisheries development and management to various States/UTs. The financial assistance is over and above the budgetary support provided to the States by the Planning Commission.

To promote export of fish and fish products, the Government of India established the MPEDA under the MoCI in 1972. While the processing aspect fall under the MoFPI, the control of marine biodiversity and marine pollution falls under the jurisdiction of MoEF and the MoES.

1.3 Role of State Governments: The State/UT Governments are the principle custodians of fisheries in their respective jurisdictions (land as well as the territorial waters). In the marine sector, they are responsible for fisheries development and management with the main objectives of planning and development of infrastructure facilities for landing and berthing of fishing craft, creating suitable marketing facilities, implementation of various fisheries development programmes *viz*., channelising financial assistance for purchase of fishing implements, implementation of socio-economic programmes and interactions with the Government of India and other agencies for technical and financial assistance. Each State/

UT has a DoF, which functions as its main implementation agency for fisheries and aquaculture development programmes.

Table E.1. Institutional setting for marine fisheries development in India

Item	**Agency/ Ministry/ Department**
Deep sea fishing (List I), Survey & assessment of fisheries resources, Research, Training & extension, Fisheries development	Ministry of Agriculture /DADF, Indian Council of Agricultural Research, Fisheries Survey of India, National Fisheries Development Board,Ministry of Earth Sciences (MoES)
Monitoring of fishing by foreign vessels (List I), Prevention of marine pollution by ships, Protection of endangered species (Wildlife Protection Act, 1972)	Ministry of Defence /Coast Guard
Fish processing, Exports	Ministry of Food Processing Industries/Ministry of Commerce & Industry (MoCI) - MPEDA
Seafood exports (List I), Quality control,Law of the Sea negotiations (List I)	MoCI - MPEDA, Export Inspection Council, Ministry of External Affairs
Potential fishing zones, ocean pollution	MoES
Fishing vessel industry (List I), Major fishing ports (List I), Minor fishing ports (List II), Fisheries in territorial waters (List II)	Ministry of Shipping, Road Transport and Highways/, Ministry of Agriculture, State Governments
Protection of marine biodiversity (List III)[1], Protection of coastal habitats (List III)	Ministry of Environment and Forests (MoEF), MoES
Infrastructure	Ministry of Agriculture/ MoCI, MPEDA

2.0 National laws governing marine fisheries

The Indian Parliament enacted the Territorial Sea, Continental Shelf, Exclusive Economic Zone and other Maritime Zones Acts in 1976, which paved the way for establishment of a 200 nautical mile (nm) EEZ effect from January 15, 1997. Since then, India has also enacted a number of other laws and regulations which have bearing on the sustainable exploitation of the marine fisheries resources in the Indian EEZ, including the Indian Coast Guard Act, 1978; the Maritime Zones of India (Regulation of Fishing by Foreign Vessels), Act, 1981 and the related Rules of August, 1982; the Environment Protection Act, 1986, etc. The other Union legislation, which has important bearing on the fisheries sector include the Merchant Shipping Act, 1958, the Marine Products Export Development Authority Act, 1972; the Wildlife (Protection) Act, 1972 and the Biological Diversity Act, 2002. However, there is still no law to regulate the Indian-owned fishing vessels operating in the EEZ.

The provisions under the Wildlife (Protection) Act, 1972 have been used to set up marine parks/ sanctuaries along the coastline in India. While the larger objectives have been towards protection/ conservation of fauna and flora, in some cases these reserves have infringed on the livelihoods of the traditional fishers. The salient features of the Union legislation having bearing on marine fisheries sector in India given in Table E.2.

[1] ***Concurrent List***

TableE.2: Major acts enacted by the Union Government relating to Indian maritime zone

Name of the Act	Main objective	Follow ups	Main implementing agency	Fisheries management	Gaps
The Merchant Shipping Act, 1958	To foster the development and ensure the efficient maintenance of an Indian mercantile marine.	• Registration • Setting up of National Shipping Board	Ministry of Shipping, Road Transport and Highways	• Defining a fishing vessel which acted as the base for later acts. • Registration procedure. • Provision for data collection	• Fisheries are not a part of its larger objectives; therefore no mandate for conservation and sustainable management of the resources.
The MPEDA Act, 1972	To promote export of fisheries product.	• Collection of information on fish production, etc.	Ministry of Commerce and Industry	• Undefined area • Licensing • Basic focus on controlling of fish export and quality control in respect of exported fish and export promotion.	• Artisanal fishing is not considered. • Enforcement mechanism is weak.
The Wildlife (Protection) Act, 1972	To protect wildlife	• Sanctuaries	Ministry of Environment & Forests	• Restriction on hunting of several mammals, fish, coral, sponge, turtle, etc.	• No in-built provision for conservation of overexploited species. Inclusion of any species threatened to be inserted via notification/ amendment.
The Territorial Waters, Continental Shelf, EEZ and other Maritime Zones Act, 1976	To establish sovereignty over Indian maritime zone.	• To ensure national security. • To facilitate exploitation and other economic uses of Indian maritime zone.	Ministry of External Affairs	• Licensing • Establishment and division of maritime zones into 4 areas.	• No provision for input control. Any number of fishing vessel can operate.
The Coast Guard Act, 1978	To establish the Coast Guard.	• National security. • Protection of national interest. • Safety at sea	Ministry of Defence	• Establishment of control and surveillance measures. • Establishment of sea rescue measures.	• The facilities are not commensurate with the area of the EEZ.
Maritime Zones of India (Regulation of Fishing by Foreign Vessels) Act, 1981	To control activities of foreign fishing vessels within Indian maritime zone.	• Basis for joint ventures and chartered vessels. Base for bilateral/ multilateral fishing access agreements.	Ministry of Agriculture	• Permit fishing by foreign vessels through licensing.	• Ignoring of sustainability criterion. • Absence of stringent rules for IUU fishing.

