Management Plans for the Marine Fisheries of Gujarat

Indian Council of Agricultural Research
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Foreword

The marine fisheries sector of India is witnessing dynamic changes and fast growth rate in the recent years. Interventions like mechanization of fishing craft, modifications in gear technology, expansion of fishing grounds, increase in fishing effort in days and opportunities in export trade are converting marine fisheries as a prime sector in the country. Gujarat is the leading state in marine fish production of the country due to its extensive coastline, diverse fishery resources and productive marine ecosystem. The stakeholder involvement in the fishery sector has increased tremendously during recent years due to open access nature and promising revenues from the sector in the state. However, overcapacity of the fishing fleet, targeted exploitation of commercially important resources and degradation of ecologically sensitive habitats are likely to negatively impact the marine fish stocks. Management interventions like mesh size regulations, minimum legal sizes, declaration of spatial & temporal closures, setting reference limits on catch & fishing fleet need to be adopted for the sustainability of the marine fishery sector of Gujarat.

Gujarat state, located in the northern Arabian Sea, has a vast continental shelf area, giving scope for extensive fishing grounds. Fishery resources in the region are multi-species in nature and exploited by multi-gear and multi-craft. Continuous monitoring of the resources, development of multi-species stock assessment models and framing and implementation of management plans are essential for sustainable utilization of the resources. Furthermore, capacity building training for fishers and other stakeholders in upcoming technologies like coastal mariculture, open sea cage farming, seaweed farming, development of value-added products, deep-sea fishing, etc. are need of the hour. The research centre of ICAR-CMFRI, Veraval, has attempted a policy brief from the output of various research projects of the Institute, which will be an input base for the policymakers and management advisors of the state to reexamine and improve the existing policies and management rules. The policy brief is a product of the collective effort of the staff of the Veraval Regional Centre of ICAR-CMFRI. The document puts forth relevant discussions that would enable decision-makers to bring in effective measures for the sustainable management of the marine fishery resources of the region.

Dr. A. Gopalakrishnan
Director, ICAR-CMFRI

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Executive summary

Gujarat state of India is blessed with a long coastline, wide continental shelf, highly productive marine ecosystems and an abundant wealth of marine fish resources. As we know, fishery resources are exhaustible if we exploit them without proper management interventions. Gujarat is the state leading in marine fish production of the country with unique fishery resources. Both pelagic and demersal resources contribute more or less equally to marine landings of Gujarat, followed by crustaceans and mollusks. The fishery sector is mainly dominated by mechanized fishing vessels, followed by motorized and very minimally by non-mechanized crafts. Fishing capacity and effort are increasing continuously due to mechanization of fishing crafts, innovations in fishing gears, market demands and export trade, etc. This trend will hamper the sustainability of the resources, leading to stock depletion, degradation of marine ecosystems, low economic returns and conflict among different stakeholders.

The current document attempts to give an insight into the marine fisheries sector, timeline and evolution of marine fisheries in the state, fishing practices, resource-wise fish landings, economics of various fishing operations, the status of commercially exploited resources, biological reference limits/parameters, allied sectors in the fishery, etc. Information on fishing and resource mapping depicting fishing pressure, suitable habitats of resources, fishing rates and sensitive fishing zones are presented. The research attempts on level of exploitation, management of by-catch and discards in the fishery to address sustainability of fish stocks, growth-over exploitation and economic returns to the catch are discussed. Marine fishers along Gujarat can now venture into promising fields like Open Sea Cage farming and coastal mariculture and reduce fishing pressure on wild marine resources. The results of various scientific studies attempted by the Research Centre were discussed with fisher stakeholders, ratified, refined and informed to the Government of Gujarat for sustainable exploitation and management of the sector. The centre has conducted regular stakeholder consultations to identify the issues in the sector and chalked out the management plans to address them through a scientific, public and participatory approach. The major recommendations suggested by the centre based on the scientific studies are

- Compliance with mesh size regulations of fishing gears and minimum legal sizes of commercially exploited resources
- Initiation and implementation of the Log Book system with due importance to the fishery data in the sector
- Regulations on the registration of new fishing vessels and modifications to the existing registration codal rules
- Reduction of fishing fleet to address overcapacity. The fleet optimization

needs to be managed based on the maximum sustainable yield and fleet strength was computed at 6012 mechanized trawlers; 1310 dolnetters; 2314 mechanized gillnetter and 3157 motorized craft.

- Mapping of protective and ecologically sensitive habitats and observation of seasonal/spatial bans
- Improve on-board safety standards and facilities to fishers with strict rules and regulations
- Need to implement post-harvest strategies like hygienic handling, processing and maintaining standards, diversification of value-added products, establishing cold chains and efficient marketing.
- Reinforce and strengthen the management information systems like Vessel Monitoring System (VMS) and Monitoring, Control and Surveillance (MCS)
- Explore the possibilities of certifying the subsistence fisheries existing in the state
- Identification and declaration of fish breeding and juvenile grounds as fish refugia
- Promote and transfer technology on open sea cage farming and coastal mariculture to the coastal fisherfolk
- Mandatory registration of boat building yards and net manufacturing units; standard designs and operating procedures of these units to be ensured.

The fishing sector in the state is open access, multi-craft and multi-stake in nature. The inter-sectoral conflicts occur between dolnet fishers and line trawler fishers of Maharashtra, and with other mechanized gillnetter and trawler fishers. Intra-sectoral conflicts arise between dolnet fishers of adjacent areas of the State concerning their fictitious claim over fishing grounds. Social instability among fisher groups operating dolnets and lack of infrastructural facilities were rated as the foremost reasons for the cause of conflicts. Fishery resources and ecological habitats are unique and distinct from location to location within the state. The fish stocks are dynamic and fishing operations are mainly dictated by market demand and availability of the resources. Therefore, continuous monitoring of resources and scientific research needs to be conducted to understand the fish stock dynamics for sustainable exploitation and management of the resources. Periodic amendments are required on the present recommendations in consultation with scientists, stakeholders and law enforcement authorities.

Acronyms

AIS	:	Automatic Identification System
BPL	:	Below Poverty Line
BRDs	:	By-catch Reduction Devices
c/h	:	Catch per hour
CBA	:	Capture Based Aquaculture
CCRF	:	Code of Conduct for Responsible Fisheries
CCPs	:	Critical Control Points
CIFT	:	Central Institute of Fisheries Technology
cm	:	Centimeter
CMFRI	:	Central Marine Fisheries Research Institute
CO2	:	Carbon Dioxide
CPUE	:	Catch Per Unit Effort
CW	:	Carapace Width
DAHDF	:	Department of Animal Husbandry, Dairying & Fisheries
DD	:	Data Deficient
DML	:	Dorsal Mantle Length
DOD	:	Department of Defense
DOF	:	Department of Fisheries
DW	:	Disc Width
E	:	Exploitation Ratio
EEZ	:	Exclusive Economic Zone
EIC	:	Export Inspection Council of India
EMSY	:	Maximum fishing effort required to attain MSY
ESZ'a	:	Eco-Sensitive Zones
ETP	:	Endangered Threatened and Protected
EU	:	European Union
F	:	Fishing mortality
FAO	:	Food and Agriculture Organization
FL	:	Fork Length
FRP	:	Fiber-Reinforced Plastic
FSI	:	Fishery Survey of India
Ft	:	Feet
GI	:	Galvanized Iron
GMFRA	:	Gujarat Marine Fisheries Regulation Act
GOI WG	:	Government of India Working Group

GoK : Gulf of Kachchh
GPS : Global Positioning System
HACCP : Hazard Analysis and Critical Control Points
HDPE : High-Density Poly Ethylene
Hp : Horsepower
HVC : High-Value Catch
ICAR : Indian Council of Agricultural Research
IMTA : Integrated Multi-Trophic Aquaculture
INCOIS : Indian National Centre for Ocean Information Service
IQF : Individual Quick Frozen
IRCS : International Telecommunication Union Radio Call Signs
ITK : Indigenous Traditional Knowledge
IUCN : The International Union for Conservation of Nature and Natural Resources
IUU : Illegal, Unreported and Unregulated
JBRD : Juvenile By-catch Reduction Devices
JTED : Juvenile and Trash Excluder Devices
K : Growth constant
Kg : Kilogram
$L\infty$: Asymptotic Length
LED : Light Emitting Diode
L_{M50}% : Length at which 50& are Mature
Lmean : Mean Length
Lopt : Optimum Length
LPG : Liquefied petroleum gas
LV : Low Value
LVB : Low-Value By-catch
m : Meter
M : Natural Mortality
MCS : Monitoring, Control and Surveillance
MDTN : Multiday Trawler
MDOL : Mechanized Dolnetter
MFRA : Marine Fisheries Regulation Act
MGN : Mechanized Gillnetter
MLS : Minimum Legal Size
mm : Millimeter
MoEF&CC : Ministry of Environment Forest and Climate Change
MNPS : Marine National Park and Sanctuary
MPAs : Marine Protected Areas
MPEDA : Marine Products Export Development Authority
MoSPI : Ministry of Statistics and Programme Implementation
MSM : Minimum Size at Maturity
MSY : Maximum Sustainable Yield

MTN	:	Mechanized Trawler
NABL	:	National Accreditation Board for Testing and Calibration Laboratories
NGOs	:	Non-Governmental Organizations
NM	:	Non-motorized crafts
NMFDC	:	National Marine Fishery Resources Data Centre
OAL	:	Over All Length
OB	:	Out Board
OBDOL	:	Outboard Dolnetter
OBGN	:	Outboard Gillnetter
PAM	:	Participatory Approach Management
PFZ	:	Potential Fishing Zone
ppt	:	Parts Per Thousands
ReaLCraft	:	Registration and Licensing of Fishing Craft
RGCA	:	Rajiv Gandhi Centre for Aquaculture
RSA	:	Rapid Stock Assessment
SAC	:	Space Application Centre
SC/ST	:	Scheduled Caste/Scheduled Tribe
SFM	:	Size at First Maturity
SST	:	Sea Surface Temperature
t	:	Ton
TED	:	Turtle Excluder Devices
TL	:	Total Length
UNCLOS	:	UN Convention on Law of Seas
VHF	:	Very High Frequency
VMS	:	Vessel Monitoring System
WFM	:	Weight at First Maturity
Z	:	Total Mortality/Instantaneous Mortality

1. Introduction

The fisheries sector plays a vital role in the country's economy through export earnings, providing livelihood options to fishers and a number of other stakeholders, and protein to the human population. Gujarat ranks top among the maritime states of India in marine capture fisheries production (7.86 lakh t in 2017) owing to abundant marine fishery resources. It has about 20% (1600 km) of the country's coastline, 33% of the continental shelf area (1,64,000 km^2) and more than 2,00,000 km^2 EEZ. Fishery-related livelihood options are often complex, dynamic and adaptive. Apart from active fishing, fishers are also engaged as laborers, fish transporters and mediators in trade, fishnet menders, boat builders, processors, traders, exporters and fish farmers in the domain of marine fisheries. Marine fisheries can address vulnerable issues in connection with the economy and food security, but are susceptible to influences such as over-exploitation of resources, environmental degradation by anthropogenic and naturally occurring events, climate change, etc. Marine living resources are natural, renewable, but exhaustible and need to be monitored and managed sustainably. There is a necessity to supervise, control and manage fishing practices and reduce harvest pressure to achieve sustainability of the sector for the benefits of future generations.

The continental shelf is widest off Gujarat, offering scope for exploitation of several types of finfish and shellfish resources by both traditional and mechanized fishing practices. Gujarat fishery is unique in its resources due to the sustained productive ecosystem through southwest monsoon upwelling and northeast monsoon winter convective mixing. Trawlers, gillnetters and dolnetters are the main fishing crafts in the mechanized sub-sector, while FRP, plank-built boats and canoes figure more prominently in the non-mechanized and artisanal sub-sectors. The pattern of marine fish landings in Gujarat during the past decades revealed a gradual shift in the fishing operation from single day artisanal sector to multi-day mechanized and motorized sectors. Trawlers target mainly fish, cephalopod and crustacean resources like sciaenids, ribbonfishes, groupers, lizardfishes, threadfin breams, shrimps, cuttlefishes, squids, etc. and contribute the bulk of the total catch, while gillnetter targets large pelagic resources like seerfish, tuna, dolphinfishes, pomfret and sharks. The dolnetters target Bombayduck, non-penaeid prawns, pomfrets and large sciaenids. The bulk of the catch is exported to foreign countries due to lower domestic consumption in the state.

Pelagic finfish resources contributed nearly 38% of the total marine fish landings of Gujarat in the year 2018, followed by demersal 30%, crustaceans 25% and mollusc resources (7%). The increase in crustacean share is mainly due to the non-penaeid shrimps, followed by penaeid prawns and crabs. Mollusc landings have shown a 1% decline in contribution in comparison with the previous year due to the significant decrease in cuttlefish catch (nearly 7,000 t) (Fig. 1.1).

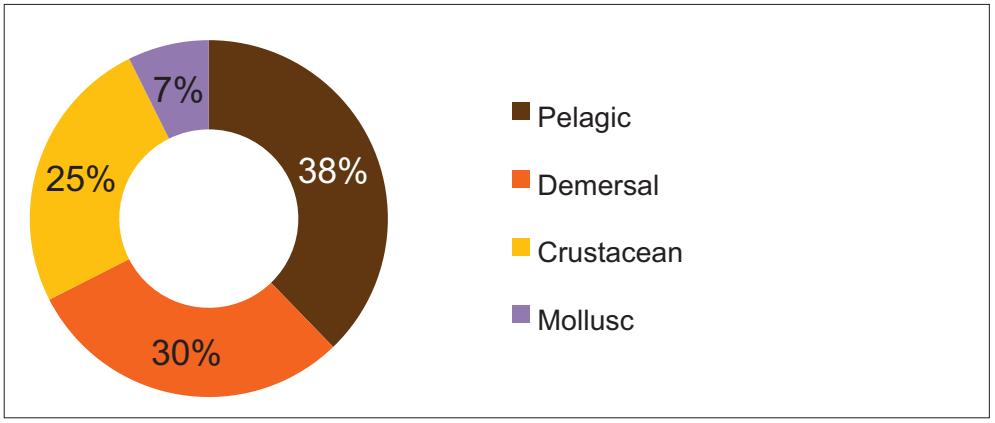


Figure 1.1. Relative resource-wise contribution to the marine fish landings of Gujarat in 2018

The non-penaeid prawns contribute maximum (1.41 lakh t–18.12% to the total catch) among all the resources in 2018, followed by ribbonfishes (0.87 lakh t), bombayduck (0.73 lakh t), croakers (0.47 lakh t), threadfin breams (0.37 lakh t), penaeid prawns (0.34 lakh t), other perches (0.29 lakh t), squids (0.27 lakh t), cuttlefish (0.27 lakh t), catfishes (0.25 lakh t), rock cod (0.21 lakh t) and Coilia (0.17 lakh t), etc. (Fig. 1.2).

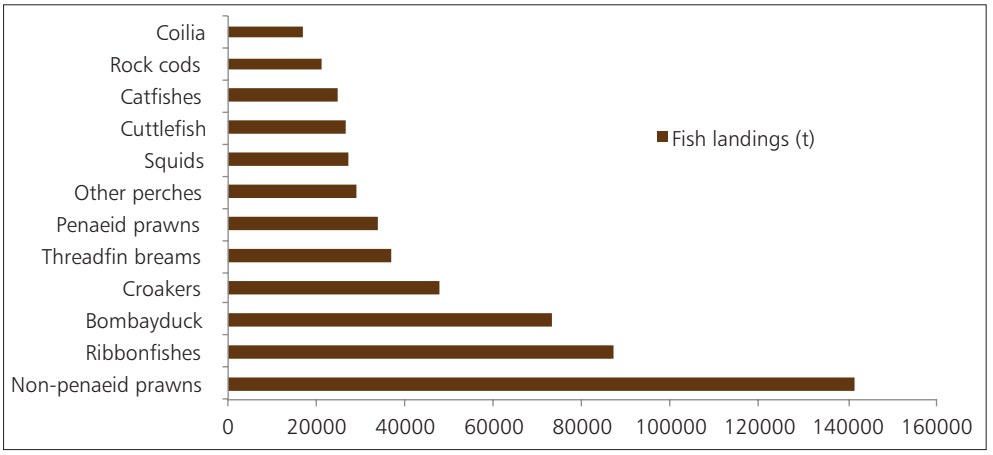


Figure 1.2. Catch (t) of major fishery resources along the Gujarat region

In district-wise production, the Gir-Somnath ranked first with 3.60 lakh t, followed by Dev Bhoomi Dwaraka (1.06 lakh t), Porbandar (0.95 lakh t), Amreli (0.85 lakh t), Junagadh (0.65 lakh t), Kachchh (0.58 lakh t), Navsari (6,380 t), Valsad (4,512 t), Jamnagar (2,385 t), Morbi (206 t) and Bharuch (3 t) (Fig 1.3).

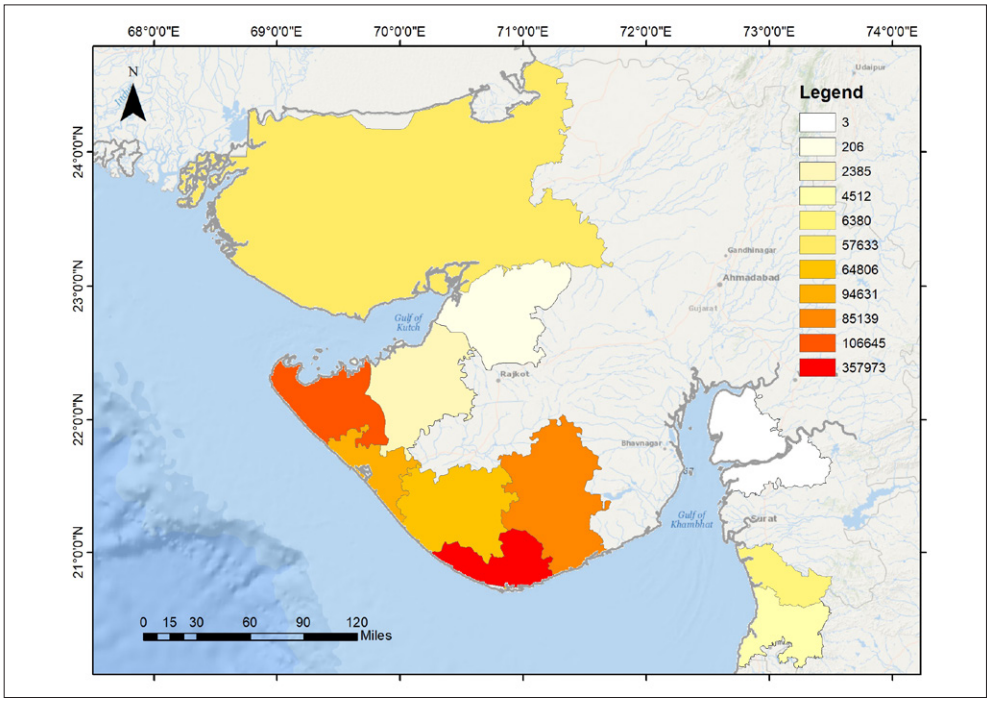


Figure 1.3. District-wise marine fish landings of Gujarat in 2018

2. Overview of marine fisheries scenario of Gujarat

Demographic profile of Gujarat

Fishing has been considered as a primary livelihood option since time immemorial, for the occupants of the coastal belt in Gujarat, stretching along 1,600 km with 12 maritime districts (presently 15) namely Valsad, Navasari, Surat, Bharuch, Anand, Bhavnagar, Amreli, Junagadh (presently Junagadh and Gir-Somnath), Porbander, Jamnagar (presently Jamnagar and Devbhoomi Dwarka), Rajkot (presently Rajkot and Morbi) and Kachchh (Fig. 2.1). Out of 247 marine fishing villages in the state, the maximum number is in Kachchh district

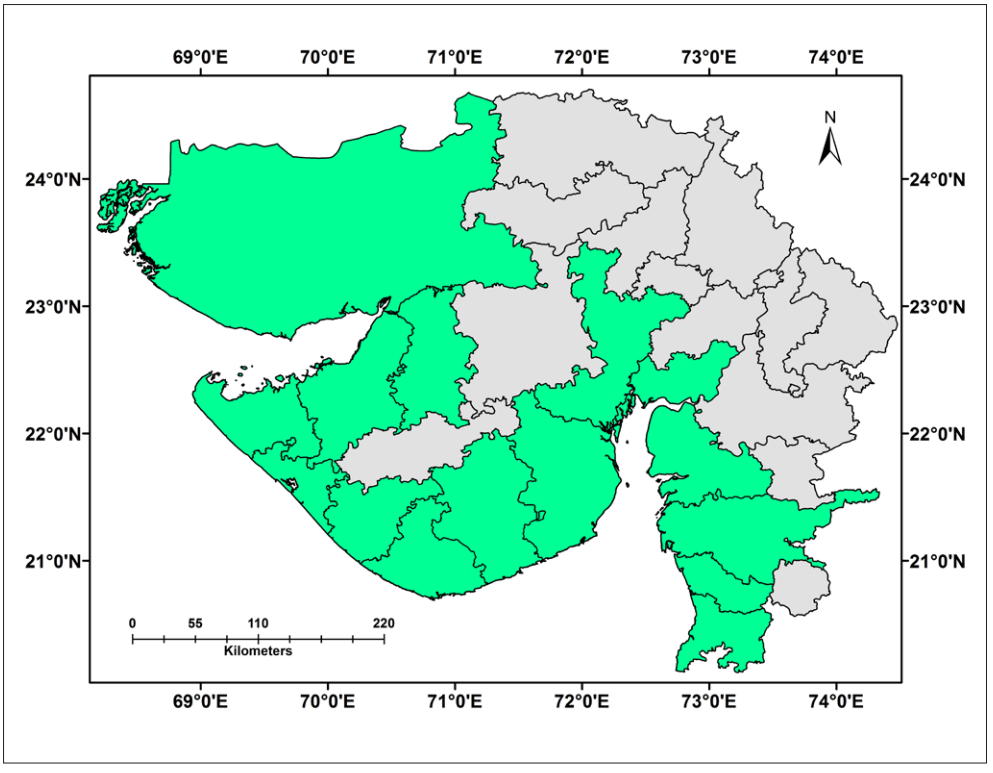


Figure 2.1. Coastal districts of Gujarat, India

(68), whereas only one fishing village was recorded from Anand district. The number of fishing villages in the remaining districts varied between 4 and 27. The total number of marine fish landing centres in the state was 121, out of which Valsad and Kachchh districts had 22 centres each. A substantial shelf area of 64,800 km^2 falls in the depth range 0-60 m, which can be conveniently fished with traditional as well as mechanized craft. The total export of marine products from the state was 82,558 t in 1995-96 with a value of ₹395 crores, which has increased to 3,12,568 t in 2017-18 with a value of ₹5,071 crores. The Pipavav port is the major export gateway for marine products from the state with minor contributions from Kandla and Mundra. The major items of export were frozen fish, shrimp, squid and cuttlefish (http://www.mpeda.gov.in). The other features related to the marine fishery in the state are presented below in Table 2.1.