The Biological Diversity Act, 2002	To protect biological diversity of India	National and State Biodiversity Boards	Ministry of Environment & Forests	• Permit fishing for commonly traded fish. • Encourages conservation. • Provision to declare a fish stock threatened if it is overexploited.	• Inclusion of too many stakeholders (Union and state Governments, NBA, users, etc) to reach a decision in timely manner. • EIA is not must for a sensitive project.

3.0 Existing legislations related to fisheries in India

3.1 National Policy on Marine Fisheries, 2017

In 2004, the Government of India brought out the first Comprehensive Marine Fishing Policy, which set a framework for sustainable development of the fisheries sector in the new millennium. As the sector is dynamic and has been unfolding new requirements from both harvest and sustainability point of view, the Government brought out, after elaborate stakeholder consultation process, the National Policy on Marine Fisheries, 2017 (NPMF, 2017) guided by the following seven pillars:

- Sustainable development;
- Socio-economic upliftment of fishers;
- Principle of subsidiarity;
- Partnership;
- Inter-generational equity;
- Gender justice; and
- Precautionary approach.

The Strategy of the NPMF is under the following broad heads:

- Fisheries management;
- Monitoring, Control and Surveillance;
- Fisheries data and research;
- Mariculture;
- Island fisheries;
- Post-harvest & Processing;
- Trade;
- Gender equity;
- Additional/Alternate livelihoods;
- Blue growth initiative;
- International agreements/arrangements;
- Regional cooperation; and
- Governance and Institutional aspects.

The NPMF is intended to lead the coordination and management of the sector in the country for the next ten years. As the Policy is holistic and adequately addresses the need of all segments in the Sector, it is expected to meet the multidimensional and growing needs of the Sector. The NPMF is also a commitment of the Government to usher in Blue Revolution in the country while ensuring healthy seas and sustainable fisheries.

As the management responsibilities of the Indian marine fisheries sector are vested with both the Central and coastal State Governments, implementation of the NPMF necessitates coordination and cooperation between the concerned Ministries and Departments of the Central and State Governments, and also active engagement of the primary stakeholders. To implement the wide range of strategies, an Implementation Plan that will specify the action points under each recommendation contained in the Policy is necessary. It is expected that through implementation of the Policy, the marine fisheries sector in India will become a sustainable and well-managed entity, ensuring enhanced utilisation of the harvest for human consumption; employment, gender equity and livelihoods; equity and equality; provision of food security and nutrition; and creation of wealth and prosperity in the sector.

3.2 Marine Fishing Regulation Acts of the coastal States/ Union Territories

The Marine Fishing Regulation Act of the coastal States/UTs in India was conceived in response to the growing conflicts in the coastal waters during the late seventies. To reduce the conflicts and also allow for regulation of fisheries in the territorial waters, the Ministry of Agriculture formulated a Model bill, which was circulated to the coastal States/UTs in 1979. Based on the Model Bill all the coastal States/UTs have enacted the Marine Fishing Regulation Act (MFRA) and the rules and regulations there under. Goa (then a UT), Karnataka and Kerala were the first States to enact their MFRA in 1980. The UT of Puducherry is the last to enact the MFRA in 2008. The MFRAs have provisions for regulating fishing and conservation measures in the territorial waters. These include regulation of mesh size to avoid catching of juvenile fish, maximum-minimum fish sizes, regulation of gear to avoid over-exploitation of certain species, reservation of zones for various fishing sectors to provide exclusive rights to traditional fishermen to fish unhindered in near shore areas and also for declaration of closed seasons during fish breeding period to avoid catching of young juvenile fish. The other important aspects include vessel movement control, vessel inspection, registration and license and colour coding.

The MFRAs of the maritime States/UT Governments and the deep sea fishing schemes as provided under the Maritime Zones of India (Regulation of Foreign Fishing Vessels) Act, 1981 of the Government of India provide for prohibition of fishing by mechanized fishing vessels in the areas earmarked for the traditional and small-motorized crafts. Presently, the Union Government exercises closure of fishing for two months in a year with relation to fishing in the EEZ is the. This closure coincides with the closure enforced by the coastal State/UTs for fishing in their territorial waters and is done through ‘Executive Orders’.

Measures such as issue of biometric card to fishermen, registration of fishing boats and colour code to fishing boats have be taken up by the Governments and is in the process of completion. These steps will facilitate better sea safety arrangements as well as monitoring boat movements.

3.3 Central Sector Schemes under “Blue Revolution: Integrated development and management of Fisheries”

GOI, MoA &FW, DADF, New Delhi in the order No 27035- 19/2015-Fy (IV) dated May 20, 2016 approved the Central Sector Scheme “Blue Revolution: Integrated Development and Management of Fisheries” (both marine and inland) at a total cost of Rs 30 000 million for implementation in all the States and UTs during a period of five years (2015-16 to 2019-20). All the on-going schemes under XII Five Year Plan and newly proposed schemes have been brought under the scheme “Blue revolution”.

The Vision of Central Sector Scheme "Blue Revolution"

"Creating an enabling environment for integrated development of the full potential of fisheries of the country, along with substantial improvement in the income status of fishers and fish farmers keeping in view the *sustainability, bio-security and environmental concern". Mission of the Scheme*

- Formulation of a "*Neel Kranti Mission Plan*" (Blue Revolution Mission Plan) for tapping the full potential of the inland and marine culture fisheries of the country by developing it as a professional modern world class industry
- Ensure doubling of income of fishers and fish farmers of the country
- Ensure sustainability and biodiversity and address environmental concern for enabling sustainability of the fishing industry

Following are the important components of the Central Sector Scheme "Blue revolution":

1. Assisting National Fisheries Development Board and its activities (NFDB)
2. Strengthening of Database and Geographical Information System of the Fisheries Sector (SoDGIS)
3. Monitoring, Control, and Surveillance and other need-based Interventions (MCS)
4. Institutional arrangements for Fisheries Sector
5. Development of Inland Fisheries and Aquaculture
6. Development of marine Fisheries, Infrastructure and Post-harvest Operations
7. National scheme of welfare of Fishermen.

4. Global conventions and commitments

Table E.3 contains the list of some of the important international instruments and agreements (both binding and non-binding) to which India is signatory and have profound bearing on the development of Indian fisheries in general and marine fisheries in particular.

Table E.3. India's international commitments under some of the important instruments relating to both fisheries and environment

Instrument	**Accession, Acceptance Ratification**	**Entry Into Force**
International Convention for the Regulation of Whaling (Washington DC, 1946)	Adherence 09 March 1981	09 March 1981
Convention on International Trade in Endangered Species of Wild Fauna and Flora (Washington DC, 1963)	Ratified 20 July 1976	18 October 1976
Convention on Wetlands (Ramsar, Iran, 1971)	01 February 1982	01 February 1982
Convention on International Trade in Endangered Species of Wild Fauna and Flora, 1973	20 July 1976	01 July 1975
The Convention on the Conservation of Migratory Species of Wild Animals (Bonn, 1979)	1 November 1983	1November 1983
Convention on the Conservation of Antarctic Marine Living Resources (Canberra, 1980)	Acceptance 17 June 1985	17 July 1985

United Nations Convention on the Law of the Sea (Montego Bay, 1982)	29 June 1995	29 July 1995
Convention on Biological Diversity (Rio de Janeiro, 1982)	Ratification 18 February 1994	18 February 1994
Global Plan of Action for the Protection of the Marine Environment from Land-Based Activities (Declaration, Washington DC, 1995)	23 November 1995	23 November 1995
Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (New York, 1995)	Accession 19 August 2003	19 August 2003

Table E.4: Important provisions of international binding and non-binding instruments those needs to be addressed

International Instrument	Important provisions
United Nations Convention on the Law of the Sea, 1982	• The coastal State will take proper conservation and management measures; • The coastal State may take such measures, including boarding, inspection, arrest and judicial proceedings, as may be necessary to ensure compliance; • Coastal States and States fishing on the high seas shall adopt measures to ensure long-term sustainability of straddling fish stocks and highly migratory fish stocks; • The coastal State will establish appropriate cooperative mechanisms for MCS; • The coastal State shall determine the allowable catch of the living resources in its EEZ; • The coastal State may include licensing, and fixing quota for domestic vessels and other foreign vessels; • The coastal State will take proper conservation and management measures based on best scientific evidences.
UN Fish Stocks Agreement, 1995	• Adoption of measures to ensure long-term sustainability of straddling fish stocks and highly migratory fish stocks; • Prevention or elimination of overfishing and excess fishing capacity to the level of sustainable limits; • Taking into account the interests of artisanal and subsistence fishers; • Establishment of a national record of fishing vessels; • Marking of fishing vessels and fishing gear for identification as per international norms; • Recording and timely reporting of vessel position, catch of target and non-target species, fishing effort and other relevant fisheries data; • Verification of the catch of target and non-target species; • Implementation of national inspection schemes; • Implementation of national observer programmes; • Development and implementation of vessel monitoring systems.
UN Convention on Biological Diversity,	• Protect ecosystems; • Manage living modified organisms;

1995	• Environmental impact assessment; • Monitor components of bio-diversity; • Precautionary approach; • Ecosystem approach; • Aichi Targets; • All forms of relevant information should be considered, including scientific and indigenous and local knowledge, innovations and practices.
The FAO Code of Conduct for Responsible Fisheries and International Plan of Actions related to marine fisheries, 1995	• States should ensure compliance with and enforcement of conservation and management measures; • Establishing effective mechanisms to monitor and control the activities of fishing vessels and fishing support vessels; • Maintaining a record, updated at regular intervals, on all authorizations to fish issued by them. • Reduce fishing to sustainable levels; • Reduce by-catches, fish discards and post-harvest losses; • Review the capacity of fishing fleets and where necessary reduce these fleets; • Strengthening and support regional, sub-regional and national fisheries organizations; • Periodic review of the effectiveness of conservation and management measures; • strengthen fisheries research and increase cooperation among research institutions; • Consultation on fisheries with the private sector and non-governmental organizations; • Effectively implement the relevant rules of international law on fisheries.
The Kyoto Declaration and Plan of Action, 1995	• Assess and monitor the present and future levels of global, regional and national production; • Enhance sub-regional and regional cooperation; • Take measures to reduce excess fishing capacity; Take actions in relation to fish and other sea life which are incidentally caught and discarded.
Safety and health of fishers at Sea: the ILO requirements	• Fixation of minimum age for work on board a fishing vessel; • Ensuring navigational training for skipper and crew. • Medical fitness especially for skippers. • Validation of workplace safety such as adequate provision of life-saving appliances on-board fishing vessel and fitness of the fishing vessels. • Demarcation of area of operation of fishing vessels based on their design.
Sustainable Development Goals	• SDG 14 ‘’Life Below Water”: Conserve and sustainably use the oceans, seas and marine resources for sustainable development. • Achieve sustainable management of marine ecosystems by 2020. • Significantly reduce marine pollution of all kinds by 2025. • Engage in international scientific partnership, regulation of harvesting and fishing, and enhanced research and knowledge on issues critical to the survival of life below water. • Aligning national policies on marine fisheries and related aspects with SDGs.