Table 2.1: Marine Fisheries Profile of Gujarat, India

Geographic location	023.13°N; 072.41°E
Coastline	1600 Km
No. of fish landing centres (2010)	123
Fish landings (2018)	7.80 lakh t
Crafts in the industry (2017)	27,347
Mechanized	16,377
Motorized	10,894
Non-motorized	76
Fishing gears used	Gillnets, bag nets, liners, dolnets, cast nets, seiners & trawl nets
Processing plants (2010)	47

Marine Fishery Census 2010 – CMFRI and ReaLCraft, Govt. Of Gujarat 2017

The state has a marine fisher population of about 5.59 lakh (1,03,072 families) (source. 2011, Commissioner of Fisheries, Gujarat), out of which the active fishermen are 2.18 lakh. Of the total fisherfolk population, Junagadh accounted for 27%, followed by Valsad (15%), Jamnagar (13%) and Porbander (9%). The fisher folks operate diverse types of craft-gear combinations with regional and seasonal variations all along the coastline. The sex ratio is close to unity, with 2.89 lakh male and 2.70 lakh females (Census, 2007). Out of 2.18 lakh active fishers, 1.49 lakh are males and 0.69 lakh are females. The average family size is 5.4, with a maximum of 7.96 in the Amreli district.

Table 2.2: Occupational profile of active fisher population of Gujarat

Activities	Numbers involved
Active Fishing	2.18 lakh
Marketing of Fish	36,376
Repair of Net	21,670
Processing of Fish	N.A
Fish Seed Collection (Hatchery)	483
Ornamental Fish	102
Others	204

Source: Census 2007, Commissioner of Fisheries, 2011

About 68% of fisherfolk, excluding children, are involved in active fishing (42%) and other allied activities (26%) (Table 2.2). The fishers are also engaged in other allied activities, such as laborers (36%), marketing (35%), making/repairing net (16%), peeling (9%) and curing/processing (3%). Women outweighed men in allied fishing activities, accounting for about 69% of the total workforce. Among the major fishing allied activities, women dominated in marketing (88%) and peeling (87%). The largest number of fisherfolk engaged in allied fishing activities was from the Junagadh district (34%). Almost 42% of the laborers were from the Junagadh district, followed by Amreli and Porbandar (15% each). Major share (62%) of those engaged in the marketing of fish belonged to Valsad (21%), Junagadh (17%), Jamnagar (13%) and Kachchh (11%) districts.

Social profile of the fishers

ICAR-CMFRI had undertaken a study in the coastal districts of Gujarat. The excerpts of the study related to literacy, health, income, savings and indebtedness are given below:

Literacy: A larger section of 56% of fisherfolk remained unschooled and the remaining 44% (excluding children below five years) were having varying levels of education. Primary, secondary and above the secondary level of education acquired by 23%, 19% and 2% of the fisherfolk population. Nearly 78% of the marine fisherfolk in Navasari district had at least primary level of education, followed by Surat (67%), Valsad (63%) and Porbander (57%). The proportion of unschooled fisherfolk was highest in Rajkot. The dropouts identified in the State were 6.23%, out of which the highest number of dropouts was at the primary level (10.48%) followed by secondary level (5.18%).

Poverty and Indebtedness: The average family size in the state is 5.4, with a maximum of 7.96 in Amreli district and 40% of the population has a family size between 5 to 6 members (Livelihood status of fisher's in India, 2014). Poverty

Timeline of Marine fisheries of Gujarat

Used traditional techniques to harvest fish.

•

Fishing was restricted in near seashore area, commercialization was not started.

•

Traditional gears were made up from cotton material

•

Mechanized goods carrier vessels, Vahan was introduced

1950-1960

Traditional craft was introduced called as 'Sadh'.

•

Radio was introduced in fishing villages to getting update weather related information.

•

Introduced motorized fishing craft at the end of the decade

•

Trawlers were introduced in the fishing sector

1960-1970

Fisheries department actively involved in technology transfer to fishermen.

•

Jetties constructions were initiated.

•

Nylon was used for fishing gear make

•

Gillnetter were introduced in the fishing sector and also increased the number of motorized craft.

•

Compass and radio was used as navigational purpose.

•

Fish catch was preserved by only traditional methods such as drying or salting.

1970-1980

Ice plants were established.

•

Started using dolnets in various parts of the state.

•

Trawl net was used mostly in all parts of state as starting of mechanized fishing.

•

FRP craft was built.

•

Engage in multiday fishing and Used ice on-board during fishing.

•

Modern method was adopted to preserve catch for a long time such as freezing .

1980-1990

Fisheries organizations were established for the transfer of technology to fishermen.

•

Length and breadth of the jetty was raised to facilitated more crafts.

•

Construction of fish processing plants, peeling sheds and drying yards.

•

Initiating of multi-day fishing in the region

•

Fuel pumps start establishing near to the jetties.

1990-2000

Gujarat Fisheries Act 2003 came into effect.

•

Impose of Fishing ban was initiated from June to August.

•

Usage of communication and navigational equipment like Mobile phones, fish finder, GPS, VHF and Wireless.

•

Net mending sheds, peeling sheds and auction halls were developed .

•

Introduced modern fish hold and cold storage facility within the fishing craft.

2001-2010

Infrastructure development of mechanized craft, fishing gear, jetty up-gradation, an auction hall, drying sheds, ice plants, etc .

•

Fishing with high power engines

•

Popularization of value added products, *surimi*, fish meal and chitin & chitosan

•

Desimination of latest farming technologies like sea cage farming, seaweed, crab and lobster fattening etc.

•

The wooden trawlers are start upgrade into FRP

2010-

and deprivations among the fisher communities have long been reported. There were 15,784 (25%) families below the poverty line, the largest proportion found in Rajkot (73%) and Anand (65%) (Marine Fisheries Census, 2010).

The savings details of the households indicated that 27% of them have no savings, which results in the indebtedness of fishers. The major lending source was the private money lenders and 55% of the borrowed money was used for the purchase of craft/gear and other fishing-related equipment.

***Health**:* Life expectancy in Gujarat is 68.7 years, which is 0.8 year higher than that of the country's average. The average birth weight of infants among the fisher households is 2.48 kg, 2.45 kg for male and 2.52 for female. The ease of access to infrastructure related to health care determines the better health status of the fisherfolk. Gujarat is having comparatively less access to health care as the average accessible distance to hospital and primary health centres in Gujarat is 18.37 and 6.06 km, respectively.

Status and Evolution of fishing craft and gear operation in Gujarat

At the time of formation of the State in 1960, the strength of the fishing fleet was 3,531 consisting of 314 mechanized and 3,217 non-mechanized boats and canoes. The size of these boats did not exceed 12 meters OAL. The engines horsepower was below 30. The fishing area covered was up to 25 meters in depth. The fishing method was predominantly surface and bottom set gillnetting, bag (dol) netting and hook and line fishing. The introduction of mechanized boats with inboard engine started in 1956, first at Veraval, one of the most important fisheries harbors of the state, though a few country crafts fitted with outboard engines had been in operation since 1953. The traditional fisheries accounted for the bulk of the State's catches until the end of the sixties. With the beginning of the seventies, however, the picture gradually began to change, owing to more and more stakeholders entering the mechanized sector employing mechanized trawlers, dolnetters and gill-netters. There were 27,347 crafts in the fishery in 2017, of which 16,377 were mechanized, 10,894 motorized and non-motorized formed the rest (76). Trawlers accounted for 61% of the mechanized crafts owned by fisherfolk, followed by gillnetter (23.8%) and dolnetters (15.2%) (source-ReaLCraft, 2017).

Table 2.3: District-wise marine craft owned by the fisher population (ReaLCraft, 2017)

District/Place of registry	Trawlers	Gillnetter	Dolnetters	Other mechanized crafts	Motorized crafts	Non-motorized crafts
Ahmedabad					1	
Veraval	5293	645	218	18	7090	2
Jamnagar	488	2399	2	1	325	1
Jafrabad	159	9	939	19	23	
Porbandar	2901	79	2		1873	
Bhavnagar		172			34	
Rajkot		1			155	2
Bhuj/Kachchh	29	13			1388	3
Valsad	1065	553	1315		1	27
Navabandar	19		5			2
Baruch		32	1		1	
Surat					3	39
Total	9954	3903	2482	38	10894	76

The district-wise ownership of craft and gear showed that 53.2% of the mechanized trawlers belonged to Veraval and 29.1% to Porbander, which altogether constituted 82.3% of trawl fleet. Mechanized gillnetter was mainly observed in Jamnagar (61.4%), Veraval (16.5%) and Valsad (14.1%) districts. The majority of mechanized dolnetters belonged to the Valsad district (52.9%), followed by Amreli (37.8%) and Junagadh (8.8%) districts (Table 2.3). Important gears owned by fisherfolk were trawl nets, gillnets, bagnets, hooks & lines, seines and castnets. The sharing pattern was more visible in seines, trawl nets and gillnets (MoSPI, 2016).

Trawlers

Trawl nets are locally known as "*Oza*." Along the Saurashtra coast, trawl fishing first started in 1965, which was limited to single-day operations. Longer duration trawling for three days started in 1975 and 11 days in 2011 due to increase in storage capacity in the boats. The percentage of long trip fishing increased in 1980 onwards and in the present situation, 90% of the trawl fishing extends up to 15 days. The target fishing by trawls started in 2005, mainly for threadfin breams. Recently the trawlers have been targeting ribbon fish and squid due to their increased demand in export markets and the emergence of EU approved export units. Trawlers carry 10 to 15 trawl nets in each voyage.

Along with it, they also keep gillnets and hook and line and operate it as and when required depending upon the species availability. The cod-end mesh size for catching ribbon fishes is 40-50 mm with a front panel having a mesh size of 2,000 to 3,000 mm while trawl net for other fishes is having a mesh size of 35-35 mm and 180-250 mm at the cod-end and front panel, respectively. Single-day trawlers are having trawlnet of cod-end size of 15-20 mm specifically to catch prawns with a front panel of mesh size 50-80 mm. Target fishing is done for two hauls and they change the gear immediately upon not getting enough catch of the targeted fish. As shrimp catch is poor in recent years and it also requires more time and labor for sorting the by-catch and debris, shrimp trawling is limited to only single day trawlers.

Trawlers along the Gujarat coast were usually made up of either completely wood or a combination of wood and FRP and are locally known as "*halvalii*" boat. Boats are having an overall length (OAL) of 12-16 m with engine power of 88-118 HP. Trawl nets with cod mesh size 15-40 mm is predominantly used. Single-day trawlers are operated up to a depth range of 20-100m and restricting fishing within the Indian EEZ off Gujarat. In the 1980s, the depth of operation was 20-60 m (Rao and Kasim, 1985). The fish trawlers operate both northward up to Kachchh and southward, extending up to Goa and Karnataka. The fishing season usually starts in the second half of August once the monsoon fishing ban from June to August is lifted. The present cost of a single day trawler ranges between 12-15 lakh rupees and multi-day trawlers are in the range of 35- 40 lakh rupees. Crew members in the single day trawlers are 3-4 and for multi-day trawlers, 8-12 depending on the duration of voyage.

Gillnetter

The use of gillnets started in the 1960s, which is known as "*Kandari jal*," made up of cotton and nylon along the coast. *Jada jal* (big mesh gillnets) and *Chokla jal* (small mesh gillnets) were initiated in 1975, but the *Chokla jal* dominating in the fishery due to less catch of seer fish and black pomfret in Kandari net. Nylon monofilament gillnets were introduced in 1976. The *Mavol jal* (thick nylon monofilament) was introduced in 2000 in place of Jada jal. In 2009, *chokla jal* was modified into *Ghaghara jal,* expanding its width up to 9 to 10 m. Recently, a new gillnet called "*Khatri jal,*" which is a modification of *Chokla jal* was introduced. Before 1975, all the gillnetters of 8 m OAL were made up of wood. Fiber boats were introduced in

1975 and the gillnetter size was upgraded to 11 m OAL in 2001. Long trip fishing by gillnetter started from the year 1995 in the region.

Mechanized gillnetter

Mechanized gillnetter usually made up of FRP or combination of wooden keel and FRP, which is locally known as "*Bethadi*." The operation of mechanized gillnets started along the Gujarat coast in 1990s. The MGN (*Jada jal*) exclusively used for the exploitation of large pelagic like tuna, ribbonfishes, dolphinfishes and seerfish. The depth of operation ranges from 50-200 m and the duration of the fishing voyage is about 5-25 days. The size range of the craft is between 12-15 m. Construction cost ranges between 22-25 lakh rupees depending on the size of the craft. The number of fishing crew are 7-10 depending on a fishing voyage.

OBGN (Hodi)

The outboard motor FRP gillnetter with an overall length (OAL) of 8-11 m is locally known as "*hodi*." The operational depth range for OBM gillnetter is from 10-50 m commonly along territorial and far waters off Gujarat. *Hodi*'s are equipped with outboard motor engines either in the aft or forward location of the craft. Each boat carries two engines when they go for long trip fishing as a safety measure. The duration of a fishing operation is for 1-3 days. The construction cost of *hodi* ranges from 3-5 lakh rupees, depending on size.

Dolnetters

Locally known as “Dor” along the Saurashtra coast, these bag nets are about 70-100 m long and each boat carries 3-5 such nets. The cod-end mesh size is 25-35 mm and the front panel has mesh size 110-240 mm. They also go for long trip fishing lasting about 4 to 8 days, taking 15-25 hauls. In 1975, the length of the dol net was 40 feet and it became 100 feet by 2001. The dol net mechanization started in 1966 and 100% mechanization happened only by 1995. Winch and pulley system came in 2001 and dolnetters started carrying ice since 2006. The overall length (OAL) of dolnetter is in the range of 12-14 m with an engine power of 85-110 HP. Mechanized dolnetter s operating in multi-day fishing are equipped with a winch and cold storage facility. The depth of operation varies from 10-60 m. The duration of the voyage for mechanized dolnetters is 4-8 days

and for motorized dolnetter’s it is limited to 1-2 days. The engine power used for searching the fishing ground in earlier days, but in recent days it is also used for shooting, pulling, hauling, etc. The construction cost of mechanized dolnetter’s ranged from 12-15 lakh rupees and for outboard dolnetter’s it is around 5-6 lakh rupees. Number of crew in the mechanized craft is 8-10 and for motorized craft, a crew size of 3-4 is prevalent.

3. Marine fish production estimates

Marine fish landings trend along Gujarat

During 1985 – 2018, the marine fish production of Gujarat varied between 2.07 lakh t (in 1988) to 7.86 lakh t (in 2017) (Fig. 3.1). The landings showed an increasing trend during the first phase from 2.88 lakh t in 1985 to 7.32 lakh t in 1998, after which it showed a declining trend up to 2004 (4.09 lakh t). Fish catches showed an increasing trend during the recent decade (4.22 lakh t in 2005 to 7.80 lakh t in 2018). In district-wise production, the Gir-Somnath ranked first with 3.60 lakh t, followed by Dev Bhoomi Dwaraka (1.06 lakh t), Porbandar (0.95 lakh t), Amreli (0.85 lakh t), Junagadh (0.65 lakh t), Kachchh (0.58 lakh t), Navsari (6380 t), Valsad (4512 lakh t), Jamnagar (2385 t), Morbi (206 t) and Bharuch (3 t) (CMFRI, 2019).

Sector-wise contribution of landings of Gujarat showed dominance of mechanized fishing vessels with 6.96 lakh t, followed by motorized vessels 0.84 lakh t and non-motorized vessels merely 397 t (Fig. 3.2). Multi-day trawlers (MDTN) mainly contribute to the mechanized sector, followed by Mechanized Dolnetters (MDOL)

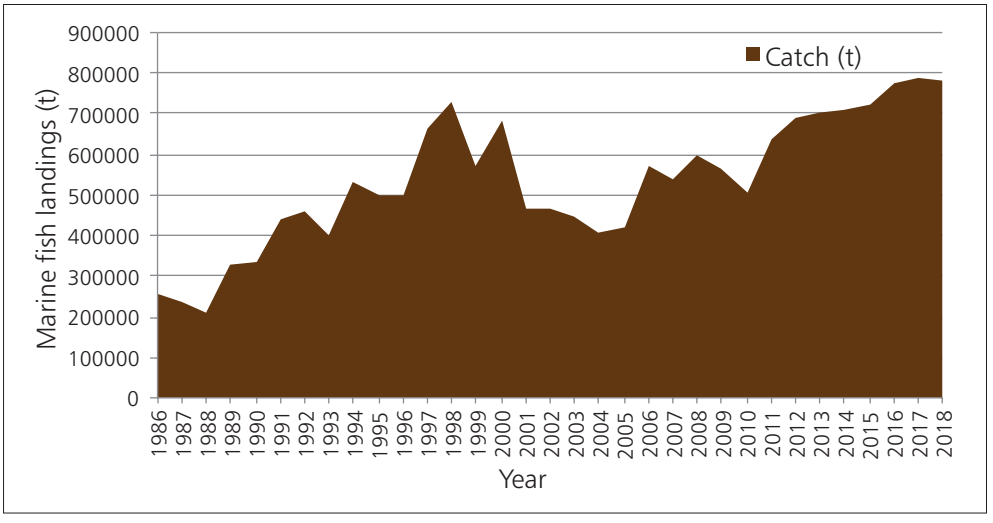


Figure 3.1. Annual marine fish landings of Gujarat (1985-2018)

Non-penaeid prawn fishery

Along the Gujarat coast, non-penaeid resources were landed majorly by dolnetters, but in recent day's trawler's contribution is also significant. The fixed bag nets operating in the inshore waters of Gujarat and Maharashtra register the bulk of non-penaeid landings in the country (70-75%), out of which about three-fourth is constituted by *Acetes* spp (Annual Report of CMFRI, 2019). The *Acetes* species are locally called as '*jawla*'. In recent years, non-penaeid prawns are the leading contributing resources to the total marine landings of Gujarat as nearly 1.40 lakh t in 2018 (average of 13.88% during 1994-2018). The diet of commercially important species like ribbonfish, bombayduck, catfishes, cephalopods, carangids, threadfin breams consists of non-penaeid prawns (mainly *Acetes*) are a key diet item. A major portion of the catch was going for sun drying (used as a fish meal) and small quantities were for domestic consumption and chutney powder. By considering the importance of non-penaeid prawn as a key prey item, a detailed study on exploitation pattern, stock status and efficient utilization of the catch need to be attempted for the integrity of the trophic ecosystem and sustainable exploitation of the fishery resources.

and Mechanized gillnetter (MGN). The highest catch rates were observed in the case of MDTN (4.69 t/unit), followed MDOL (2.44 t/unit) small quantities and MTN (0.65 t/unit). The catch per unit effort (kg/h) was the maximum for the MDOL (91 kg/h), followed MTN (77 kg/h), MDTN (42 kg/h), OBDOL (36 kg/h) OBGN (13kg/h) and MGN (7kg/h).