4.1 Regional Instruments and Regional Cooperation

India is member of various regional fisheries bodies including the Asia-Pacific Fishery Commission (APFIC); Network of Aquaculture Centres in Asia and the Pacific (NACA); Intergovernmental Organization for Marketing Information and Technical Advisory Services for Fishery Products in the Asia and Pacific Region (INFOFISH); Indian Ocean Tuna Commission (IOTC) and the Bay of Bengal Programme Inter-Governmental Organisation (BOBP-IGO) (Table 2). Besides, it is also member of other regional bodies that deal with environment (e.g. South Asian Cooperative Environment Programme, International Union for Conservation of Nature) and Trade (Bay of Bengal Initiative for Multi-Sectoral Technical Economic Cooperation- BIMSTEC). Even economic and geopolitical set-ups such as South Asian Association for Regional Cooperation or SAARC has undertaken initiatives in both fisheries and environment related matters form time to time. Table E.5 provides a snap-shot of India's membership in regional fisheries organizations:

Table E.5. India's membership in Regional Fisheries Organization

Regional Fishery Body	Date of Signing	Entry into force
Agreement for the Establishment of the Asia-Pacific Fishery Commission (Baguio, 1948)	Acceptance 09 November 1948	09 November 1948
Agreement for the Establishment of the Network of Aquaculture Centres in Asia and the Pacific (Bangkok, 1988)	Accession 04 July 1992	04 July 1992
Agreement for the Establishment of the Intergovernmental Organization for Marketing Information and Technical Advisory Services for Fishery Products in the Asia and Pacific Region (INFOFISH) (Kuala Lumpur, 1985)	Accession 19 September 1986	03 March 1987
Agreement for the Establishment of the Indian Ocean Tuna Commission (1993)	Acceptance 13 March 1995	27 March 1996
Agreement for the Establishment of the Bay of Bengal Programme Inter-Governmental Organisation (Chennai, 2003)	Acceptance 26 April 2003	26 April 2003

Most of the regional organizations to which India is party (APFIC, BOBP-IGO, NACA) are advisory in nature and as such their roles and functions are limited to policy advocacy and capacity building. However, other organizations like the Indian Ocean Tuna Commission (IOTC) have management and regulatory mandates, making the decisions of the Commission binding on the member-states. Table E.6 gives some of the important resolutions adopted by the IOTC for compliance by its member-states.

Table E.6. Important resolutions and recommendations of IOTC and compliance requirements by member-countries

Resolution/ Recommendation	Required action by CPCs/Indian response
Resolution 99/02 Calling for actions against fishing activities by large scale flag of convenience longline vessels	The Members need to ensure that large-scale tuna longline vessels under their registry do not engage in IUU fishing activities

Resolution 05/03 Establishment of an IOTC programme of inspection in port.	1. Port inspection programmes to be framed so as to inspect documents, fishing gear and catch on board fishing vessels, when such vessels are voluntarily in the ports or at its offshore terminals. Inspections have to be carried out so that the vessel suffers the minimum interference and inconvenience and that degradation of the quality of the fish is avoided. 2. List of foreign vessels which have landed in ports tuna and tuna like species caught in the IOTC area in the preceding year has to be submitted to the Commission before 1st of July.
Recommendation 05/07 Management standard for the tuna fishing vessels.	While issuing the licenses to authorized fishing vessels, ensure that minimum management measures as per the format provided are met with. An annual report on the measures taken in this regard is to be submitted to the Commission in the given format.
Resolution 10/08 Concerning a record of active vessels fishing for tunas and swordfish in the IOTC area	Vessels fishing for tunas and swordfish in the IOTC Area of Competence shall submit to the Secretary by 15 February every year a list of their respective vessels that were active in the Area during the previous year and that are: a. larger than 24 metres in length overall, or b. in case of vessels less than 24m, those operating in waters outside the economic exclusive zone of the flag state.
Resolution 15/03 Vessel monitoring system (VMS) programme	Any CPC with vessels not equipped with VMS shall be required to fully implement its national VMS obligation within a maximum of 1 year, i.e. by April 2016 in respect of those vessels.
Resolution 15/10 Target and limit reference points and a decision framework	When assessing stock status and providing recommendations to the Commission, the IOTC Scientific Committee should, where possible, apply MSY-based target and limit reference points for tuna and tuna-like species.
Resolution 16/02 Harvest control rules for skipjack tuna in the IOTC area of competence	To use a pre-agreed harvest control rule (HCR) to maintain the Skipjack tuna stock at, or above, the target reference point (TRP) and well above the limit reference point (LRP).
Resolution 17/04 On a ban on discards of bigeye tuna, skipjack tuna, yellowfin tuna, and non-targeted species caught by purse seine vessels in the IOTC area of competence	To ban the discards, members should require all purse seine vessels to retain on board and then land all bigeye tuna, skipjack tuna, and yellowfin tuna caught, except fish considered unfit for human consumption.
Resolution 17/05 On the conservation of sharks caught in association with fisheries managed by IOTC	Requires that the members prohibit the removal of shark fins on board vessels and encourage the release of live sharks, especially juveniles and pregnant sharks.
Resolution 17/07 On the prohibition to use large-scale driftnets in the IOTC area	The use of large-scale driftnets (gillnets or other nets or a combination of nets that are more than 2.5 kilometres in length) on the high seas within the IOTC area of