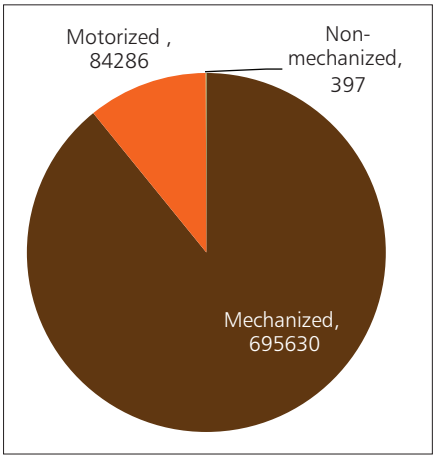


Figure 3.2. Sector-wise marine fish landings (t) of Gujarat (2018)

Pelagic fishery resources contribute as high as 39% to the total marine fish landings of Gujarat, followed by the demersal fishes (31%), crustaceans (22%) and cephalopods (8%). The average contribution of major fishery resources for the period 2006 to 2018 along the region are non-penaeid prawns (89290 t), ribbonfishes (85298 t), croakers (63175 t), bombayduck (57073 t), cephalopods (54414 t), catfishes (35517 t), threadfin breams (35279 t), penaeid prawns (33162 t), crabs (16968 t) and other perches (16102 t). The major pelagic resources include bombayduck, ribbonfishes, tunas, seerfishes, carangids,

mackerel, anchovies and shads. The major demersal fishes landed are sciaenids, threadfin breams, catfishes, groupers, lizardfishes, bull's eye, flatfishes, other perches and sharks. Penaeid and non-penaeid prawns, crabs and lobsters constitute the crustacean fishery, while squids and cuttlefishes contribute to the cephalopod landings. The decadal average landings of major resources are depicted in Figure 3.3.

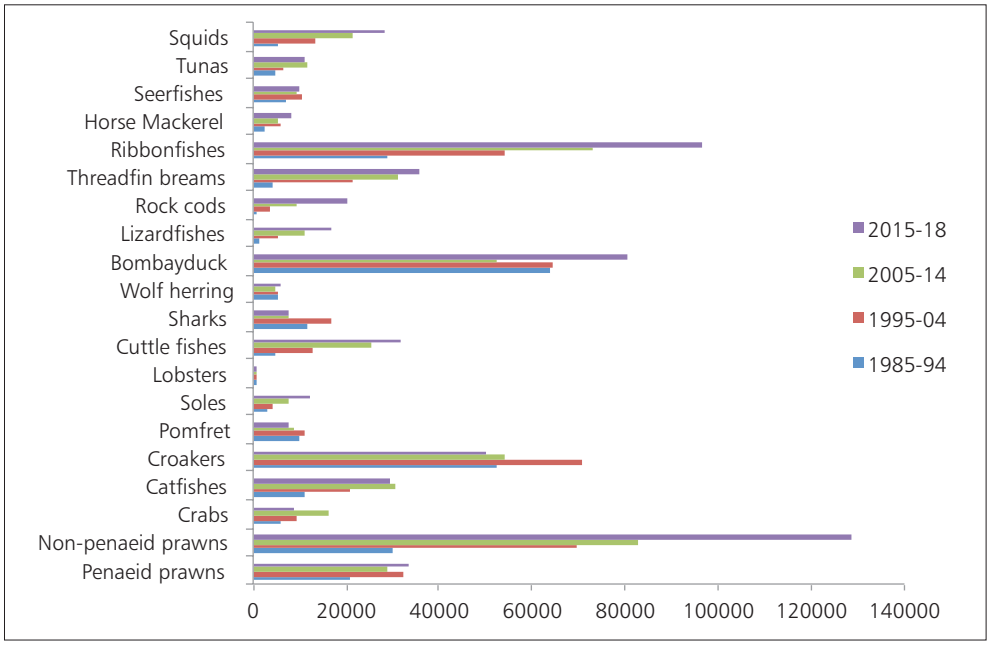


Figure 3.3. Decadal average landings (t) of major resources of Gujarat

Resource-wise fish landings by major gears

Production trends of major resources in Mechanized Dolnetters (MDOL)

The mechanized dolnetter's (MDOL) contribute 25.63% to the total marine fish landings of Gujarat. MDOL has emerged as the second most dominant gear,

Golden anchovy fishery

Golden anchovy *Coilia dussumieri* (Gold spotted grenadier anchovy) are known to have a discontinuous distribution along the Indian coast. The landings of golden anchovies ranged from 6,298 t to 25,115 t during the period 1994-2018. The period from 1994-2000 was found to be the most productive phase of the resource with the average annual landing of 17,640 t. The subsequent two decades showed a declining trend in catches with an average annual catch of 11,562 t (2001-2010) and 9,035 t (2011-18). The dolnets (86.38%) are the major gear accounting for the harvest of golden anchovies. The multiday trawlers (11.27%) are the next most productive means of harvesting the resource. The golden anchovy fishery in the region has shown gradual decline in catch and catch rates. The species is one of the key prey items for several predatory fishes like Bombayduck, Lizardfishes and perches which form lucrative fishery in the region. The key role played by the resource in the food chain (predation mortality) needs to be considered in addition to declining catch rates while setting up any reference limits (catch limits) for the fishery.

contributing to the total marine fish catch. Non-penaeid prawns were the most dominant group landed by this gear, with an average catch of 78,031 t from 2006 to 2018, followed by bombayduck (56,227 t), croakers (11,429 t), ribbonfish (10,354 t) and catfishes (9,517 t) (Fig.3.4).

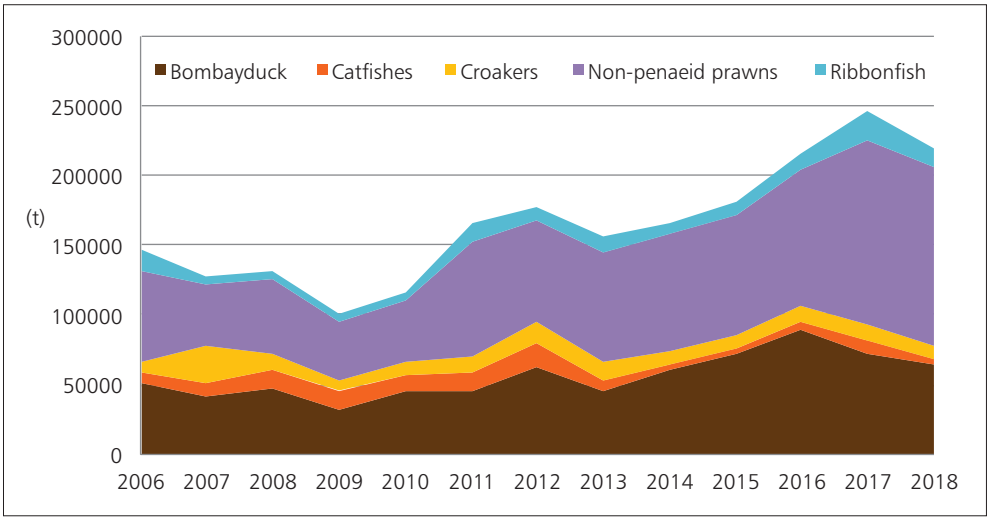


Figure 3.4. Time series catch of major resources landed by multi-day dolnetters (2006-18).

Production trends of major resources in Multi-day trawlers (MDTN)

The mechanized multi-day trawlers (MDTN) contribute 51.13% of the total marine fish landings of Gujarat. MDTN has emerged as the most dominant gear, contributing to the total marine fish catch after 2006. Ribbonfish was the most

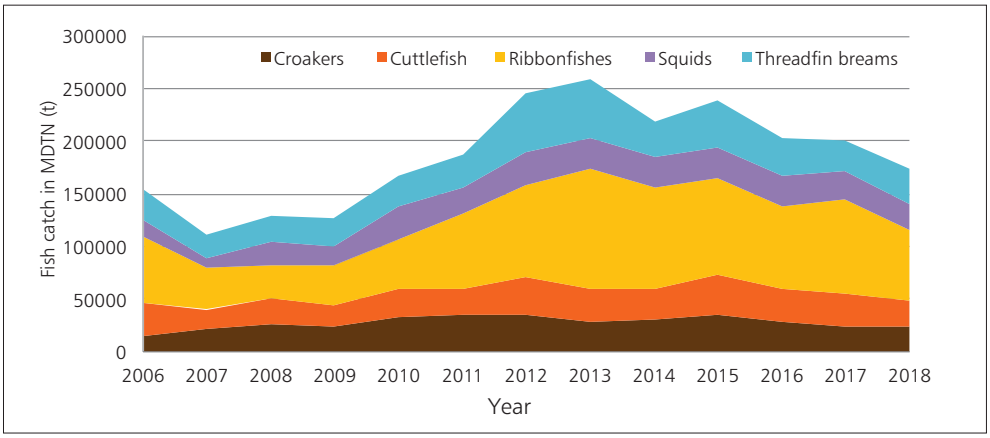


Figure 3.5. Time series catch of major resources landed by multi-day trawlers (2006-18).

dominant resource with an average landing of 70, 281 t from 2006 to 2018, followed by threadfin breams (34,371 t), cuttlefishes (28,897 t), croakers (27,454 t) and squids (24,177 t) (Fig.3.5).

Croakers fishery

Croakers are fishes belonging to the family Sciaenidae, which form one of the major demersal fishery resources with high species diversity along the Indian coast. The Northwest coast of India encompassing two large maritime states, i.e., Gujarat and Maharashtra with a combined coastline of 2,320 km and characteristic wider continental shelf is believed to be one of the most productive regions of the sciaenid fishery. The landings of croakers in the Gujarat state were fluctuating between 37,674 t and 1,15,964 t over the period of 1994-2018. The period of 1994-2000 was the most productive period for the fishery with an average annual landing of 92,400 t. The following decade (2001-2010) saw a drastic decline in landings with recorded annual average landings of only 48,448 t. The present decade (2011-18) showed marginally improved catch over the previous decade and

registered an average annual catch of 61,733 t. The landings of croakers not only declined in absolute tonnage but also in its percentage contribution to the total marine fish landings of the state. The average percentage contribution of the croakers to the total landings of state during 2011-18 was 8.64%, which was lower than figures of 9.69% (2001-10) and 15.63% (1994-2000) recorded in previous decades. Croakers are a multi-species fishery with more than a half a dozen species forming substantial fishery in the region. The species can be broadly classified into two groups *viz.,* small to medium-sized croakers and large-sized croakers. The smaller and medium-sized species belong to genus *Johnius, Otolithes,* and *Nibea* and have faster growth and shorter life span. The Gujarat coast is known for the fishery of large-sized croakers namely *Protonibea diacanthus* (Ghol) and *Otolithoides biauritus* (Koth) which are slow-growing species and attaining late maturity (L_{m50}% > 85 cm, Ghosh *et al.,* 2009 & 2010). Like most of the tropical fishery, it is also a multi-gear fishery with the dominance of multiday trawlers (MDTN) accounting for 51.41% of the total landings, followed by multiday Dolnetters (MDOL, 19.59%), outboard gillnetters (OBGN, 18.77%) and multiday gillnetters (MGN, 5.13%). The gear-wise contribution is not consistent across all the species. In the case of Ghol and Koth, the contribution of MDTN reduced to 36.56% and the multiday gillnetters (MGN) emerged as the second most dominant gear with a contribution of 24.49%. The contribution of Ghol ranged between 4.57% and 7.09% of the total sciaenid fishery during 2007-18. The Koth contributed marginally higher than Ghol ranging from 8.14% to 18.11% over the period of 2007-18. The two species, contribute lesser in tonnage but have higher market value. These two species are not only sought for meat, but also for high valued air bladder. The croaker catch and catch rates, in general, have decreased over the years and hence an effective management regime is a must to sustain the resources in the future. The substantial biological distinctness of Ghol and Koth from other smaller croakers renders it more vulnerable to the fishing pressure and hence a separate assessment and management strategies are required. Most of the estimates of potential yield (Maximum Sustainable Yield) made for the resources are based on catch and effort data that too for the entire group undermining the differences in life-history traits among species. Further, in the case of species like Ghol and Koth where the bulk of the landings is comprised of immature specimens, the estimates of such reference points should be made by considering the age structure (= length composition) of the catch and healthy spawning stock biomass. The conventional surplus production models with no information on biological aspects would be a serious compromise. A stringent management regime is required to revive the fishery of these two flagship croaker species from the region.

Production trends of major resources in Mechanized Gillnetter (MGN)

The mechanized gillnetters (MGN) contribute 5.84% of the total marine fish landings of Gujarat. The MGN has emerged as one of the important gears significantly contributing to the total marine fish catch as large-sized commercially important pelagic and demersal catch were dominant in gear. Croakers formed the most dominant group with an average catch of 5,250 t from 2006 to 2018, followed by catfishes (5,080 t), silver pomfret (3,114 t), sharks (2,397 t) and longtail tuna (2,249 t) (Fig.3.6).

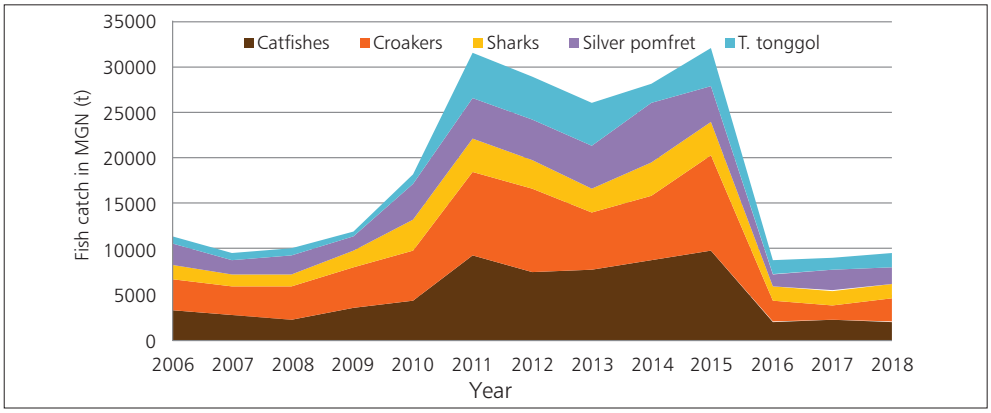


Figure 3.6. Time series catch of major resources landed by multi-day gillnetter (2006-18).

Production trends of major resources in Mechanized trawlers (MTN)

The mechanized trawlers (MTN) going mostly for daily trips contribute 6.57% of the total marine fish landings of Gujarat. Non-penaeid prawns formed the most dominant resource

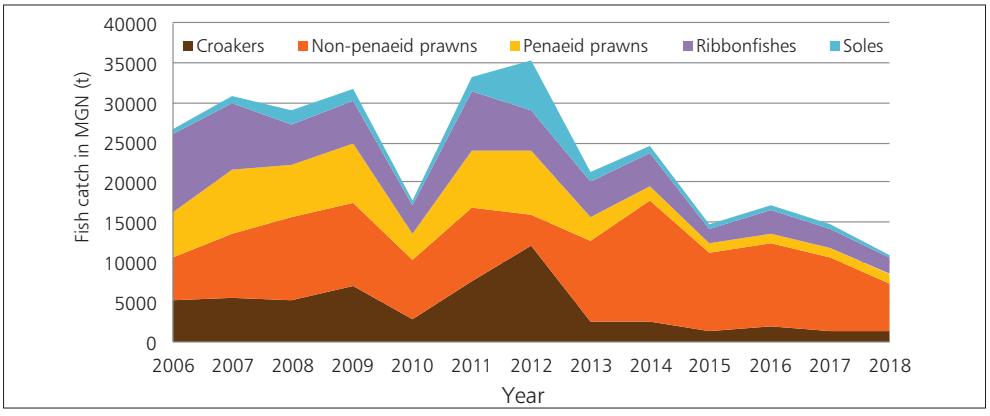


Figure 3.7. Time series catch of major resources landed by single day trawlers (2006-18).

Silver pomfret fishery

Fishes of the genus *Pampus*, popularly known as pomfrets or butterfishes are among the most relished plates of seafood. The northwest coast of India is traditionally known for good landings of pomfrets. The silver pomfret fishery is supported with two species, black pomfret and Chinese silver pomfret. The silver pomfret from Indian waters have long been believed to be *Pampus argenteus*, but a recent study (Divya *et al.,* 2019) claimed that the silver pomfret from Indian waters comprised of two species. The most common and widely distributed *Pampus candidus* and a rare but distinct species than the former which still requires further study to affirm its identity. The silver pomfret landings oscillated between 4,223 t and 13,127 t during the period of 1994-2018. The initial period of 1994-2000 was the most lucrative phase for the fishery with average annual landings of 9,307 t. The succeeding decade (2001-10) saw a considerable drop in catches and the recorded average annual catch was only 6,938 t. The present decade (2011-18) has an average annual catch of 8,753 t. *P. candidus* is the most dominant species, accounting for an average of 95.35% of total silver pomfret landings over the period of 1994-2018. The rest is contributed by Chinese silver pomfret (*Pampus chinensis*). In the year 2018, multiday trawlers (MDTN) accounted for 41.21% of the total silver pomfret landings which was followed by multiday gillnetters (30.91%), outboard gillnetters (12.3%) and mechanized dolnetters (10.69%). The sustainability of the resources is mostly challenged by the indiscriminate and increasing incidence of juvenile landings. The instances of almost entire catches of pomfret being juveniles are not so uncommon, especially in dolnetters. The deep-bodied morphology of the group poses a great challenge in reducing juvenile catches through mesh size regulation (the most common way of reducing catches of juveniles). Other approaches like resource-specific spatio-temporal restriction could be explored for sustainable management of the fishery.

group with an average catch of 8,952 t from 2006 to 2018, followed by ribbonfishes (4,818 t), croakers (4,351 t), penaeid prawns (4,240 t) and soles (1,376 t) (Fig.3.7).

Production trends of major resources in Outboard Gillnetter (OBGN)

The outboard gillnetters (OBGN) contribute 9.45% of the total marine fish landings of Gujarat. OBGN is the third dominant gear, contributing to the total marine fish catch. Most of the motorized crafts are OBGN craft with fishing grounds restricted mostly up to 50 m depth. Croakers formed the most dominant group with an average catch of 10,260 t during 2006 to 2018, followed by Indian mackerel (4,458 t), catfishes (4,359 t), horse mackerel (4,024 t) and longtail tuna (3,652 t) (Fig.3.8).

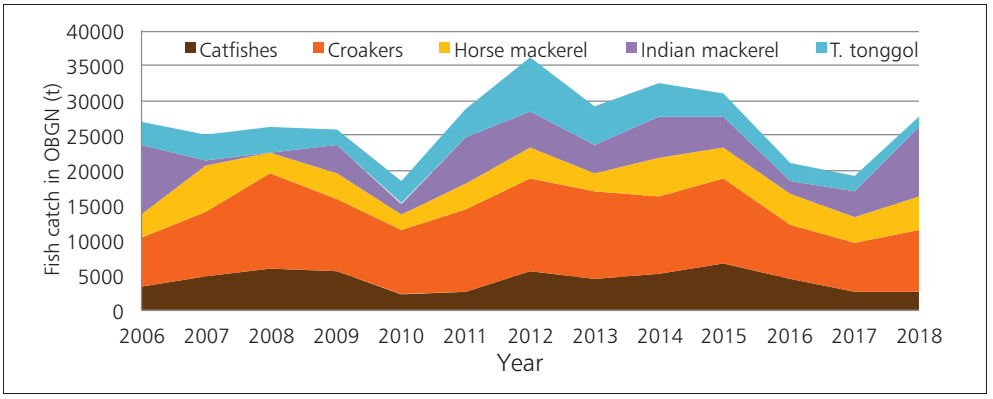


Figure 3.8. Time series catch of major resources landed by outboard Gillnetter (2006-18).

4. Economics of marine fisheries of Gujarat

Valuation of marine fish landings in Gujarat

The valuation of marine fish landings in the state for the past decade showed an increasing trend from 4.11 thousand crores in 2010 to 6.64 thousand crores in 2017 at landing center level and 7.52 thousand crores to 10.20 thousand crores respectively at retail center level. The provisional estimates of the valuation of marine fish landings for the year 2018 are 11.54 thousand crores at the landing center level, and the valuation for the retail center is estimated at 17.38 thousand crores (Table 4.1, Fig.4.1).

Table 4.1: Valuation of marine fish landings in the state

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018
Landing center Valuation ('000 crores)	4.11	4.41	4.52	5.65	5.96	7.03	7.57	6.64	11.54
Retail center Valuation ('000 crores)	7.52	7.72	8.09	9.09	9.85	11.7	13.02	10.20	17.38

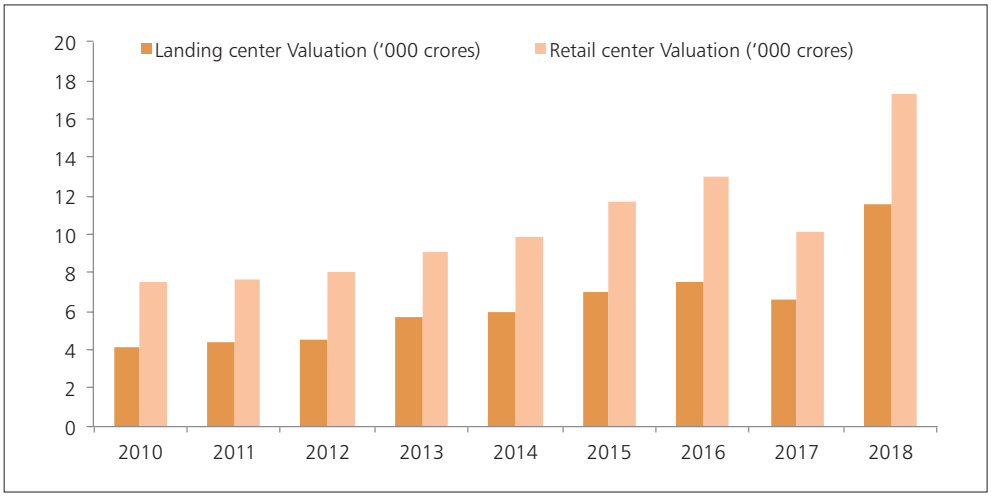


Figure 4.1. Valuation of marine fish landings of Gujarat

The unit price per kg of fish at landing center (LCP) is estimated ₹147.95 in 2018 (₹84.48 in 2017). The unit price at the retail market level (RCP) is ₹222.82 in 2018 (₹129.77 in 2017). The data are expressed in figure 4.2.

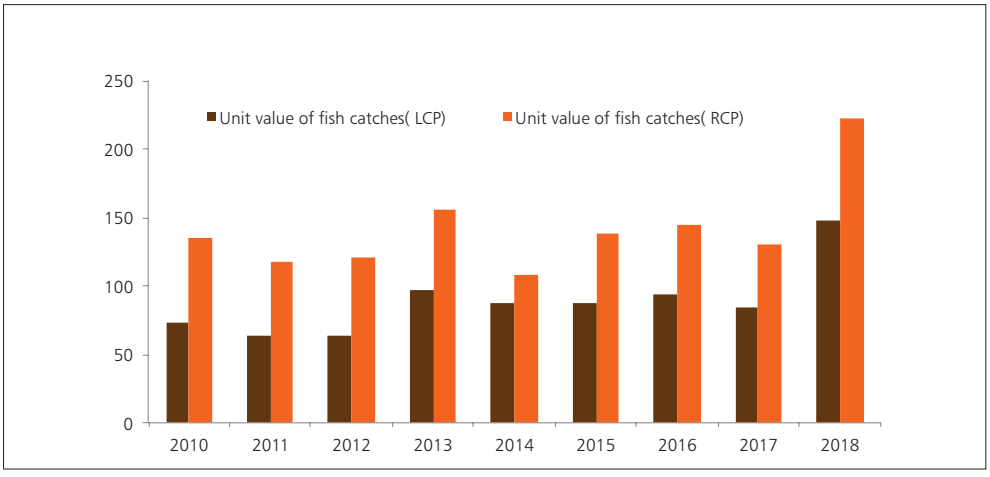


Figure 4.2. Unit value of fish catches at landing center and retail level (in ₹/ kg)

Factor shares in marine fisheries sector

The factor shares include the wages and salary, rents, profit, interests on loans availed and depreciation on fishing equipments (Fig.4.3). It is to be noted here that in case of fisheries, the rents do not arise, because, unlike agricultural production system, open access areas like a sea (marine capture fisheries) due to non-excludability and non rivalry, the factor share (land) doesn't attract any rent. Since there are no license fees or quota system, the factor- rent cannot hold good.

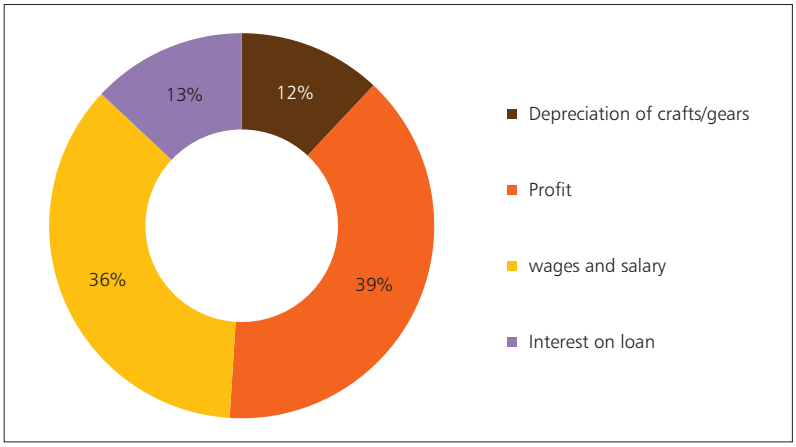


Figure 4.3. Average factor shares in marine fisheries sector

Inputs share: Intermediate Consumption

The inputs used in capture fisheries include labor wages (if wages are paid directly), food charges, cost of ice, salt, auction charges, and jetty charges. These are also factors of intermediate consumptions.

Intermediate consumption with wages

In the operating costs, the intermediate consumption includes the expense of labor wages (if paid directly), food costs, fuel costs, jetty charges, auction charges, water charges and others. In the first case, the labor wages are treated as directly paid. The inputs share with labor wages as intermediate consumption is given in table 4.2.

Table 4.2: Intermediate consumption with wages

Sl. No.	Items of intermediate consumption	Value (₹ In crores)	Percent to total
1.	Labor wages	1758.44	44.37
2.	Food (including LPG cost-	186.80	4.71
3.	Fuel (Diesel) /kerosene	1573.95	39.72
4.	Ice cost	246.95	6.23
5.	Jetty charges	56.48	1.43
6.	Auction charges	7.54	0.19
7.	Water charges	13.04	0.33
8	Others	119.84	3.02
	Total operating cost	3963.05	100.00

Intermediate consumption without wages:

In the operating costs, the intermediate consumption includes the expense of labor wages (if paid directly), food costs, fuel costs, jetty charges, auction charges, water charges and others. In the first case, the labor wages are treated as directly paid. The inputs share without labor wages as intermediate consumption is provided in table 4.3.

Table 4.3: Intermediate consumption without wages

Sl. No.	Items of intermediate consumption	Value (₹ In crores)	Percent to total
1.	Food (including LPG cost-	186.80	8.47
2.	Fuel (Diesel)/kerosene	1573.95	71.39
3.	Ice cost	246.95	11.20

Sl. No.	Items of intermediate consumption	Value (₹ In crores)	Percent to total
4.	Jetty charges	56.48	2.56
5.	Auction charges	7.54	0.34
6.	Water charges	13.04	0.59
7.	Others	119.84	5.44
8.	Total operating cost	2204.61	100.00

Economic performance of fishing methods

The economic performance of marine fishing operations is affected by various factors viz., diminishing catch per unit of effort, fluctuations in revenue, and unforeseen increase in the cost of key inputs as well as catch and effort restrictions. The economic performance plays a crucial role in the investment decisions at the micro-level. The economic performance of various fishing methods was assessed for the year 2014-15 and presented in table 4.4 and figure 4.4. Inorder to assess the economic performance, the following indicators were used, namely (1) Net operating Income, (2) Capital productivity ratio (3) Profitability ratio (4) Net profit ratio (5) Labor productivity (kg/crew/trip) and (6) Input-output ratio (MoSPI Report, 2016).

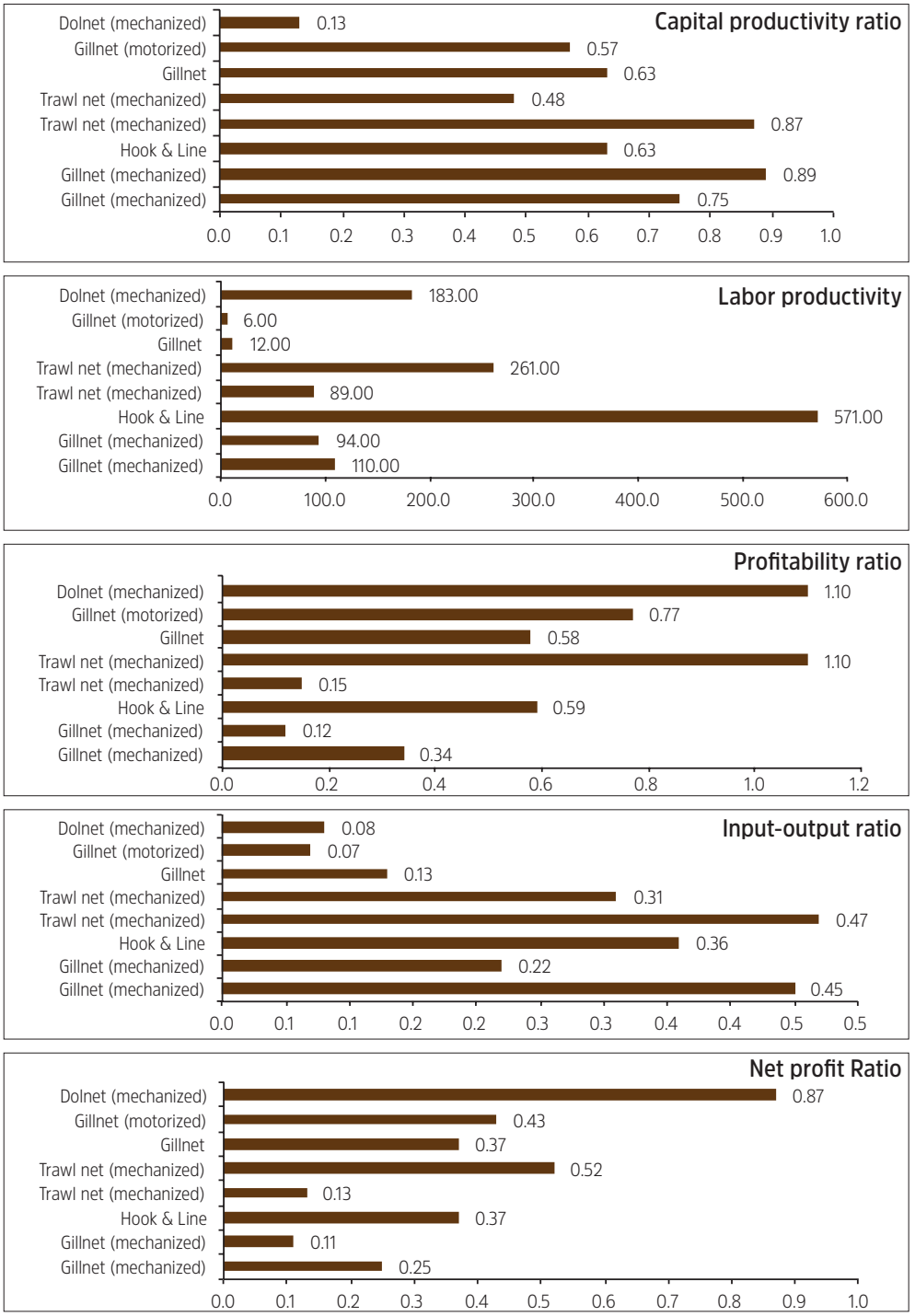


Figure 4.4. Economic indicators of fishing operations in different craft and gear combinations.

Table 4.4: Indicators of economic performance of different fishing operation (craft & gear combinations) along Gujarat coast.

Fishing Craft/ Gear	Duration of fishing	Total input costs	Operating cost	Gross revenue	Net operating Income	Capital productivity ratio	Profitability ratio	Net profit ratio	Labor productivity (kg/crew/trip)	Input-output ratio
Gillnet (mechanized)	MD > 6 days	19403	31878	42708	10,829	0.75	0.34	0.25	110	0.45
Gillnet (mechanized) 2-5 days		10308	40974	45902	4,929	0.89	0.12	0.11	94	0.22
Hook & Line	MD > 6 days	10	18	29	11	0.63	0.59	0.37	571	0.36
Trawl net (mechanized)	2-5 days	73632	137600	157574	19,973	0.87	0.15	0.13	89	0.47
Trawl net (mechanized)	MD > 6 days	101213	155786	327381	1,71,595	0.48	1.10	0.52	261	0.31
Gillnet	SD	401	1919	3035	1,116	0.63	0.58	0.37	12	0.13
Gillnet (motorized)	2-5 days	1437	12278	21684	9,407	0.57	0.77	0.43	6	0.07
Dolnet (mechanized)	2-5 days	2529	4325	32461	28,136	0.13	1.10	0.87	183	0.08
		220461	396305	630773	2,34,469	0.63	0.59	0.37	166	0.35

The ratio of average operating costs to the average gross earnings is the net profit or loss which is high for multi-day mechanized dolnets. Here labor productivity is expressed as the gross earnings per fisherman which is high for fisherfolk working in hook and line and capital productivity as the gross earnings per unit of capital invested is high for gillnetter. The value of the catch or gross earnings per man-hour of effort or per trip show the efficiency or productivity of the fishing unit when it is in operation. Input output ratio was expressed as the cost of all inputs excluding the labor cost by the gross returns per trip is high for trawlers followed by gillnetter. Analysis of economics of different types of fishing units indicated that almost all types of fishing units, on an average, run for profit as their production surpasses the break-even point.

Average landing Centre Price realization

The average landing center price for major species in the State is given in figure 4.5. There is a wide variation in prices across species. The landing center price ranged from ₹30 /kg for oil sardine to ₹700/kg for silver pomfret, followed by lobsters at ₹500/kg. The price of a particular species also varies based on size and freshness.

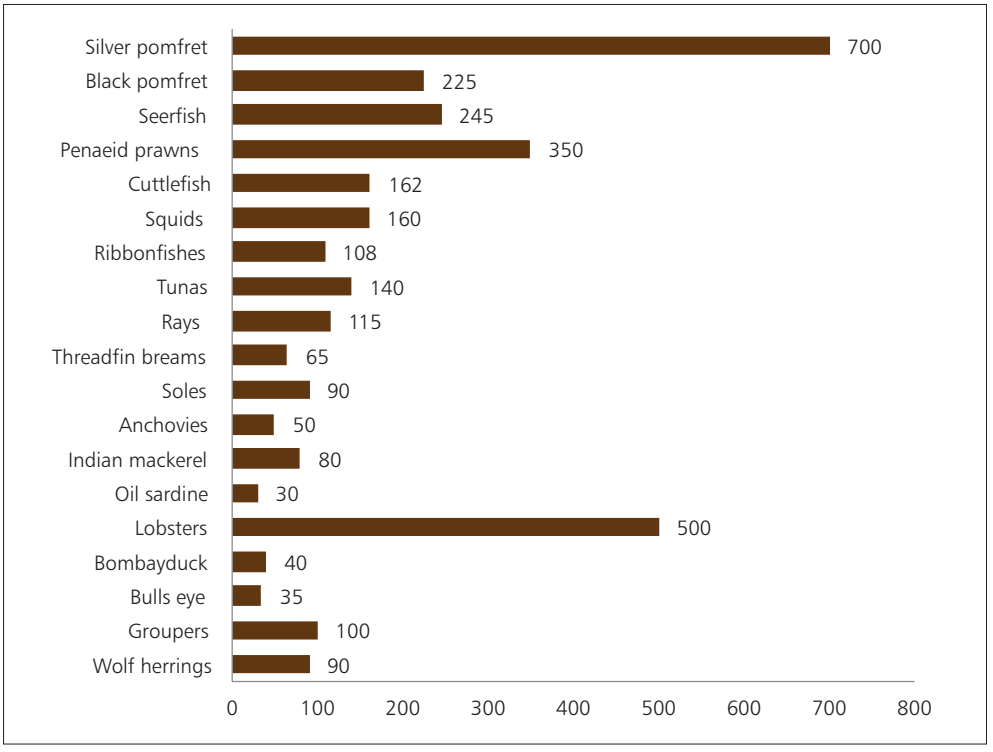


Figure 4.5. Average landing center prices of major species landed in Gujarat (2016)

Marketing efficiency

The marketing efficiency measured as the fishermen share in the consumer's rupee across the major species is given in Fig.4.6. In general, high value species like anchovies (79%), penaeid prawns (73%), rays (73%) and soles (72%) registered higher marketing efficiencies compared to sardines, breams, pomfret and squids.

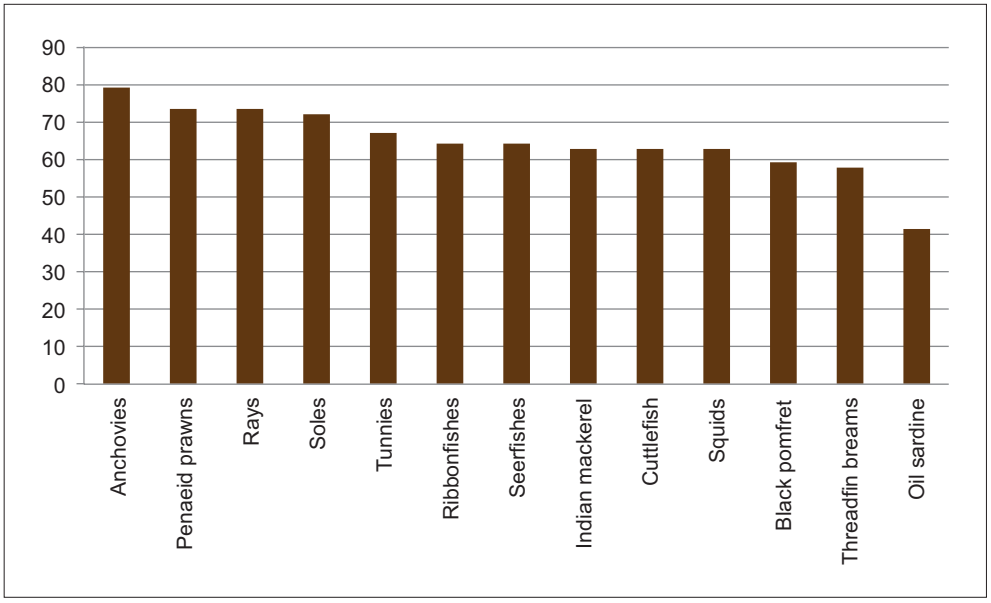


Figure 4.6. Market efficiencies of major species landed along the Gujarat coast (2016)

Export performance of the State

The export performance during 2006-07 has shown a record growth rate of 37.9% over the previous year with a total export of 1,88,166 t worth ₹1264.60 crores. In the subsequent four years, the quantum of export failed to surpass the figure of 2006, which was a matter of concern. Since 2011-12, the total quantity exported was above 2 lakh t, but in a couple of recent years export quantity crossed 3 lakh t. Earning in dollars shows steady growth with minor declines in 2012-13, 2014-15 and 2015-16 compared to their previous years (Table 4.5).

Table.4.5: Annual seafood export from Gujarat (2005-06 to 2018-19)

Year	Qty (t)	Value (crores)	$ (mIllion)	Annual growth rate		
				Qty	Value	$
2005-2006	136,485	934.88	210.87	NA	NA	NA
2006-2007	188,166	1264.60	281.30	37.9	35.3	33.4
2007-2008	150,727	1141.97	285.46	-19.9	-9.7	1.5
2008-2009	164,725	1485.73	325.25	9.3	30.1	13.9
2009-2010	183,870	1838.75	396.35	11.6	23.8	21.9
2010-2011	198,296	2156.21	481.27	7.8	17.3	21.4
2011-2012	220,562	2728.03	567.96	11.2	26.5	18.0
2012-2013	242,057	2929.61	548.16	9.7	7.4	-3.5
2013-2014	251,919	3658.47	604.49	4.1	24.9	10.3
2014-2015	244,910	3610.27	592.06	-2.8	-1.3	-2.1
2015-2016	208,134	3534.40	541.27	-15.0	-2.1	-8.6
2016-2017	237442	4417.38	659.70	14.1	25.0	21.9
2017-2018	312568	5071.04	791.39	31.6	14.8	20.0
2018-2019	305326	5202.30	744.60	-2.3	2.6	-5.9

5. Spatial and temporal distribution of major fishery resources

Trawl fisheries

Trawls are the most dominant fishing gear, which contributes maximum to the marine fish landings of Gujarat. Trawlers operating along Gujarat waters can be classified into two major categories, i.e., single day trawlers and multi-day trawlers based on the duration of fishing voyage and mechanization. The major resources exploited by the trawlers are ribbonfishes, croakers, cephalopods, threadfin breams, catfishes, lizardfishes, groupers, penaeid prawns, etc. The spatial distribution of the targeted catch by the trawlers operating from the Gujarat coast is shown in Figure 5.1. The operational area extended from the Kachchh coast to the Mangalore coast. The abundance of resources was high within 50 m depth zone and beyond 100 m depth.

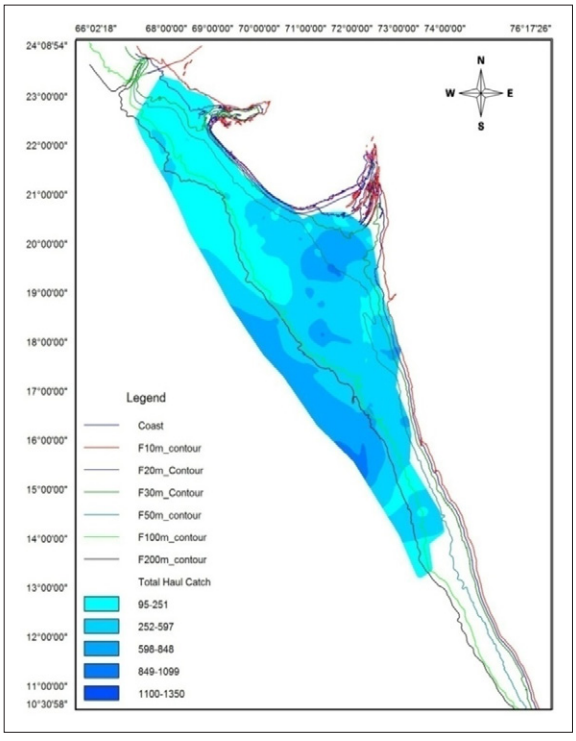
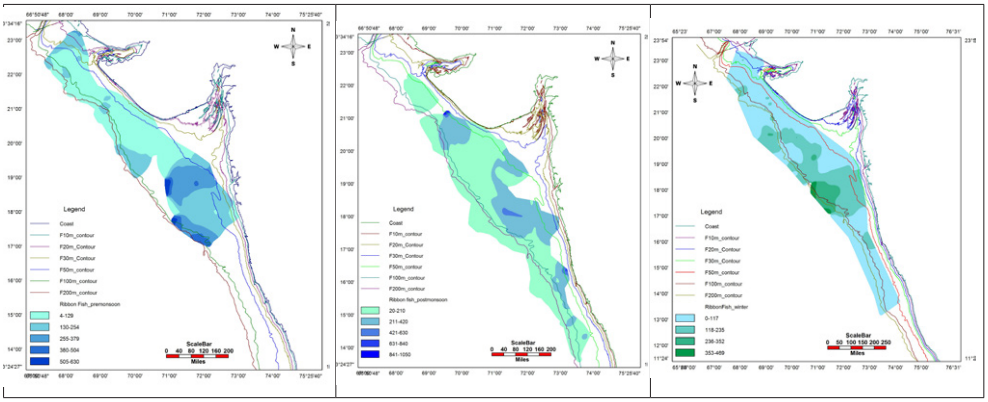


Figure 5.1. Spatial distribution of the targeted catch exploited by the trawlers operating from Gujarat

Ribbonfish

The CPUE of ribbonfish is lower during the winter compared to the pre-monsoon. The highest CPUE for the species was observed during the post-monsoon. The fishing ground of the species showed the

widest spread during the post-monsoon season that extended from Okha coast to Mangalore coast, which showed a decrease in the spread during the winter, followed by pre-monsoon. Extension of fishing ground in the Kachchh region was observed during winter and pre-monsoon seasons. Better catch rate was observed in a depth range of 50 to 100 m during post-monsoon, which shifted further to deeper water (100 to 200 m depth) during winter (Fig. 5.2).