	competence shall be prohibited. The use of large-scale driftnets in the entire IOTC area of competence shall be prohibited by 1 January 2022.
Resolution 18/01 On an interim plan for rebuilding the Indian Ocean yellowfin tuna (YFT) stock in the IOTC Area of Competence	To ensure the conservation of the YFT stock in the Indian Ocean, the Registered tuna fishing vessels need to reduce their catch of YFT as 2014 as base year at the rate of 15% (purse seines, if the catch was above than 5000 MT); 10% (gillnets, if the catch was above 2000 MT); 10% (longlines, if the catch was above 5000 MT); 5% (other gears, if the catch was above 5000 MT)
Resolution 18/02 On management measures for the conservation of blue shark caught in association with IOTC fisheries	To ensure the conservation of the blue shark stock in the Indian Ocean, contracting Parties and Cooperating non-Contracting Parties,(CPCs) whose vessels catch blue shark need to collect and report the blue shark catch, undertake scientific research on blue shark that would provide information on key biological/ecological/behavioural characteristics, life-history, migrations, post-release survival and guidelines for safe release and identification of nursery grounds, as well as improving fishing practices.
Resolution 18/03 On establishing a list of vessels presumed to have carried out illegal, unreported and unregulated fishing in the IOTC Area of Competence	This Resolution sets out rules and procedures for the maintenance and updating by the Commission of the system of lists of vessels considered to be involved in illegal, unreported and unregulated (IUU) fishing activities and set forth the procedures for reporting the IUU activities, inclusion of vessels in the IUU list, action against listed IUU Vessels, and delisting of a vessel from IUU list.
Resolution 18/05 On management measures for the conservation of the billfishes: striped marlin, black marlin, blue marlin and indo-pacific sailfish	To ensure the conservation of the striped, black and blue marlins and Indo-Pacific sailfish stocks in the Indian Ocean, the members shall ensure that the overall catches, of the species, in any given year do not exceed either the MSY level or, in its absence, the lower limit of the MSY range of central values as estimated by the Scientific Committee
Resolution 18/06 On establishing a programme for transhipment by large-scale fishing vessels	The transhipment at sea by large scale tuna longline fishing vessels need to be monitored by the flag state and the IOTC and the carrier vessels authorised to receive transhipments from these vessels at sea must have onboard an IOTC observer.
Resolution 18/10 On vessel chartering in the IOTC Area of Competence	The IOTC establish procedures to regulate charter agreements for ensuring that IUU fishing activities are not promoted or undermine IOTC Conservation and Management Measures. The chartering member need to intimate the IOTC about the vessels to be chartered and also need to ensure that the chartered vessel complies with both the chartering Contracting Party and the flag Contracting Party or Cooperating Non-Contracting Party shall ensure compliance by chartered vessels with relevant IOTC Conservation and Management Measures.

Marine fish landings of mainland India - 2017 (Source: CMFRI) **Annexure 1**

Resource/ state	WB	OR	AP	TN	PO	KL	KA	GO	MH	GJ	DD	Total
Sharks	2736	1045	729	893	54	2936	670	45	3086	6169	1414	**19777**
Skates/Guitarfish	177	1	182	668	18	154	18	0	60	1266	85	**2628**
Rays	1434	601	1721	7491	774	2095	633	9	686	2034	289	**17766**
Eels	1124	1458	2469	907	26	174	671	9	1449	4398	488	**13174**
Catfishes	27354	4485	4530	6089	252	101	1272	214	9140	30241	4498	**88177**
Wolf herring	5610	754	650	3626	128	82	551	0	669	5969	526	**18566**
Oil sardine	0	226	2233	51716	232	126988	98082	48054	8325	1526	8	**337390**
Other sardines	29771	13261	39014	110193	654	17504	7341	352	8264	606	11	**226970**
Hilsa shad	57991	4529	0	0	0	0	0	0	244	672	0	**63437**
Other shads	0	738	2103	2642	0	34	34	0	802	510	104	**6967**
Coilia	10090	3946	127	717	0	5	14	0	11093	7504	77	**33574**
Setipinna	5561	2976	0	237	3	0	0	0	0	0	0	**8777**
Stolephorus	4729	1134	8907	13789	542	31588	3965	22	66	117	0	**64859**
Thryssa	2694	2579	4165	9132	417	5109	2952	127	1747	8424	655	**38003**
Other clupeids	23946	8542	5669	8457	333	10849	3875	110	2334	3096	395	**67607**
Bombayduck	37952	2388	248	0	0	0	0	0	27167	76574	787	**145115**
Lizardfishes	592	160	2446	6342	475	16557	12407	81	2480	14824	1441	**57803**
Halfbeaks & Fullbeaks	549	254	75	2045	0	929	2850	157	398	626	0	**7883**
Flyingfishes	0	0	80	1094	0	11	29	0	1	129	0	**1345**
Rock cods	128	96	507	4063	686	4319	7130	537	10608	22491	3359	**53924**
Snappers	27	576	592	5923	156	1269	254	0	636	1087	0	**10518**
Pig-face breams	0	1	4	15137	353	244	37	0	6	684	16	**16483**
Threadfin breams	2195	1678	3643	20705	564	41841	27755	236	27538	28393	3222	**157773**
Other perches	8343	2581	4495	27121	714	34681	67023	3200	6104	40762	2232	**197258**
Goatfishes	849	809	4522	11223	396	395	0	0	82	2026	4	**20306**
Threadfins	2821	404	921	417	46	2	0	0	1390	3978	784	**10764**
Croakers	15808	14113	8650	13164	787	4886	6344	367	36658	44771	4693	**150241**