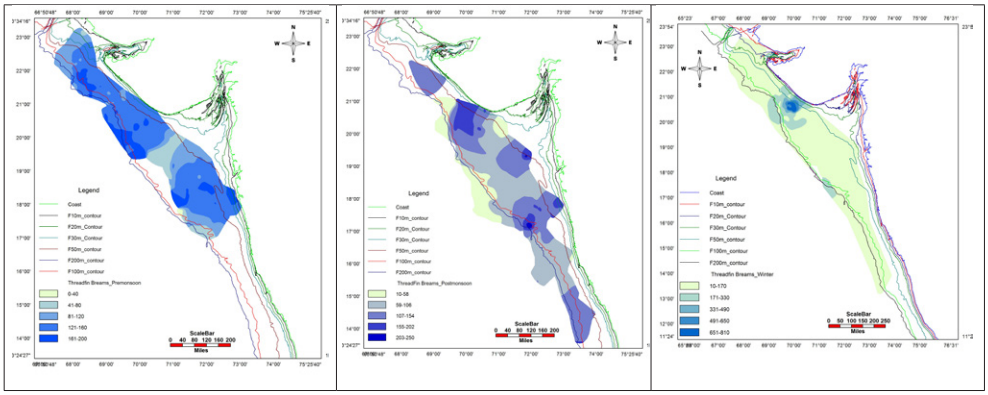


Pre-monsoon Post-monsoon Winter

Figure 5.2. Spatio-temporal distribution of ribbonfish exploited by trawlers operating along Gujarat coast

Threadfin breams

The higher CPUE for the species was recorded during post-monsoon and pre-monsoon seasons. The overall CPUE of threadfin breams is lower during the winter except for some sporadic high abundance zones. The fishing ground was the widest in the post-monsoon season, extended from Okha in the north to Mangalore in the south. The expansion of fishing ground in the Kachchh region is also observed during winter and pre-monsoon seasons. Good catch rates were observed in a depth range of 50 to 200 m during pre-monsoon and post-monsoon, followed by a decline in catch rates during winter and shift to shallower water (10 to 50 m depth) (Fig. 5.3).

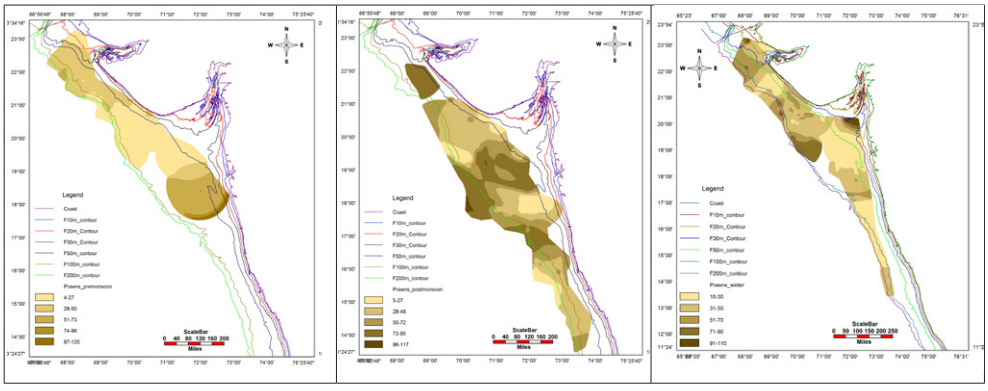


Pre-monsoon Post-monsoon Winter

Figure 5.3. Spatio-temporal distribution pattern of threadfin breams exploited by trawlers operating from Gujarat

Penaeid Shrimps

The CPUE of shrimps was found to be lower during winter but a few high abundance zones were located in the inshore and offshore waters. The catch rates were highest during pre-monsoon season than the post-monsoon in the region. The spread of fishing ground was widest during the post-monsoon season but showed a decrease during winter, followed by pre-monsoon. An increase in the spread of fishing ground along the Kachchh region was observed during the winter and pre-monsoon seasons. During post-monsoon season highest catch rates were recorded at depth range of 50-200m, but lower catch rates were recorded at 30m depth during winter season (Fig. 5.4).

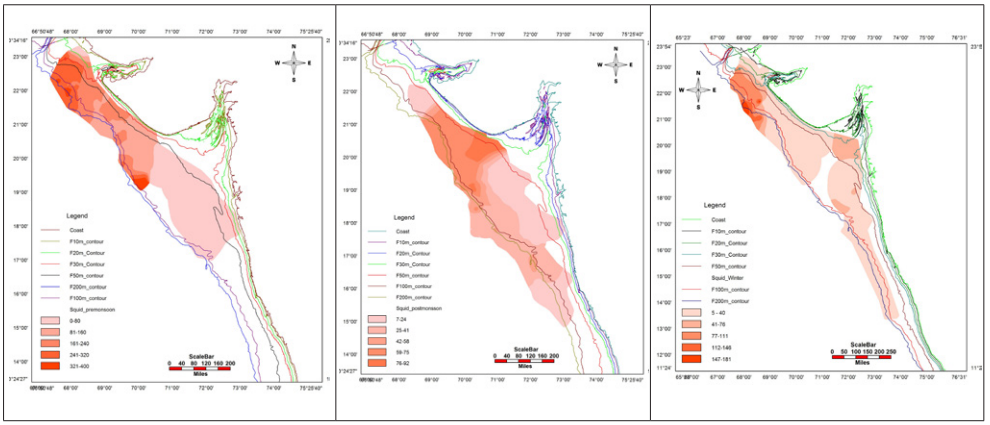


Pre-monsoon Post-monsoon Winter

Figure 5.4. Spatio-temporal distribution pattern of shrimps exploited by trawlers operating from Gujarat

Squids

The catch rates of squids were lower during the pre-monsoon, the fishing ground of species extended all along the north to the south of the west coast of India. The abundance of the species is higher in the winter season compared to the pre-monsoon season. Good catch rates observed at a depth of 50m, but during post-monsoon season abundance zones were mapped beyond 100 m. In winter season, catch rates were higher in the near shore shallower waters (Fig. 5.5).



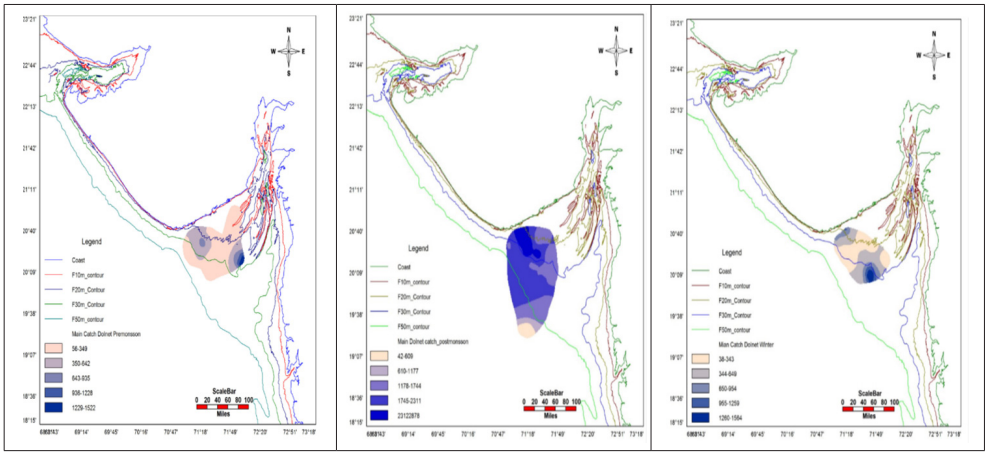
Pre-monsoon Post-monsoon Winter

Figure 5.5. Spatio-temporal distribution of squids exploited by trawlers operating from Gujarat

Dolnet Fisheries

Dolnet fishery is unique and a major one in the marine fisheries of Gujarat after trawl fisheries, which contribute around 37% of the total marine landings of Gujarat. The major operation grounds of dolnets spread from Umergaon to Kavi along southern Gujarat, Siyalbet to Diu along the Saurashtra coast and Takkara to Modhwa in the Gulf of Kachchh region. Among these, Saurashtra is the most important region for dolnet fishery and the main fish landing centres are Jafarabad, Rajpara, Navabunder and Goghla. Jafarabad is one of the major landing centres with 360 dolnetters operating at a depth of 10-50 m. At Rajpara, around 230 dolnet units operate at a depth of 10-70 m. Navabandar is the second-largest dolnet landing centre with 280 dolnetters operating at a depth of 10-70 m. Dolnets are operated in the strong tidal current, depending on the turn of the tide. The length of dolnet varies from 35-60 m with a cod-end mesh size of 20 mm. To exploit the targeted species, cod-end mesh size and depth of operation are changed twice in a year. Each boat carries 3-5 nets to draw 2-3 hauls keeping a gap of 6 hrs in between the hauls. The major species caught in dolnets are *Harpadon*

nehereus, *Trichurus lepturus*, *Lepturacanthus savala*, *Coilia dussumieri*, *Sciaenids*, *Acetes* spp., *Nematopalaemon tenuipes*, *Solenocera crassicornis*, *Plicofollis spp.* and *Cynoglossus* spp. Spatio-temporal distribution of the targeted catch by the dolnetters operating from the Gujarat coast is shown in Figure 5.6. The operational area is found to be limited to Navabandar and Jaffrabad coast. The abundance is high within 20 to 30 m depth zone. The abundance is highest during post-monsoon months when higher landings are observed in 30 to 50 m depth. The spatio-temporal distribution pattern of important dolnet fishery resources is given below.



Pre-monsoon Post-monsoon Winter

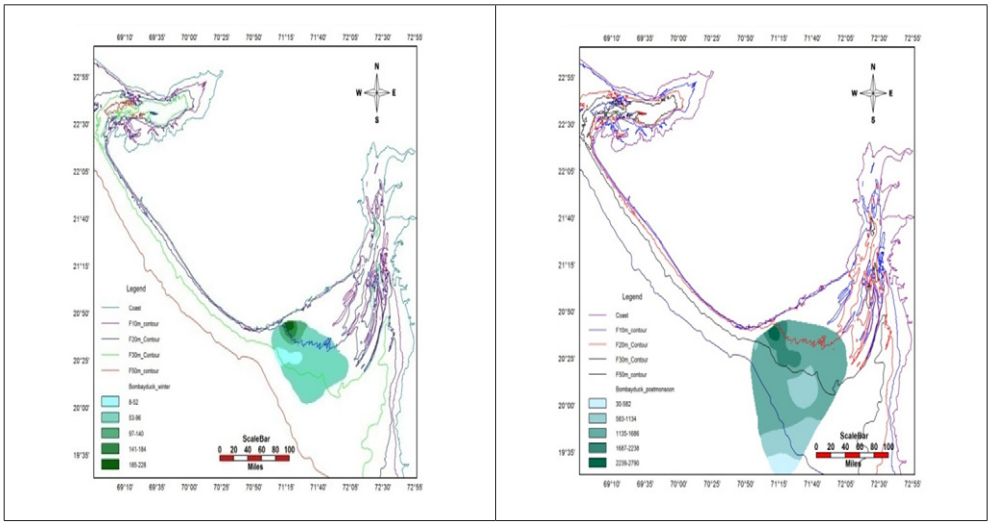
Figure 5.6. Spatial distribution of the targeted catch exploited by the dolnetters operated from Gujarat

Bombayduck

The operational area of dolnetters is mostly limited to 30 m depth during the pre-monsoon that extends beyond 50 m depth during the post-monsoon season. The abundance of bombayduck is much higher in the post-monsoon season compared with the pre-monsoon season. During pre-monsoon, the abundance is higher between the depth zones of 10 to 20 m, but during post-monsoon season catch rates were higher in the zones beyond 20 m depth (Fig.5.7).

Bombay duck

Bombay duck (*Harpadon nehereus*) forms one of the important commercial fishery along the Gujarat coast accounting for 10.43% (62,548 t) of the total state catch during 1994-2018. The resources are known for the discontinuous distribution and exist as indicator species in the region. However, the bulk of the fishery is concentrated within a narrow belt of 45 km at the depth range of 20 – 70 m and the important landing centres are Nawabunder, Rajpara and Jaffrabad. The species is primarily caught with the bag-net, better known as "dol" net of 35 – 60 m length and with a cod-end mesh of 20 mm. The operation of this gear is timed to a strong tidal current. Bombay duck is a very soft fish and is highly perishable due to its body composition. A large part of the catch particularly during the peak fishing season is sun-dried on raised bamboo platforms by hanging them on the ropes and the dried fish is exported.

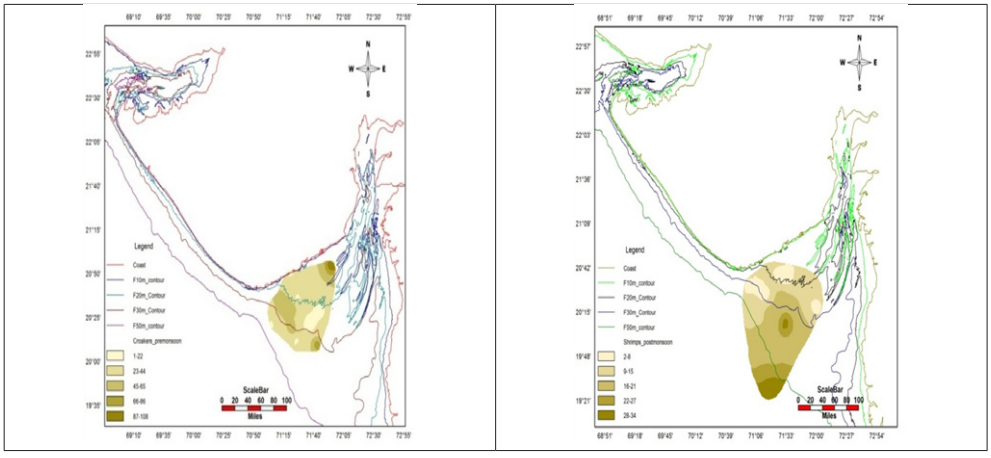


Pre-monsoon Post-monsoon

Figure 5.7. Spatio-temporal distribution of bombayduck exploited by the dolnetters operating from Gujarat

Croakers

The abundance of croakers was much higher in the post-monsoon season than the pre-monsoon season. During the pre-monsoon season, the fishing operation was restricted up to 30 m depth, unlike post-monsoon, where fishing was done even beyond 50 m of depth (Fig. 5.8).

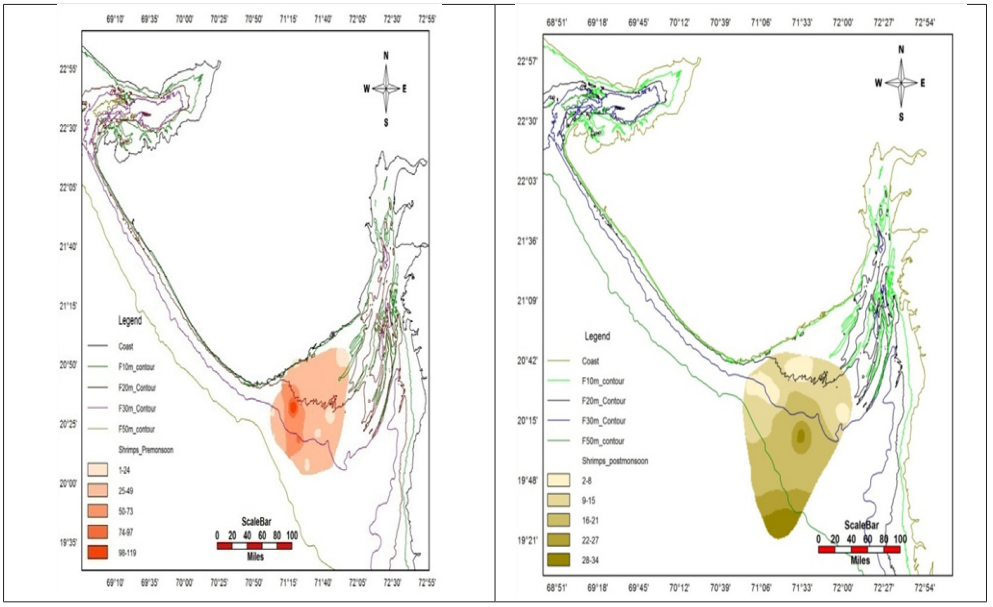


Pre-monsoon Post-monsoon

Figure 5.8. Spatio-temporal distribution pattern of croakers exploited by the dolnetters operating from Gujarat

Penaeid Shrimps

The highest catch rates of shrimps were recorded during the post-monsoon season than the pre-monsoon season. The dolnets were operated near coastal waters (up to 30 m) during the pre-monsoon, but the fishing grounds shifted beyond 30 m depth during the post-monsoon (Fig. 5.9).



Pre-monsoon Post-monsoon

Figure 5.9. Spatio-temporal distribution of Shrimps exploited by the dolnetters operating from Gujarat

Gillnet Fisheries

Gillnet is one of the major gear landing large quantities of pelagic and mid-water fishes. Small meshed gillnets target the small pelagics like the mackerels, clupeids, ribbonfishes, horse mackerels, etc. and medium-size pelagics like the spotted seer, scombroids, wolf herrings, etc. in the inshore areas, all along the coast up to a depth of 40-50 m. Small or medium-mesh gillnets set at the bottom of the sea, target bottom-dwelling fishes like the pomfrets, sciaenids, etc. in certain seasons. Large meshed gillnets catch larger pelagics like the tunas, billfishes, dolphin fishes, larger leatherjackets, seerfishes, queen fishes, etc. Besides, sharks and rays were also caught occasionally. The crafts involved in the large mesh gillnet fisheries are of two categories. Medium size FRP boats of 8-12m propelled by outboard motors or inboard diesel engines and the larger wooden / FRP boats of 16-19 m having inboard diesel engines with facilities for storage of iced

Seerfish fishery

Gujarat is the leading seerfish producing state in India, lands roughly a quarter of the total catch of the country (CMFRI, 2019). The annual average catch of seerfish in the state during 1994-2018 was 0.10 lakh t (contributes nearly 2% of the total state landings). The fishery is dominated by the spotted seer *Scomberomorus guttatus* and the king seer *Scomberomorus commerson*, a very meagre share by streaked seer *Scomberomorus lineolatus* and the wahoo *Acanthocybium solandri*. The biology and stock assessment of the species have been well documented from India. Jeena *et al.,* (2020) used the 600 bp region of Cytochrome c oxidase subunit I gene for phylogeographic analysis of *S. guttatus* to study genetic diversity. The analysis revealed two robustly supported clades, the Bay of Bengal + Western Pacific Ocean Clade and the Arabian Sea Clade with a significant genetic divergence of 2.42%, which was signaling a strong genetic population division. The resources were mainly exploited by both mechanized and motorized gillnetters, followed by dolnetters and trawlers in the region. The fishery assumes greater importance owing to their higher economic value and export demand. Part of the catch is consumed fresh and the remaining is frozen and exported.

fish. The fishing duration ranged from 3 to 8 days, depending on the size of the crafts. The target catch depends on the size of the craft and area of operation, as well as the seasons. While neritic species like the longtail, kawakawa, frigate and bullet tunas, seerfishes, cobia, leather jackets (*Aluterus monoceros*), etc. dominated the catches in the inshore areas, the skipjack, yellowfin tunas and billfishes dominated the catch from the oceanic areas.