Resource/ state	WB	OR	AP	TN	PO	KL	KA	GO	MH	GJ	DD	Total
Ribbon fishes	12671	10502	15476	7075	927	20729	24055	332	18583	113904	15101	**239355**
Horse Mackerel	11745	4076	4842	2422	315	2874	5349	4341	6452	8318	1229	**51964**
Scads	551	24	2049	17306	2903	43463	30261	1623	2885	6638	307	**108010**
Leather-jackets	3127	1249	739	2425	102	323	2145	402	1156	3786	784	**16237**
Other carangids	448	3047	5843	26020	1732	30065	25680	7635	9242	8922	1386	**120019**
Silverbellies	427	1211	5635	76221	1162	1672	2977	220	297	80	0	**89901**
Big-jawed jumper	0	47	347	263	0	731	998	53	749	596	23	**3807**
Black pomfret	1123	2847	2877	823	264	436	895	60	1312	1649	335	**12622**
Silver pomfret	10966	2238	1408	1006	504	689	1460	15	2649	6227	1627	**28789**
Chinese pomfret	2989	971	695	34	0	0	0	0	173	590	15	**5466**
Indian mackerel	20258	7603	20547	21928	526	33336	119527	20546	37299	5628	680	**287880**
Other mackerels	0	487	83	23	34	0	0	0	9	0	0	**636**
S. commersoni	179	575	1350	7886	357	3380	7044	287	4517	4252	369	**30195**
S. guttatus	5264	1377	1888	1717	117	253	139	110	2090	4511	671	**18138**
S. lineolatus	0	72	0	0	0	1	0	0	0	0	0	**74**
Acanthocybium spp.	0	0	0	156	4	106	1	0	0	0	0	**268**
E. affinis	100	201	1512	3203	27	6682	8342	1450	2951	2720	492	**27680**
Auxis. spp	159	0	684	778	32	5258	1499	6450	764	830	184	**16640**
K. pelamis	0	76	662	4851	100	3838	52	0	0	413	568	**10559**
T. tonggol	6	0	0	724	0	119	146	0	493	3511	2350	**7350**
Other tunnies	0	34	1074	8541	28	6959	283	10	407	567	257	**18161**
Bill fishes	80	5	903	2216	28	6980	164	0	273	656	21	**11328**
Barracudas	172	316	2241	16678	709	2634	5376	128	831	3360	891	**33337**
Mullets	901	1012	179	3630	90	61	278	9	148	1632	0	**7939**
Unicorn cods	0	0	0	0	0	0	0	0	325	0	0	**325**
Halibut	0	4	420	182	47	13	352	0	90	924	38	**2069**
Flounders	0	0	81	3	0	4	1	0	0	0	0	**90**
Soles	4383	1586	987	2275	138	10254	4099	527	4146	14424	353	**43173**

Resource/ state	WB	OR	AP	TN	PO	KL	KA	GO	MH	GJ	DD	Total
Penaeid prawns	25142	8615	14932	23159	3197	43468	15489	1438	37642	35287	1143	**209513**
Non-penaeid prawns	6301	0	1062	415	0	3696	0	0	41296	148973	1004	**202748**
Lobsters	310	37	68	763	211	57	3	0	370	1032	13	**2863**
Crabs	3789	3629	4581	17276	682	5080	6918	428	1440	8980	674	**53476**
Stomatopods	0	2	216	15	5	1611	8524	49	1055	3278	28	**14784**
Bivalves	0	0	0	1	0	48	0	0	3	0	0	**52**
Gastropods	0	0	0	1490	4	590	0	0	0	0	0	**2083**
Squids	231	665	1039	32642	1011	22384	14395	427	27859	28021	3100	**131774**
Cuttlefish	4318	1276	1941	24265	3123	15686	11355	42	10291	33227	3563	**109089**
Octopus	0	0	0	4191	384	5143	379	0	260	440	19	**10816**
Miscellaneous	3352	3835	4618	18695	669	3308	5688	73	2053	24237	1755	**68283**
Total	**361474**	**126958**	**199659**	**655090**	**27040**	**584686**	**547784**	**100175**	**381142**	**786495**	**64070**	**3834574**

9.References

Alagaraja, K, 1989. A brief appraisal of marine fisheries in India. CMFRI Bulletin No. 44, Part I: 36-41.

Behrenfield, MJ and Falkowski, PG, 1997. Photosynthetic rates derived from satellite based chlorophyll concentration. Limnology and Oceanography, 42; 1 -20.

Brotz, L, 2016. Jellyfish fisheries of the world. PhD Thesis, University of British Columbia**,** Vancouver, Canada. 179p.

CMFRI, 2018. India's marine fish landings increase by 5.6% in 2017. http://www.cmfri.org.in/news/marine-fish-landings-in-india-increase-by-56-percentage-in-2017

Cushing, DH, 1973. Production in the Indian Ocean and the transfer from the primary to the secondary level. *In*: The biology of the Indian Ocean. Ecological studies. B. Zeitzschel, (ed.), 3: 475-486.

Desai, BN, Bhargava, RMS and Sarupria, JS, 1989. Biological productivity and estimates of fishery potential of the EEZ of India. Estuarine, Coastal and Shelf Science, 30, 635–639.

Eva, EP, 2014. Multispecies fisheries management and conservation: tactical applications using models of intermediate complexity, Fish and Fisheries, 15: 1-22.

FAO, 2016. The State of World www.fao.org/in-action/globefish/fishery-information/resource-detail/en/c/338597/ (accessed 9 August 2018)

FAO,. 2018. The State of World Fisheries and Aquaculture 2018 - Meeting the sustainable development goals. Rome. FAO, 2016. The State of World www.fao.org/in-action/globefish/fishery-information/resource-detail/en/c/338597/ (accessed 9 August 2018)

FAO-GLOBEFISH 2018. Analysis and information on world fish trade. http://www.fao.org/in-action/globefish/fishery-information/resource-detail/en/c/338597/ (accessed 9 August 2018)

George, PC, Raja, ABT and George, KC, 1977. Fishery resources of the Indian Exclusive Zone. Souvenir of the Integrated Fisheries Project Silver Jubilee Celebration, 79-120.