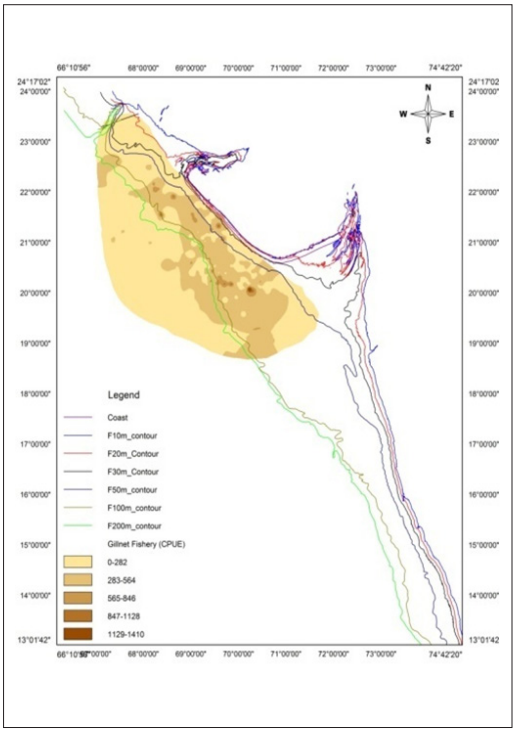


Figure 5.10. Spatial distribution of targeted catch exploited by the gillnetters operating from Gujarat

The Gillnetters from Gujarat are mainly fishing off the Gujarat coast, extending from Kachchh to Valsad district. A large quantum of fishing effort is in grounds off the Saurashtra coast, especially off Veraval and Porbandar. The depth of the fishing grounds ranged from 20 m to over 1000 m, with the fishing efforts concentrated mainly between 50 m and 100m depth contours. A plot of the CPUE values revealed that better catch was obtained in the depth range of 50 m and 100 m contours spread between off Diu and Okha (Fig.5.10). The highest CPUE values off Diu were principally due to the large incidence of leatherjackets (*Aluterus monoceros*) locally known as 'Don'. The Leatherjacket fishery is during the winter months, especially during mid December to mid February when the gillnet fishing slows down, said to be due to the low catch of the main target, i.e., the tunas.

Coastal Tunas

Neritic tunas were contributing a major catch in gillnets. The principal coastal tuna occurring in the neritic region is the longtail tuna, a medium-size tuna having a commercial value in export as well as the domestic market. Kawakawa is another neritic tuna occurring in large numbers in the gillnets. Frigate tunas and bullet tunas occur in small numbers in the inshore areas. Neritic tunas occur from 30 m onwards up to 200 m depth along the Saurashtra coast (Fig.5.11). The high CPUEs for the neritic tuna were in the depth range of 30m to 100m.

Oceanic Tunas

Oceanic tunas caught in the gillnet fishery in Gujarat are the yellowfin and skipjack. Fishing for yellowfin tuna is developing fast in the Saurashtra coast owing to the demand for the frozen fish export. The abundance of the yellowfin tuna shoals in the oceanic realms off Gujarat has triggered targeted fishing by gillnets and lines. These tunas are mainly caught during the winter months from November to February, with the catch getting poorer during the period of mid-December to January. Physical hindrance to fishing due to wind chill and the low catch consequent to very low sea surface temperature are the reasons attributed by the fishers for a poor catch during the peak winter. The best CPUE values occurred in the oceanic areas off Veraval beyond the 200 m depth contour. The higher CPUE values occurred between the depth contours of 50 m and 100 m were during the winter months when the oceanic tunas were seen migrating towards inshore areas (Fig. 5.12).

An emerging fishery for 'Don'

The catch of *Aluterus monoceros*, popularly known as 'Don,' has been increasing in the gillnet fishery in Gujarat since 2008.

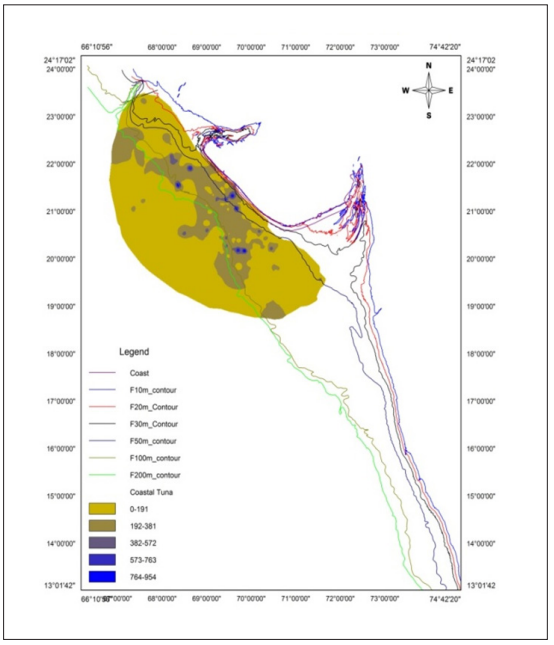


Figure 5.11. Spatial distribution of Neritic tunas along the Gujarat coast

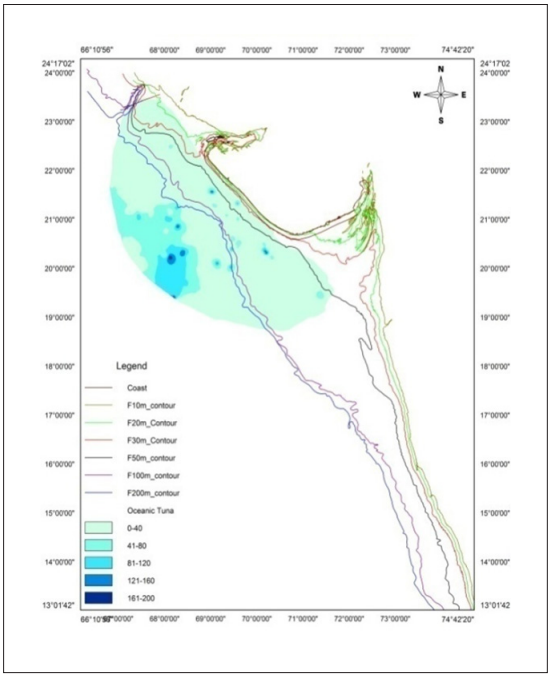


Figure 5.12. Spatial distribution of oceanic tunas along the Gujarat coast

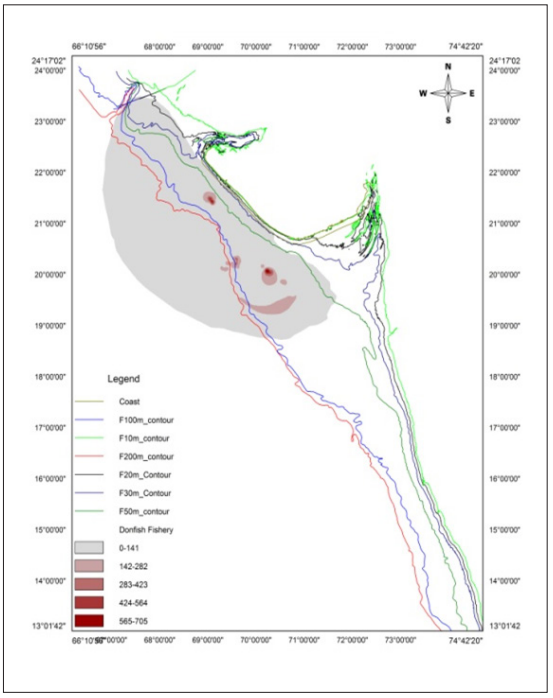


Figure 5.13. Spatial distribution of *Aluterus monoceros* along the Gujarat coast

Once a menace, the fish has become a commercially valuable resource having a good export market. The fish is skinned and frozen for export by the Veraval based processing companies. The catch is better during the peak winter months when the yield for other valuable resources like the tunas is poor. Its main ground is off Diu south of Veraval in the depth range of 50 m and 100 m (Fig.5.13). The CPUE is good in Porbandar too at the same depth range.

6. Rapid stock analysis and fishery of commercially exploited fishery stocks

Rapid Stock Status Analysis (RSA) was carried out for 52 commercially important fish species/groups to understand the dynamics and status of exploitation of fish stocks in the Gujarat state. The RSA was carried out for 32 years (1986-2017). Classification criteria used for categorizing the fish stocks was by calculating the change in percentage contribution of the recent three-year average catch of species from the historic maximum fish catch of the same species/group (Fig. 6.1, Mohamed *et al.,* 2010). Based on the percentage of difference, the stocks were grouped into five types, i.e., Abundant (>71%), Less Abundant (51-70%), Declining (11-50%), Depleted (6-10%) and Collapsed (0-5%) (Fig. 6.1). Out of 52 fish stocks analyzed, 24 stocks were found Abundant in status *viz.* catfishes, wolf herring, bombayduck, rock cod, threadfin bream, ribbonfish, seer fishes, longtail tuna, soles, penaeid prawns, cephalopods, etc. followed by nine less abundant stocks of snappers, pig-face breams, croakers, scad, black pomfret, etc. The numbers of declining stocks were 17, which include sharks, rays, golden anchovies, goatfishes, halfbeaks and fullbeaks, billfishes, unicorn cod, skipjack tuna, halibut, lobsters, etc.

Figure 6.1. Criteria (percentage-based) used for the classification of stocks

Lobster fishery

Lobsters are specialized crustaceans that form delicacy in several world cuisines. Being one of the prized seafood commodity, the resource has faced the wrath of exploitation through the targeted fishery. Northwest coast of India in general and Gujarat, in particular, is known for the rich fishing grounds of mud spiny lobsters (*Panulirus polyphagus*) and slipper lobsters (*Thenus unimaculatus*). The lobster landings of the state ranged between 182 t and 1,306 t during the period of 1994-2018. The average annual catch during 1994-2000 was as high as 1,152 t which declined to meager 397 t during 2001-2010. The average annual landing during the present decade (2011-18) was 724 t which was a substantial improvement over the previous decade. The bulk of the lobster landings was contributed by spiny lobsters with *P. polyphagus* as a dominant species. The contribution of spiny lobsters to the total lobster landings ranged between 78.38% to 97.81% during 2007-18. The contribution of slipper lobsters fluctuated between 2.19% and 21.62% (2007-18). The spiny lobsters are mostly exploited by outboard gillnetters (OBGN, 53.28%) followed by multiday trawlers (MDTN, 31.62%) and mechanized dolnetters (MDOL, 8.25%). The large proportion of landings, especially by OBGN comprised of smaller individuals fetching the lower value of local markets. These individuals can be released back to ensure the attainment of maturity in the wild and spawning at least once prior to getting eliminated by fishing. The fattening of a proportion of these sub-adults in cages could also be practiced for better price realization and economic returns from the resource. The incidence of berried females caught in nets and their retention was also not so uncommon. This practice of retention of live berried females needs to be discouraged among fishers through awareness programs. In the case of slipper lobster, almost entire catches come from trawlers. In most of the cases, the quality of the landings is not very good. This is because of very less demand for the resources in the region. As the resource neither forms bulk landings nor prefered by the fishers in the region, the development of a mechanism to selectively avoid its capture in trawlers would do wonders in reviving and conserving the resource. Lobsters owing to inherent biological characters like slow growth, late maturity and complex larval cycle are more vulnerable to increasing fishing pressure and hence require special attention in order to ensure a healthy stock status.

Fishery resources like big-jawed jumper were in depleted state and silverbellies in a collapsed state in the study region (Table.6.1). Rapid stock status was performed for 52 commercially exploited fishery resources, out of which 24 were abundant, 9 less abundant, 17 declining, one depleted and one collapsed. (Fig.6.2). Most of the marine fishery resources along the region are sustainable in status except some resources which are under targeted exploitation in recent years. Resources wise RSA plots are given under Annexure 2 section.

Table 6.1: Status of commercially exploited fishery resources of Gujarat based on RSA

Species/Groups	Historic max catch (t)	Recent 3-year average catch (t)	Percentage maximum catch	Status of stocks
Sharks	26643	8851	33	Declining
Skates	1725	1353	78	Abundant
Rays	6728	3575	53	Declining
Eels	6577	4033	61	Declining
Catfishes	46851	33581	72	Abundant
Wolf herring	7820	6126	78	Abundant
Hilsa shad	2011	1357	67	Abundant
Other shads	5453	796	15	Declining
Coilia	25304	9984	39	Declining
Thryssa spp.	11576	7949	69	Abundant
Other clupeids	12510	3469	28	Declining
Bombayduck	93582	83129	89	Abundant
Lizard fishes	22077	18652	84	Abundant
Half beaks & full beaks	1958	615	31	Declining
Rock cods	22491	20819	93	Abundant
Snappers	1557	1029	66	Less Abundant
Pig-face breams	1340	802	60	Less Abundant
Threadfin breams	55231	35976	65	Abundant
Other perches	40762	29875	73	Less Abundant
Goatfishes	5613	3585	64	Declining
Threadfins	7361	4699	64	Abundant
Croakers	115964	54863	47	Less Abundant
Ribbon fishes	132275	104288	79	Abundant
Horse mackerel	11614	8992	77	Less Abundant
Scads	6638	4768	72	Less Abundant
Leather-jackets	6501	4656	72	Abundant
Other carangids	9037	8285	92	Abundant
Silverbellies	2964	105	4	Collapsed
Big-jawed jumper	7254	452	6	Depleted

Species/Groups	Historic max catch (t)	Recent 3-year average catch (t)	Percentage maximum catch	Status of stocks
Black pomfret	6769	2019	30	Less Abundant
Silver pomfret	13012	6283	48	Abundant
Chinese pomfret	590	414	70	Abundant
Indian mackerel	10269	4874	47	Less Abundant
King seer	8960	5022	56	Abundant
Spotted seer	10151	5658	56	Abundant
Little tuna	5699	3211	56	Abundant
Auxis spp	1512	1106	73	Less Abundant
Skipjack tuna	4140	686	17	Declining
Longtail tuna	12136	5272	43	Abundant
Other tunnies	5112	872	17	Declining
Bill fishes	1925	884	46	Declining
Barracudas	5681	4526	80	Abundant
Mullets	7550	1808	24	Declining
Unicorn cod	244	10	4	Declining
Halibut	1929	1086	56	Declining
Soles	17268	12196	71	Abundant
Penaeid prawns	50290	34224	68	Abundant
Non-penaeid prawns	148973	124973	84	Abundant
Lobsters	1306	884	68	Declining
Crabs	26283	9761	37	Declining
Stomatopods	7283	2652	36	Declining
Cephalopods	70762	64704	91	Abundant

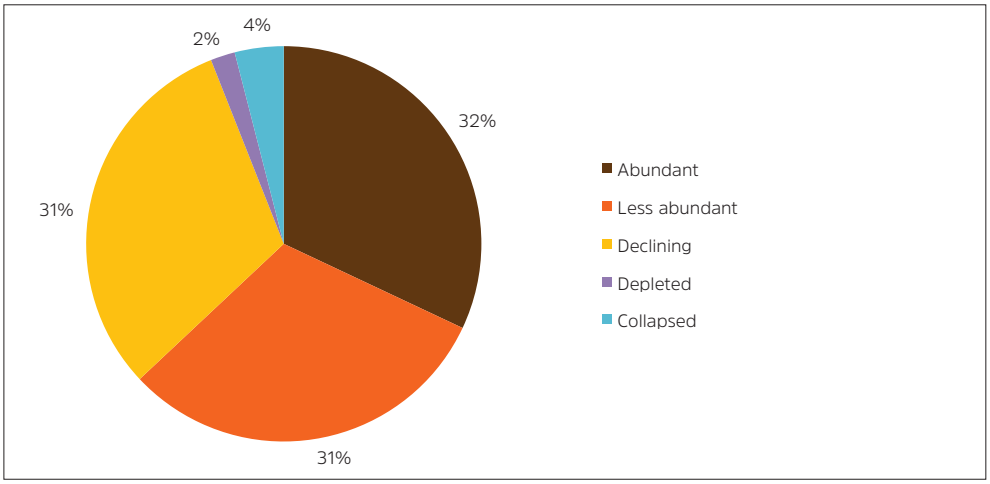
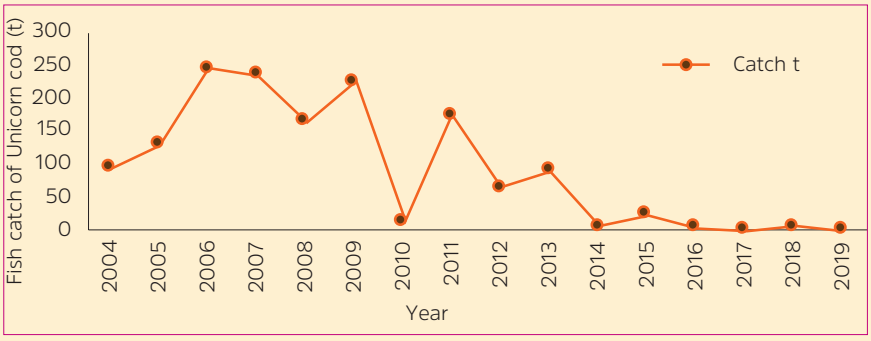


Figure 6.2. Status of commercially exploited fishery resources landed in Gujarat

A brief note on Unicorn cod fishery

The fishes of the family Bregmacerotidae are represented by a single genus Bregmaceros (Thompson 1840) with 14 valid species distributed in tropical and subtropical Seas (Cohen, 1990; Froese and Pauly, 2021). McClelland's unicorn-cod, or unicorn cod, *Bregmaceros mcclellandi* (Thompson, 1840) is a small codlet fish having elongated and silvery-brownish body with two dorsal fins, the first one originate above the head and modified into a single ray. The second dorsal and anal fins are widely notched and extended towards the tail. The jugular ventral fin is composed of 5-6 long rays of which one or two are larger than the rest of the rays. The species is known to grow up to the size of 12 cm with 7 cm being

Photo of *Bregmaceros mcclellandi* caught in dolnetters



Time series catch of Unicorn cod landed along the Gujarat state

the common size in commercial catches along the North West coast of India, where it is known to be abundant within the depth zone of 200 m (Parulekar et al., 1969). The Unicorn cod was commercially exploited by dol net units mostly along the coastal waters of Maharashtra and to some extent along the south Gujarat. The resource was found more abundant along the Mumbai and Ratnagiri coast and to smaller extent along south Gujarat (Reghu et al., 1996). The gradual decline in landings of this resource has been observed from 6,880 tonnes in 1950 to 1081 tonnes in 2012 (CMFRI, 2013). The species do not have much commercial value but have much higher ecological role as key prey item in the guts of commercially important fishery resources. The species mostly preys up on crustacean zooplankton and larvae and forms the major diet component of fishes like croakers, threadfin breams, polynemids, synodontids and Bombay duck (Reghu et al., 1996; Ghosh et al., 2014; Mali et al., 2017; Rahangdale et al., 2018) and hence holds key position in trophic structure of the region.

Cohen, D. M., 1990. Bregmacerotidae. p. 524-525. In J. C. Quero, J. C. Hureau, C. Karrer, A. Post and L. Saldanha (eds.) Check-list of the fishes of the eastern tropical Atlantic (CLOFETA). JNICT, Lisbon; SEI, Paris; and UNESCO, Paris. Vol. 2.

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Froese, R. and Pauly, D. (Eds.) 2021. FishBase.www.fishbase.org.

Ghosh, Shubhadeep, 2014. Fishery, reproductive biology and diet characteristics of Bombay duck *Harpadonnehereus* from the Saurashtra coast. Indian Journal of Geo-Marine Sciences, 43 (3). pp. 418-426.

Mali K. S., Vinod Kumar M, Farejiya MK, Bhargava AK., 2017. Food and Feeding Habits of Two MajorLizardfishes (Family: Synodontidae)Occurring along North-West Coast of IndiaBetween Lat. 18°-23°N. Int. J. Life. Sci. Scienti. Res., 3(3): 1039-1046.

Parulekar, A. H. and Bal, D. V., 1969. Observations on the seasonal changes in chemical composition of Bregmacerosmcclellandi. J. Univ. Bom., 38 (65), 88-92.

Rahangdale, S., Gohel, J., BharadiyaSangita, A., Rajan, K., Vase, V. K., Divu, D., Kumawat, T., Sukhadane, K. S. and Abdul Azeez, P., 2018. Gapers-An important component of the diet matrix of predatory demersal fishes. *Marine Fisheries Information Service; Technical and Extension Series*, (235), pp.19-20.

Reghu, R., Balachandran, K., Menon, N. G., Vivekanandan,E., Chakraborthy, S. K. and Devadoss, P., 1996. Distribution, abundance and biology of unicorn cod, Bregmacerosmcclellandi in the deep scattering layers of Indian Exclusive Economic Zone, In: Proceedings of the SecondWorkshop on Scientific Results of FORV SagarSampada, edited by V. K. Pillai, S. A. H. Abidi, V. Ravindran, K. K. Balachandran& V. V. Agadi, (Department of Ocean Development, New Delhi), 411-418.

Mean length (L_{mean}) and Optimum length (L_{opt}) of important resources

The comparative observation of mean length and optimum length of the commercially exploited resources are given in Table.6.2. The comparative analysis of L_{mean} and L_{opt} depicts the impact of fishing on size structure, and the level of resource exploitation. Exploited stocks with a higher mean length than the calculated optimum length shows the non occurrence of growth overfishing.

The mean lengths of the commercially important stocks like *Trichurus lepturus*, *Nemipterus japonicus, Johnius glaucus, Pampus argenteus, Plicofollis tenuispinis, Uroteuthis duvaucelli* in the fishery are just near to the optimum length. In recent years, the mean lengths of some of the resources are declining mainly due to the demand from surimi plants, dry fish yards, fish meal plants, etc. The resources like ribbonfish, croakers and catfishes mainly go for surimi products. The small-sized pomfrets are mainly used for drying and curing. The small size cephalopod resources like baby squids are mainly used for export to southeastern countries. The mean length is lower than the optimum length for stocks like *Thunnus tonggol* and *Parapenaeopsis stylifera,* which is not a healthy indication of the sustainability performance of the fishery. Harvest of stocks with a mean length lower than the L_{opt} may lead to growth overexploitation of stocks and reduction in the mean biomass, which may finally cause huge economic loss to the fishery. Framing and implementation of best management measures, i.e., seasonal fishing ban, spatial fishing closures, mesh size regulations, minimum legal sizes and juvenile & trash excluder devices, need to be adopted for the sustainable management of the resources.

Table 6.2: Mean Length and Optimum Length of commercially important fishery resources

Species	Mean length (mm)	L_{opt} (mm)
Euthynnus affinis	522	466
Megalaspis cordyla	335	298
Trichurus lepturus	696	517
Thunnus tonggol	594	852
Coryphaena hippurus	917	665
Nemipterus japonicus	256	105
Johnius glaucus	190	173
Pampus argenteus	158	79

Species	Mean length (mm)	L_{opt} (mm)
Plicofollis tenuispinis	379	243
Scoliodon laticaudus	458	432
Solenocera crassicornis	90	87
Parapenaeopsis stylifera	95	97
Metapenaeus affinis	137	129
Metapenaeus monoceros	150	137
Penaeus semisulcatus	160	151
Portunus sanguinolentus	120	114
Charybdis feriata	113	108
Uroteuthis (photololigo) duvaucelii	116	107
Uroteuthis (photololigo) singhalensis	110	102

Minimum Legal Size (MLS)

Minimum legal size is one of the implementable output management tools to deal with growth overfishing. MLS helps to reduce the exploitation of juveniles, maintain reproductive cohorts and allow fish to grow for better price realization. The logic criteria used for the estimation of MLS for the commercially exploited stocks along the region were adopted from Mohamed *et al*., 2014. For setting MLS for the commercially exploited fish stocks, the minimum size at maturity (MSM) and size at first maturity (SFM) were taken as logic criteria based on the species growth, biological and reproductive characteristics. The MSM criteria can be used for the stocks which are resilient to fishing pressure to prevent growth overfishing in stocks. SFM criterion is used for the depleted or rebuilding stocks to reduce the recruitment overfishing by allowing fish to spawn before undergoing exploitation.

The MLS criteria were based on the time series moving average trend, growth or condition, exploitation rate and reproductive strategies of species. The MSM can be considered as MLS for the commercially exploited resources like *T. lepturus, N. japonicus, A. tenuispinis, E. affinis, M. cordyla, C. hippurus* and *J. glaucus*. The SFM was taken as logic criteria as MLS for resources like *S. laticaudus, P. argenteus*, crustacean resources, i.e., *S. crassicornis, P. stylifera, M. affinis, P. semisulcatus* and *U. duvaucelli,* etc. MLS for the commercially exploited fishery resources along the region is provided in table 6.3.

Table 6.3: Minimum Legal Size (MLS) of 50 commercially important marine resources along the Gujarat coast

Species Name	Common Name	Vernacular Name	Recommended MLS (mm/g)	Decision Logic	Remarks
Major Pelagic resources					
Rastrelliger kanagurta	Indian Mackerel	Malabar Bhangda	140 TL	MSM	Most of the fish stocks are in the declining stage other than tuna and large pelagics. Therefore MSM is used as a conservative measurement as MLS
Harpodon nehereus	Bombayduck	Bhumla	185 TL	MSM	
Coilia dussumieri	Golden anchovy	Mandeli	115 TL	MSM	
Euthynnus affinis	Little tuna	Gedra	377 TL	MSM	
Megalaspis cordyla	Horse mackerel	Bhangda	261 TL	MSM	
Trichurus lepturus	Ribbonfish	Baga	448 TL	MSM	
Thunnus tonggol	Longtail tuna	Sherva	480 TL	MSM	
Thunnus albacares	Yellowfin tuna	Veer gedra	500 FL	MSM	
Katsuwonus pelamis	Skipjack tuna	Nani gedra	350 FL	MSM	
Coryphaena hippurus	Dolphin fish	Apnus	545 TL	MSM	
Scomberomorus commerson	King seer	Surmai	500 FL	MSM	
Scomberomorus guttatus	Spotted seer	Surmai	370 FL	L_{M50}	The mean size in the fishery is declining. Therefore L_{M50} is used as MLS
Rachycentron canadum	Kingfish	Sakra	610 FL	L_{M50}	
Decapturus russelli	Indian scad	Pira bhangda	110 TL	MSM	
Major Demersal resources					
Nemipterus japonicus	Threadfin bream (yellow)	Ranimach	125 TL	MSM	Small size fishes are being exploited due to the demand from surimi market and conservation measures need to be adopted.
Nemipterus randalli	Threadfin bream (red)	Ranimachla	100 TL	MSM	

Species Name	Common Name	Vernacular Name	Recommended MLS (mm/g)	Decision Logic	Remarks
Lactarius lactarius	Whitefish	Katali	100 TL	MSM	The fishery is almost in a collapsed condition
Saurida tumbil	Greater lizardfish	Bhungar	170 TL	MSM	
Saurida undosquamis	Lizardfish	Bhungar	100 TL	MSM	
Protonibea diacanthus	Black spotted croaker	Ghol	700 TL	MSM	
Otolithoides biauritus	Bronze croaker	Koth	660 TL	MSM	
Otolithes cuvieri	Lesser tiger toothed croaker	Dhoma	160TL	MSM	
Otolithes ruber	Tiger toothed croaker	Dhoma	170 TL	MSM	
Johnius glaucus	Pale spotfin croaker	Dhoma	148 TL	MSM	
Johnius dussumieri	Sin croaker	Dhoma	110 TL	MSM	
Pampus candidus	Silver pomfret	Vichudo/Paplet	133 SL	MSM	
Parastromateus niger	Black pomfret	Halvo	170 TL	MSM	
Epinephelus diacanthus	Spiny cheek grouper	Whekli	180 TL	MSM	
Priacanthus hamrur	Bull's eye	Dorali	140 TL	MSM	
Cynoglossus macrostomus	Malabar sole	Jib	90 TL	MSM	
Plicofollis layardi	Thinspine sea catfish	Khagi	291 TL	MSM	Stocks are in the recovery phase
Leptomelanosoma indicum	Indian threadfin	Dara	530 FL	MSM	
Pomadasys argenteus	Silver grunt	Karkara	250 TL	MSM	
Congresox talabnoides	Indian pike conger	Wam	950 TL	MSM	
Scoliodon laticaudus	Spadenose shark	Sandho	376 TL	L_{M50}	The fishery is in a declining stage. Therefore L_{M50} used as MLS

Species Name	Common Name	Vernacular Name	Recommended MLS (mm/g)	Decision Logic	Remarks
Himantura imbricata	Scaly whip ray	Warkhol patari	140 DW	MSM	
Major Crustacean resources					
Solenocera crassicornis	Coastal mud-prawn	Lalkolmi	63 TL	MSM	Most of the stocks are under fishing pressure by exploitation rates, need to manage by implementing MSM as a conservative measure
Parapenaeopsis stylifera	Kiddi prawn	Kolmi	65 TL	MSM	
Metapenaeus affinis	Jinga prawn	Medium jinga	102 TL	MSM	
Metapenaeus monoceros	Speckled prawn	Kapsi jinga	105 TL	MSM	
Metapenaeus dobsoni	Flower tail prawn	Flower jinga	60 TL	MSM	
Penaeus semisulcatus	Green tiger prawn	Patta jumbo	120 TL	MSM	
Portunus sanguinolentus	Spotted crab	Karchala	74 CW	MSM	The catch is in plateau state, create awareness among fishers on release back of berried females into the sea
Portunus pelagicus	Blue crab	Karchala	90 CW	MSM	
Charybdis feriata	Cross crab	Karchala	66 CW	MSM	
Panulirus polyphagus	Mud spiny lobster	Teetan	300 g	WFM	Notified as MLS for export by MPEDA
Panulirus homarus	Scalloped spiny lobster	Teetan	200 g	WFM	
Major Molluscan resources					
Uroteuthis (photololigo) duvauceli	Indian squid	Narsinga	107 DML	MSM	The mean size of the resources in the fishery is decreasing
Uroteuthis (photololigo) singhalensis	Long barrel squid	Nani narsinga	83 DML	MSM	
Sepia pharaonis	Pharaoh cuttlefish	Dedka	110 DML	MSM	

Abbreviations: TL – Total Length; FL – Fork length; SL – Standard Length; CW – Carapace Width of Crabs; DML – Dorsal Mantle Length of Cephalopods; DW – Disc Width of Rays; L_{M50} – Length at which 50% of the fishes are mature; MSM – Minimum Size at Maturity or size of the smallest mature fish; WFM – Weight at first maturity or the weight of the animal where 50% of the fishes are mature

Spawning seasons of commercially exploited fishery resources of Gujarat

Spawning season is not common for all the fishery resources. Investigations on resource specific spawning season are pivotal and will aid in temporal fishery management. We attempted to estimate the spawning season for the 35 commercially exploited fishery resources in the region. The percentage of matured specimen in the catch wasconsidered asproxy to spawning season (Gillanders et al. 2003). The specimens above the estimated

Resources	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Coilia dussumeri						***	***					
Coryphena hippurus						***	***	***				
Euthynnus affinis						***	***	***				
Harpodon nehereus						***	***					
Megalapsis cordyla						***	***					
Rastrelliger kanagurta						***	***					
Scomberomorus guttatus			***	***	***	***	***	***				
Trichurus lepturus						***	***					
Thunnus tonggol						***	***					
Epinephalus diacanthus						***	***					
Nemipterus japonicus						***	***					
Johnius glaucus						***	***					
Otolithes cuvieri						***	***					
Parastromateus niger						***	***					
Pampus argenteus						***	***					
Priacanthus hamrur						***	***					
Plicofollis layardi (=P. tenuispinis)						***	***					
Saurida tumbil						***	***					
Muraenesox bagio						***	***					
Scoliodon laticaudus						***	***					
Rhizoprionodon oligolinx						***	***	***				
Rhinobatos annadalai						***	***					
Penaeus monodon					***	***	***	***				
Penaeus semisulcatus					***	***	***	***				
Metapenaeus affnis					***	***	***					
Metapenaeus monoceros					***	***	***	***				
Parapenaeopsisstylifera					***	***	***	***				
Solenocera crassicornis					***	***	***	***				
Portunus sanguinolentus						***	***	***	***			
Panulirus polyphagus						***	***	***	***			
Uroteuthis duvauceli						***	***	***	***			
Uroteuthis singhalensis				***	***	***	***	***				
Sepia inermis						***	***	***				
Sepia pharonis						***	***					
Sepia elliptica						***	***	***	***			

Scale
0-100 0 10 20 30 40 50 60 70 80 90 100

*(*** No samples)*

length at first maturity (L_{m50}) were only considered for the estimation of percentage matured specimen. The results showed distinct variations in spawning season between the species and demonstrate winter season as major spawning season for most species. The output can be considered while framing any management strategies to combat reproductive overfishing for the sustainable exploitation of fishery resources in the region.

Gillanders, B. M., Able, K. W., Brown, J. A., Eggleston, D. B., & Sheridan, P. F. (2003). Evidence of connectivity between juvenile and adult habitats for mobile marine fauna: an important component of nurseries.Marine Ecology Progress Series,247, 281-295.

Growth, Population and Mortality parameters

Growth and mortality parameters (Table 6.4) were analyzed for the commercially exploited fishery resource along the region to understand the status of the stock and the exploitation level of resources. Exploitation rate (E) depicts the status of exploitation (under exploitation/overexploitation) of the resources. The large pelagic resources like *E. affinis*, *C. hippurus* are underexploited in status, which can be considered as a future fishery in the region. Commercially important resources like *T. lepturus*, *N. japonicus*, *P. tenuispinis* and most of the crustacean resources showed slightly overexploited status. The cephalopod resources show a moderate rate of harvest along the region. Exploitation status of resources is needed to be assessed and managed by framing the species-specific management plans to maintain the sustainability of the resources.

Table 6.4: Growth, mortality and population parameters of commercial fishery resources (2012-17)

Species	L_∞ (mm)	K (yr^{-1})	M (yr^{-1})	F (yr^{-1})	Z (yr^{-1})	E
Euthynnus affinis	714	0.520	0.89	0.83	1.72	0.48
Megalaspis cordyla	510	0.750	0.98	1.34	2.32	0.57
Trichurus lepturus	1218	0.300	0.53	0.92	1.45	0.63
Thunnus tonggol	1134	0.650	0.48	0.55	1.03	0.53
Coryphaena hippurus	1470	0.140	0.31	0.12	0.45	0.26
Nemipterus japonicus	441	0.500	1.00	1.86	2.49	0.65
Johnius glaucus	336	0.520	1.10	1.36	2.46	0.55
Pampus argenteus	316	0.710	1.38	1.58	2.96	0.53
Plicofollis tenuspinis	1020	0.310	0.32	0.94	1.26	0.74
Scoliodon laticaudus	679	0.490	0.87	0.88	1.75	0.50

Species	L_∞ (mm)	K (yr^{-1})	M (yr^{-1})	F (yr^{-1})	Z (yr^{-1})	E
Penaeus semisulcatus	247	1.500	2.30	4.59	6.89	0.67
Metapenaeus monoceros	236	1.500	2.30	4.18	6.48	0.65
Metapenaeus affinis	205	1.700	2.61	4.64	7.25	0.64
Parapenaeopsis stylifera	152	1.600	2.46	5.40	7.86	0.69
Solenocera crassicornis	142	1.700	2.61	5.22	7.83	0.67
Portunus sanguinolentus	184	1.200	1.84	2.42	4.26	0.57
Charybdis feriata	173	1.200	1.84	2.71	4.55	0.60
Uroteuthis (photololigo) duvauceli	273	0.640	1.36	1.56	2.92	0.53
Uroteuthis (photololigo) singhalensis	242	0.770	1.59	1.59	3.18	0.50

7. Estimation of potential yield and optimum fishing fleet size

The potential fishery yield is one of the key management input information for determining the measures required for sustainable management of fishery resources. Limiting exploitation levels to the fishery reference points is important for sustainability of resources. For the estimation of potential yield off Gujarat, the commercially exploited fishery resources were grouped into five categories along the region viz., small pelagics, large pelagics, demersals, crustaceans and mollusks. The fishing effort (active fishing hours) was standardized based on the weighted catch per unit effort (CPUE) for the major fishing crafts *viz.,* mechanized single-day trawler, mechanized multiday trawler, mechanized gillnetter, mechanized dolnetter, other mechanized, motorized and non-motorized fishing crafts. These major fishing gears were contributing more than 98% of the total marine fish landings of the region. The landings data available with the National Marine Fisheries Data Centre (NMFDC) of ICAR-Central Marine Fisheries Research Institute (CMFRI) was used as model input data. The CMFRI sub-group of the working 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 (GOI, 2018). The estimated potential yields (MSY) for the different categories off Gujarat were *viz.,* pelagic finfish (3.46 lakh t), demersal finfish (2.74 lah t), crustaceans (1.51 lakh t) and mollusks (0.88 lakh t) and miscellaneous (0.35 lakh t) (Fig. 7.1). The recent year (2017) catch for the above said groups were, pelagic finfish (3.03 lakh t), demersal finfish (2.53 lah t), crustaceans (2.00 lakh t) mollusks (0.68 lakh t) and miscellaneous (0.26 lakh t), which indicates marginal scope for increasing the catches of pelagic finfish and mollusks.

Determining and maintaining optimum fleet size is one of the key input controlling management measures for the sustainable exploitation of marine fishery resources. The optimum fleet size was calculated based on the potential yields of different fishery resources. The total number of vessels required to optimally exploit the resources at potential yield level is estimated as 13,035 by the Expert Committee for Revalidation of the Potential Yield of Fishery Resources (GOI, 2018) for Gujarat

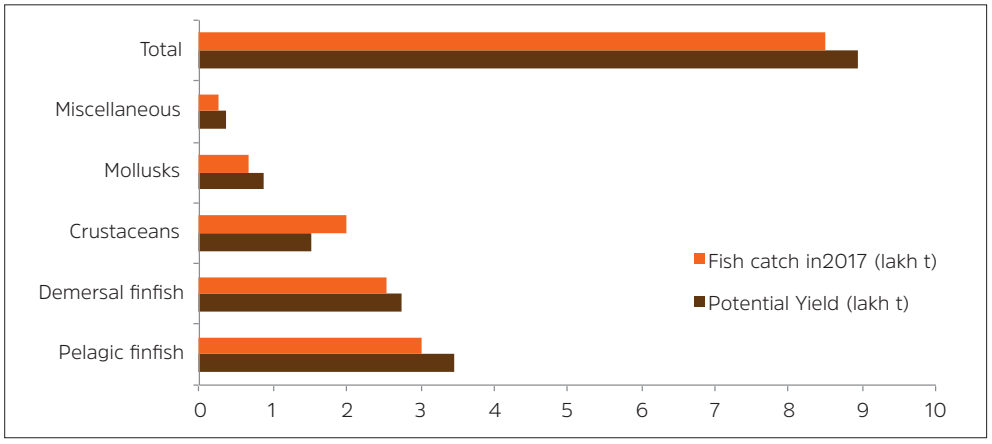


Figure 7.1. Realm-wise present catch and maximum sustainable yield (MSY) for the region

and Daman & Diu. The potential yield was proportionately distributed to each of the identified major craft categories to arrive an optimum fleet size estimates. The average catch per hour for the craft was computed from the catch and effort in hours. Finally, by dividing the potential yield corresponding to a craft with its catch per hour, the optimum fishing hours was required to harvest the potential yield was obtained. The optimum fleet size was calculated by dividing the optimum hours with the trips per annum of the craft and hours per trip of the respective craft. Fleet overcapacity for different fishing crafts was estimated as mechanized trawler (171%), mechanized gillnetter (185%), mechanized dolnetter (201%), motorized fishing craft (372%) and non-motorized fishing craft (150%) (Table 7.1). The optimum fishing fleet needs to be implemented for the sustainable exploitation of fishery resources in the region.

Table 7.1: Comparison of the optimum fishing fleet in different craft categories against the current fleet size

Type of fishing craft	Current Fleet (ReaLCraft, July 2019)	Optimum Fleet size	Overcapacity of fishing fleet (%)
Mechanized trawler	10292	6012	71.2
Mechanized Gillnetter	4272	2314	84.6
Mechanized Dolnetter	2628	1310	100.6
Other mechanized craft	38	190	-62
Motorized fishing craft	11734	3157	271.7
Non-motorized fishing craft	78	52	50

8. Estimation of by-catch and discards for different fisheries

Trawl Fisheries

The overall composition of targeted catch and by-catch of trawlers were worked out. About 18% of the catch by trawlers operating along the Saurashtra coast goes as discards. Nearly 11% of the total catch comprised of low valued by-catch. About 71% of the total catch was estimated to be the targeted catch (Fig. 8.1).

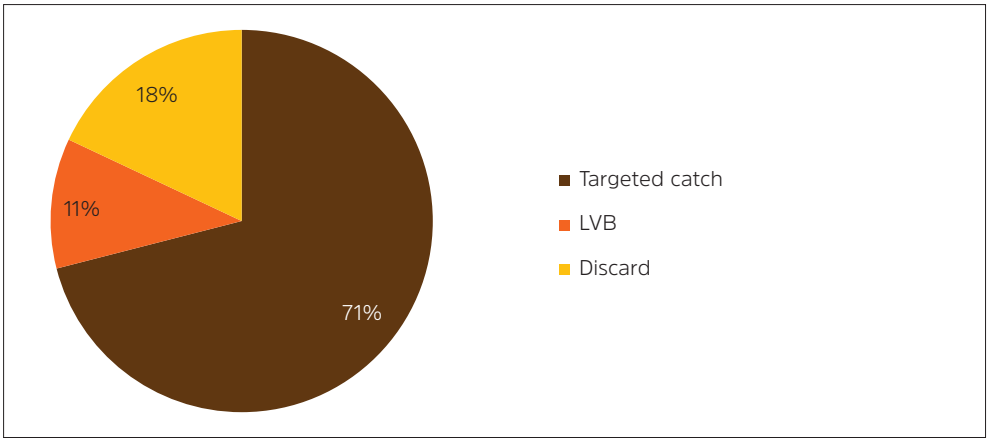


Figure 8.1. Composition of targeted catch, by-catch and discard from trawlers

The composition of the targeted catch and by-catch from the single-day trawlers is given in figure 8.2. About 37% of the total catches by single-day trawlers was observed to be low valued catch (LVB), which was landed along with targeted catch (63%). No noticeable quantity of discards was observed from the single-day trawlers operating along the Saurashtra coast. The composition of the targeted catch and by-catch from the multi-day trawlers is given in figure 8.3. Low valued by-catch (LVB) constituted nearly 8% of the total catch by multi-day trawlers, along with targeted catch (72%). About 20% of the catch was found to be discarded by the multi-days trawlers operating in the region.