Gerlach, SA, 1978. Food-chain relationships in subtidal silty and sand marine sediments and the role of meiofauna in stimulating bacterial productivity. Oecologia, 1978, 33: 55-69.

Gjosaeter, J, 1984. Mesopelagic fish, a large potential resources in the Arabian Sea. Deep Sea Research Part A. Oceanographic Research PapersDeep-Sea Res., 31: 1019-1035.

GLOBEC, 1993. Implementation plan and workshop report for US GLOBEC studies in the Arabian Sea, US Global Ocean Ecosystems Dynamics, US GLOBEC Report No. 9, 105 p.

GOI, 1991. Report of the Working Group on revaldation of the Potential marine fisheries resources of Exclusive Economic Zone of India. pp. 1-43.

GOI, 2000. Report of the Working Group for revalidating the potential of fishery resources in the Indian EEZ, pp. 1-43.

GOI, 2011. Report of the Working for revalidating the potential fishery resources in the Indian EEZ, DADFF, MoA, New Delhi, pp. 1-69.

Gulland, JA (Ed.) 1971. The Fish Resources of the Ocean, Fishing News (Books) Ltd., England, 255p.

Harris, RP, Wiebe, FH, Lenz, J, Skjoldal, HR and Huntley, M, 2000. ICES Zooplankton methodology manual. Academic Press, London. 634p.

IOTC, 2017[a] Report of the 20th Session of the Scientific Committee. Victoria, Seychelles, 30 November -4 December 2017. IOTC-2017-SC-R(E): 232pp.

IOTC, 2017[b] Review of the statistical data and fishery trends for tropical tunas. IOTC-2017-WPTT19-07,49pp.

IOTC, 2017[c] Estimation of EEZ catches in the IOTC database: Report on the availability and quality of catch estimates. Victoria, Seychelles,30 November -4 December 2017. IOTC-2017-SC20-INFO5, 14pp.

James, PSBR, Alagarswami, K, Rao, KVN, Muthu, MS, Rajagopalan, MS, Alagaraja, K and Mukundan, C, 1986 Potential Marine Fishery Resources of India. Seminar Potential Marine Fishery Resources, Cochin, April 23, 1986; CMFRI Special l. Publication 30.

John ME and Pillai NGK, 2009. Current status of tuna fisheries in India. *In*: 13th Session of the Indian Ocean Tuna Commission, 30 March - 03 April 2009, Bali; Indonesia.

John, ME and Varghese, BC, 2009. Decline in CPUE of oceanic sharks in the Indian EEZ: urgent need for precautionary approach. IOTC Working Party on Ecosystems and Bycatch, Mombasa, Kenya, 12-14 October 2009.

John, ME, Bhargava, AK, Varghese, S, Gulati, DK, Kadam, AS and Dwivedi, SK, 2005. Fishery Resources of the Indian EEZ around Andaman and Nicobar Islands. FSI Bulletin 28.

Jones, S and Banerji, SK, 1973. A Review of the living resources of the Central Indian Ocean. Proceedings of the Symposium on living resources of the seas around India. CMFRI Special Publication: 1-17.

Joseph, KM, 1985. Marine Fishery Resources of India, In: E.R. Kulkarni & U.K. Srivastava (Eds.) A system frame work of marine food industry in India, 90-149 p.

Joseph, KM, 1987. The fish resources of the Indian Exclusive Economic Zone. National Seminar Planning Export Strategy for Indian Marine Fisheries, New Delhi, March 11, 1987.

Madhupratap, M and Haridas, P, 1990. Zooplankton especially calanoid copepods in the upper 1000m of the South East Arabian Sea. Journal of Plankton ResearchJ. Plank. Res., 12:305-321.

Martell, S., and Froese, R. 2013. A simple method for estimating MSY from catch and resilience. Fish and Fisheries, 14: 504–514

Mathew, KJ, Naomi, T.S Antony, G, Vincent, D, Kumar, RA, and Solomon, K, 1990. Studies on Zooplankton biomass and secondary tertiary production of the EEZ of India. Proceedings of. First Workshop Scientific Result FORV *Sagar Sampada*, 5-7 June, 1989: 59-69.

Mikael G and Kjell N, 1999. Benthic foraminifera and their response to hydrography, periodic hypoxic conditions and primary production in the Koljöfjord on the Swedish west coast. Journal of Sea Research 41: 163-178.

Mitra, GN, 1973. Method of estimation of fish abundance in the Indian Ocean and steps to be taken for management of the commercial fisheries. Proceedings of the Symposium on Living Resources of the Seas around India CMFRI Special Publication 121:Proc. Symp. Living Res. Of Seas Around India, Spl. Pub. CMFRI: 145-154.

Mohamed, KS, Sajikuma,r KK, Ragesh, N, Ambrose, TV, Jayasankar, J, Said Koya, KP and Sasikumar, G, 2018. Relating abundance of purpleback flying squid *Sthenoteuthis oualaniensis* (Cephalopoda: Ommastrephidae) to environmental parameters using GIS and GAM in south-eastern Arabian Sea. Journal of Natural History. 52:29-30 https://doi.org/10.1080/00222933.2018.1497721.

Mohamed, KS, Vijayakumaran, K, Zacharia, PU, Sathianandan, TV, Maheswarudu, G, Kripa, V, Narayanakumar, R, Rohit, P, Joshi, KK, Sankar, TV, Edwin, L, Ashok Kumar, K, Bindu, J, Gopal, N and Pravin, P, 2017. Indian Marine Fisheries Code: Guidance on a Marine Fisheries Management Model for India. Marine Fisheries Policy Series (4). Central Marine Fisheries Research Institute, Kochi, pp. 1-102. ISBN ISSN 2394-8019

Mohamed, KS, Zacharia, PU, Muthiah, C, Abdurahman, KP and Nayak, TH, 2008. Trophic Modelling of the Arabian Sea Ecosystem off Karnataka and simulation of fishing yields. Bulletin of . Central. Mar.ine Fisheries Research. Institute., 51: 140p.

MPEDA, 2017. Marine products Exports. http://mpeda.gov.in/MPEDA/marine_products _exports.php# (accessed 9 August 2018)

Nair, PVR and Gopinathan, C P, 1981. Productivity of the Exclusive economic Zone of India. Journal of the Marine Biological Association of India, 1981, 23 (1 2) : 48-54.

Parulekar, AH, Dhargalkar, VK and Singbal, SYS, 1980. Benthic studies in Goa estuaries. Part III. Annual cycle of macrofaunal distribution, production and trophic relations. Indian Journal of Marine Science.J.Mar.Sci, 1980, 9: 189 -200.

Pauly, D and Christensen, V, 1995. Primary production required to sustain global fisheries. Nature. 374: 255 – 257.

Pennington, M, 1996. Estimating the mean and variance from highly skewed marine data. Fishery Bulletin, 94: 498-505.

Plagányi, É, Ellis, N, Blamey, LK, Morello, E, Norman-Lopez, A, Robinson, W, Sporcic, M, Sweatman, H, 2014. Ecosystem modelling provides clues to understanding ecological tipping points. Marine Ecology Progress Series 512: 99–113.

Prasad, R R, Banerji SK and Nair, PVR 1970. A quantitative assessment of the potential fishery resources of the Indian Ocean and Adjacent Seas. Indian Journal of Animal Sciences 40 (1): 73:98.

Raman, M and James, PSBR 1990. Distribution and abundance of lanternfishes of the family Myctophidae in the EEZ of India, In: Mathew, K.J. (Ed.) Proc. First Workshop Scient. Resul. FORV Sagar Sampada, pp 285-290, Department of Ocean Development, New Delhi.

Robertson, AI 1979. The relationship between annual production: biomass ratios and life spans for marine macrobenthos. Oecologia (Berl) 38,193-202 (1979).

Ryther,J, 1969. Photosynthesis and fish production in the sea. Science, 166: 72 – 76.

Sanjeevan VN, Jasmine P, Smitha BR, Ganesh T, Sabu P, Shanmugaraj T 2009. Eastern Arabian Sea Marine Ecosystems. In: MECOS '09 – International symposium on Marine Ecosystems Challenges and Opportunities, Book of Abstracts (Ed. Vivekanandan E et al.). Kochi: ESO-01.

Sparre, P and Venema, SC, 1998. Introduction to tropical fish stock assessment. Part-I. Manual FAO Fisheries Technical Paper.306.1, Rev. 2 FAO, Rome. 407pp.

Sudarsan, D, John ME and Somvanshi, VS, 1990. Marine fishery resources potential in the Indian Exclusive Economic Zone – an update. Bulletin of Fishery Survey of India 20: 27 pp.

Sudarsan,D, John, ME and Somavanshi, VS, 1990. Marine fishery resources potential in the Indian Exclusive Economic zone – An Update. Bulletin of Fishery Survey of India, 20: 27pp.

Sudarsan,D, Sivaprakasam, T E, Somvanshi, V S and John, ME, 1989. Assessment of oceanic tuna and allied resources I Indian EEZ. National Conference on Tunas, Cochin, 21-22 April 1989.

Sudarsan,D, Sivaprakasam, TE, Somvanshi, VS, John, ME, Nair, KNV and Joseph, A, 1988. An appraisal of marine fishery resources of the Indian Exclusive Economic zone. Bulletin of Fishery Survey of India, 18: 18pp.

Sudarsan,D, Somvanshi, VS and John, ME, 1988. Atlas of tunas, billfishes and sharks in the Indian EEZ and adjacent oceanic regions. FSI/FC(FA)/2/88 : 57pp.

Ugo, VC and MMistri, 1991. Production of the meiobenthic harpacticoid copepod Canuella perplexa. Marine. Ecol.ogy Progress. Ser.,ies, 68: 225-234.

Vijayakumaran, K and Varghese, SP, 2011. India's National Report to the Scientific Committee of the Indian Ocean Tuna Commission, 2011. IOTC-2011-SC14-NR09

Vipin, P M, Renju, R, Fernandez, T J, Pradeep, K, Boopendranath, MR and Remesan, MP 2012. Distribution of myctophid resources in the Indian Ocean. Rev. Fish Biol. Fish., 22: 423-436.

Vivekanandan, E and Srinath, M and Kuriakose, S., 2005. Fishing the marine food web along the Indian coast. Fisheries Research, 72 (2-3): 241-252.

WTO, 2010. Trade and Fisheries: Key Issues for the World Trade Organization. WTO Staff Working Paper ERSD-2010-03.

Zaika, VE and NPMakarova, 1979. Specific production of free living marine nematodes. Mar Eco Prog Ser 1: 153-159.

Zhou, S., Punt, A.E., Smith, ADM, Ye,Y, Haddon,M, Dichmont, CM, Smith, DC, 2017. An optimized catch-only assessment method for data poor fisheries. ICES Journal of Marine Science, 75: 964–976.

Zuyev, G, Nigmathullin, C, Chesalin, M and Nesis K, 2002. Main results of long-term worldwide studies on tropical nektonic oceanic squid genus *Sthenoteuthis*: an overview of the Soviet investigations. Bull Mar Sci. 71:1019–1060.