Jellyfish fishery

In many cases, the jellyfishes were a persistent nuisance to fishers due to clogged nets, spoiled catch, fouled gear and stings. The catch of jellyfish was often not reported clearly due to their inconsistent availability, including the boom and bust phenomenon. Due to this, they are either not reported in catch statistics or categorized as miscellaneous invertebrates. Fishers continue to catch large amounts of jellyfish as bycatch, but in several incidents already caught jellyfishes were thrown back to sea due to lack of buyers and technical knowledge to process them. The jellyfish fishery has been existing in Gujarat for decades and a regular seasonal export of jellyfishes was observed since 2005. Gujarat has emerged as one of the top jellyfish producers among other maritime states including Andhra Pradesh and Kerala. The jellyfish fishery of Gujarat is one of the special and unique fisheries supporting the livelihood of small-scale fishers along the Gulf of Kachchh.

Fishers are engaging in the unloading of the jellyfishes using a scoop net in Jakhau fish landing centre, Gujarat

The jellyfish fishery in Gujarat is a seasonal fishery that occurs in two dispersed locations for two species by using different types of gears including scoop net, bag net and gillnet. The processing is performed in temporary sheds during jellyfish fishing seasons. Occasionally, the processing of jellyfish can also be important supplementary employment for fishers, but the improvement in processing methods is necessary by taking care of environmental health concerns. Participatory management approaches are most appropriate to upscale the jellyfish fishery in the region. The new research dimensions have been worked out by ICAR-CMFRI on the species diversity of jellyfish resources; medusae abundance zones, surveys to mark and protect important polyp areas; relationships between polyp mass and medusae proliferation; investigations on medusae to identify the factors that control bloom and documentation of the catch statistics on a regular basis, etc.

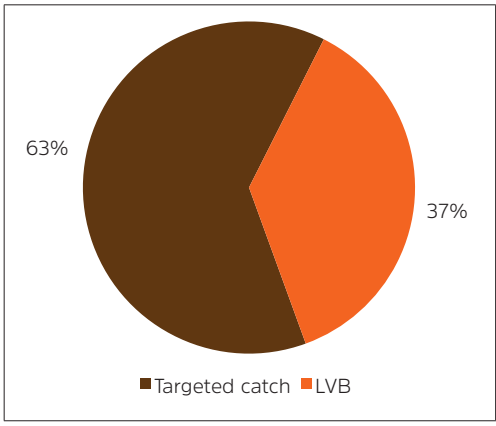


Figure 8.2. Composition of targeted catch and by-catch from the single-day trawlers (MTN)

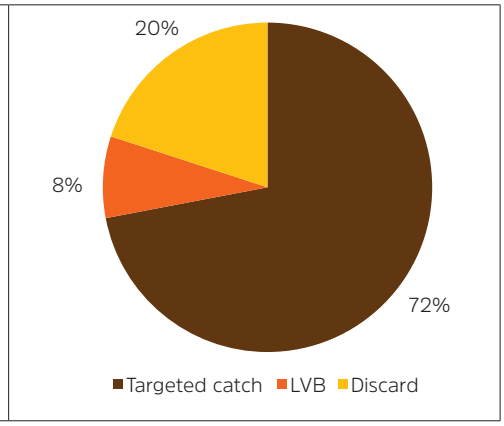


Figure 8.3. Composition of targeted catch, by-catch and discard from the multi-day trawlers (MDTN)

Monthly composition of targeted catch, by-catch and discard for single day trawlers and multi-day trawlers are given in Figure 8.4 & 8.5. The highest percentage of low valued by-catch (LVB) was landed during April, whereas, the lowest landing

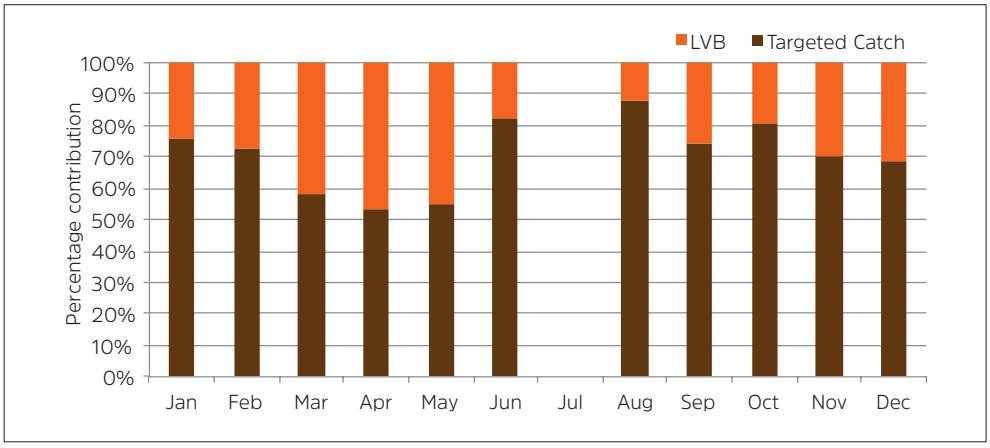


Figure 8.4. Monthly composition of targeted catch and by-catch for single day trawlers

of LVB was observed during August in the case of single day trawlers. LVB landing was highest during May and comparatively lower during August in the case of multi-day trawlers. Higher discards were observed during February, whereas the discard was lowest during August (Fig.8.5).

Spatio-temporal distribution of by-catch exploited by the trawlers operating from the Gujarat coast is given in figure 8.6. The lowest by-catch was reported during the winter

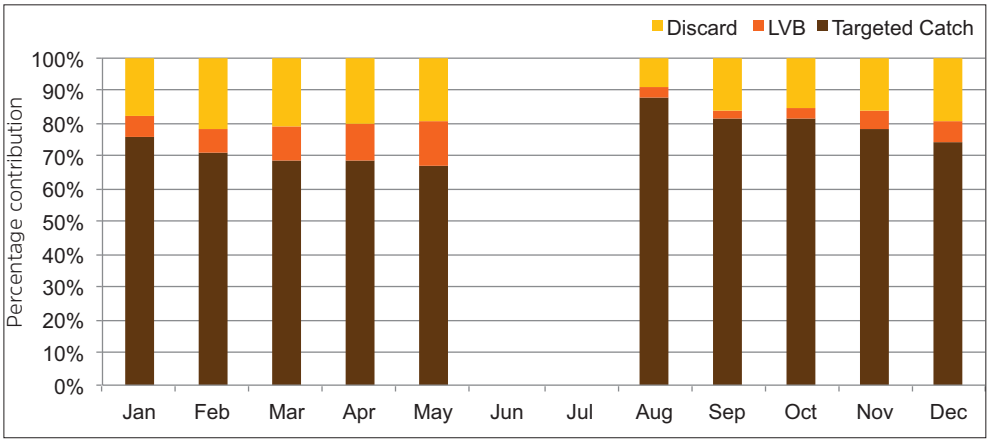


Figure 8.5. Monthly composition of targeted catch, by-catch and discard for multiday trawlers

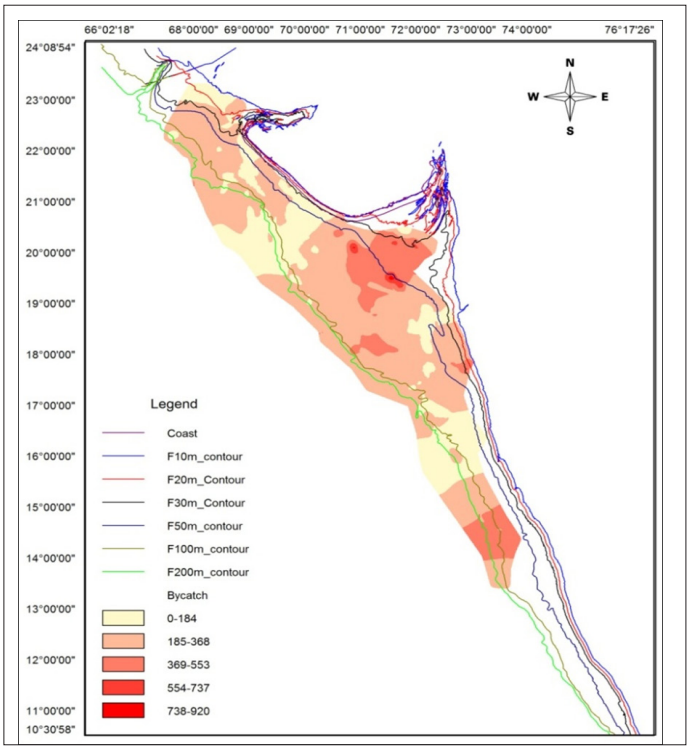
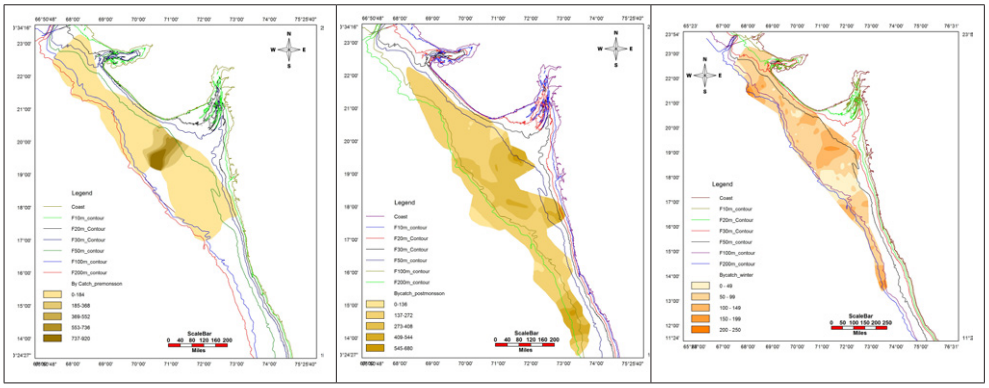


Figure 8.6. Spatial distribution of by-catch exploited by the trawlers operating from Gujarat

season with sporadic high landings from the inshore waters. The highest by-catch landing was observed during pre-monsoon. The by-catch landing was considerably higher during post-monsoon season and the effort was mostly concentrated south

of Gujarat up to Mangalore coast. Abundance of by-catch was observed in a depth range of 50 to 200 m irrespective of seasons (Fig. 8.7).

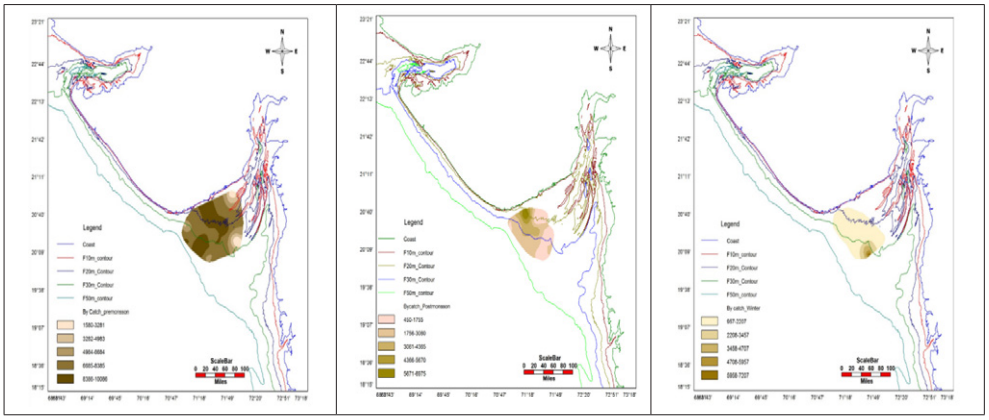


Pre-monsoon Post-monsoon Winter

Figure 8.7. Spatio-temporal distribution of by-catch exploited by trawlers operating from Gujarat coast

Dolnet Fisheries

About 25% of the catch was observed to be by-catch from the dolnet fishery. The remaining 75% of the targeted catch was comprised of ribbonfishes, bombayduck, anchovies, croakers and prawns. An increase of by-catch landings was observed from November to February in the dolnetters (Fig. 8.8).



Pre-monsoon Post-monsoon Winter

Figure 8.8. Spatio-temporal distribution of by-catch exploited in the dolnetters operating along the Gujarat coast

Gillnet Fisheries

Low-value by-catch comprised of sucker fishes, oceanic triggerfishes, moonfish, sunfish, etc. in the gillnet fishery. Turtles and dolphins are major ETP species encountered in the gillnet fishery off Gujarat. Out of 567 numbers of observations spread across the coastline of Gujarat, turtles or dolphins occurred in 75 observations (13%). The turtle incidence points were spread across the depth contours ranging from 30 m to beyond 200 m, while the dolphin incidence points were concentrated around the 100 m depth contour. The turtle abundance points are nearer to shore along the Saurashtra coast (between Veraval and Porbandar coast), which is known for turtle nesting. The catch rate for the LVB was more during the winter months compared to other seasons, while the incidence rates for the ETP species did not show any specific variations over the seasons (Fig. 8.9). The turtle and dolphins are normally released back to sea soon on landing onboard or allowed to wade away from the net before hauling.

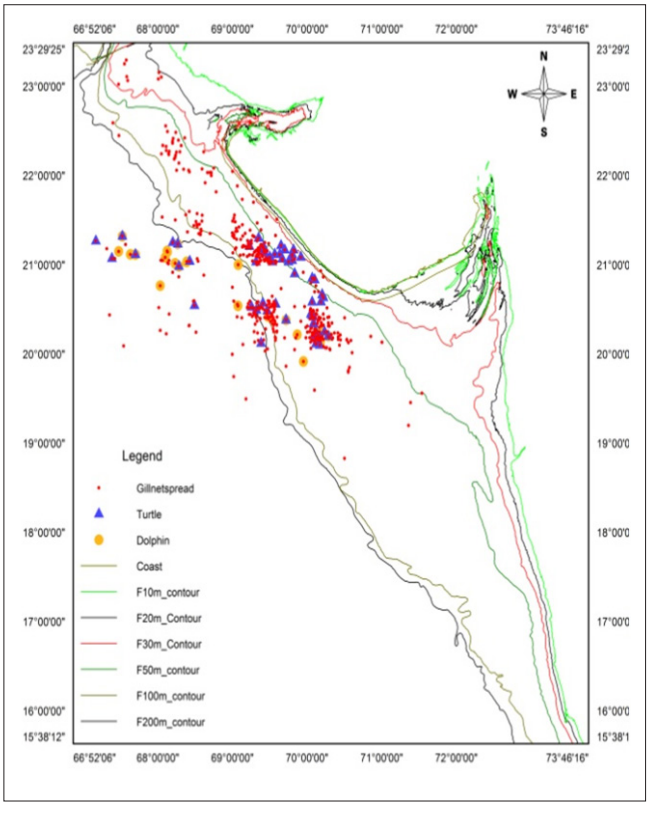


Figure 8.9. Incidence points of ETP species in the gillnets from the Gujarat coast

9. Climate change and marine fisheries of Gujarat

The deleterious/undisruptive impacts of climate change have been studied along the coast of Gujarat by assessing the trend in various environmental parameters such as sea surface temperature (SST), rainfall and chlorophyll a (Chl-*a*). Sea surface temperature (SST) act as a principal component in deciding the phenology and distribution of marine species, thereby having direct implications on fisheries and sustainability. Hence, the variability in SST was studied using trend analysis for 105 years and it has been found that there has been an increase in SST in the lower latitudes (tropical) and waters of lesser depths. The results also revealed an increase in SST during the winter months, i.e., from November to January along the coast (Fig. 9.1).

An overall shift in rainfall regime in all the districts of Gujarat was detected, with a significant increase in trend for Kachchh, Junagadh and Jamnagar (Saurashtra) region for April and September. However, a decreasing trend in rainfall was observed for districts of south Gujarat (Surat and Valsad) and north Gujarat (Sabarkantha and Banskatha). A decrease in chlorophyll concentration (-0.016 mg chlorophyll/m^3) was noticed from 1998 to 2015. The dynamics of Chl-*a* has shown a visible impact on the phenology of marine fishes. The changing SST was impacting the maturity of Indian mackerel and ribbonfish. The spawning season of mackerel was also triggered by higher current speed. Rainfall has a significant positive influence on the maturity of mackerel, threadfin bream and bombayduck. Differential distribution pattern of skipjack tuna indicated an abundance of tuna in the offshore areas (100 m zone) during the winter season (November, December and January), while the migration is towards inshore areas (30-50m depth zone) during pre-monsoon and post-monsoon seasons, depicting the SST preference by the migratory species along the Gujarat Coast.

The adaptation and mitigation potential of susceptible coastal villages to climate change have been assessed by taking consideration of five variables *viz.,* Environmental, Fishery, Economy, Social standards and Developmental drivers. The results indicated a high vulnerability of coastal fishermen of Gujarat, with "Economy" as the major factor impacted by climate change followed by "Social." The socioeconomic conditions reveal poor financial conditions of fisher with insignificant support from the government (Fig. 9.2). The adaptive capacity of the fishermen

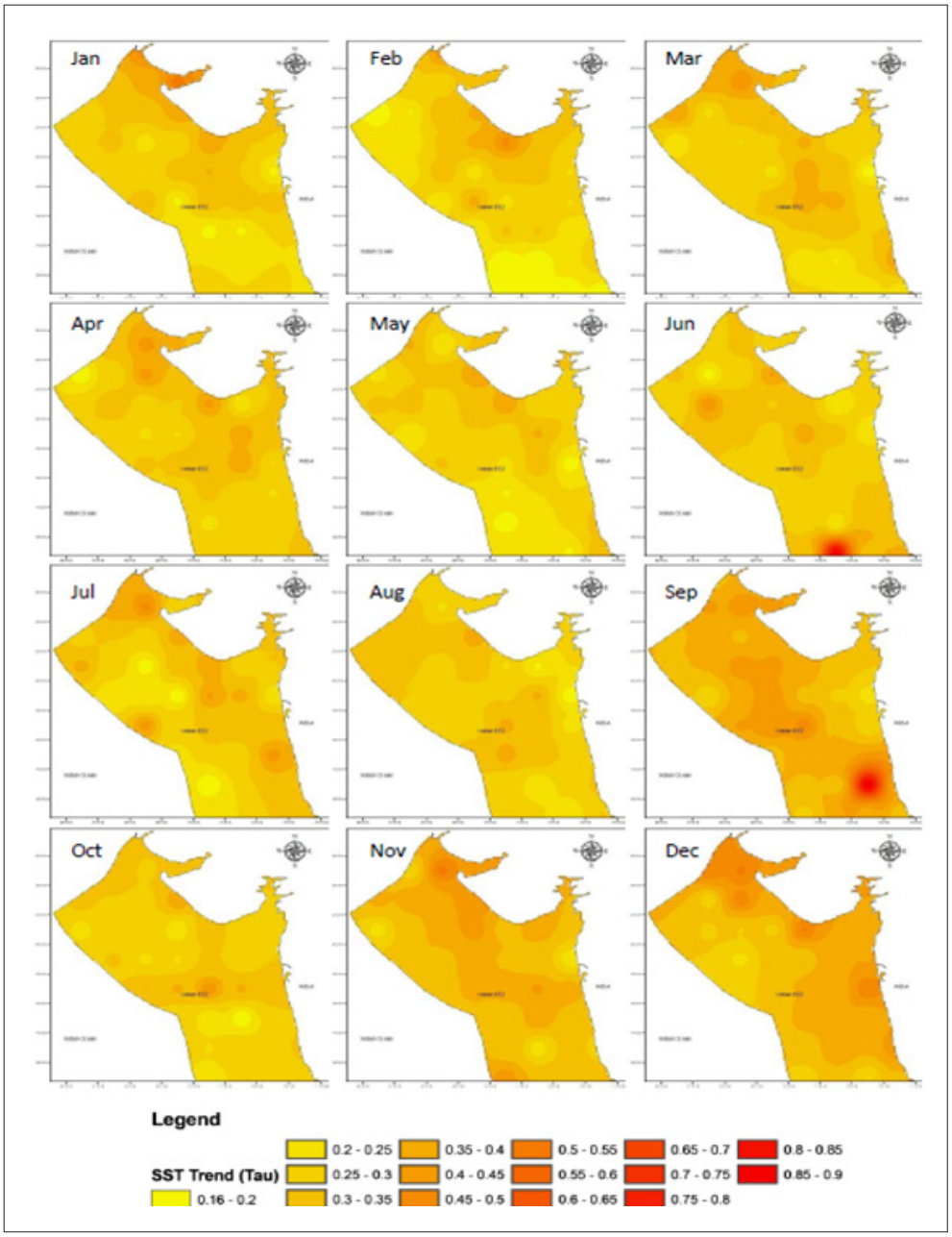


Figure 9.1. Kendall's Tau value of monthly trend over different months across the northwest Indian EEZ

was found to be low due to constraints like low income and poor facilities, lack of shelter/home during natural calamities, poor disaster risk management, lack of awareness, preparation and mitigation options. It was found that the fisherman depends on Indigenous Technical knowledge (ITK) as a prime line for their defense during the distress and to attain higher catch.

The vulnerability index for thirty-six (36) commercially important fish species have been studied along the northwest coast of India, by taking consideration of their exposure, sensitivity and adaptive capacity. The results proclaimed six commercially important species *viz. Otolithoides biauritus, Panulirus polyphagus, Epinephelus diacanthus, Protonebia diacanthus, Harpadon nehereus* and *Thunnus tonggol,* as

Figure 9.2. A pictorial depiction of the vulnerability of Gujarat's fishers to climate change

highly vulnerable species. Restricted horizontal distribution pattern, low growth rate and high exploitation ratio were found to be the major disposing factors for the species towards vulnerability. Twenty-eight species were found to be low to moderately vulnerable with two species, namely *Megalaspis cordyla* and *Charybdis feriata* having no impacts of climate change in the present scenario (Fig. 9.3).

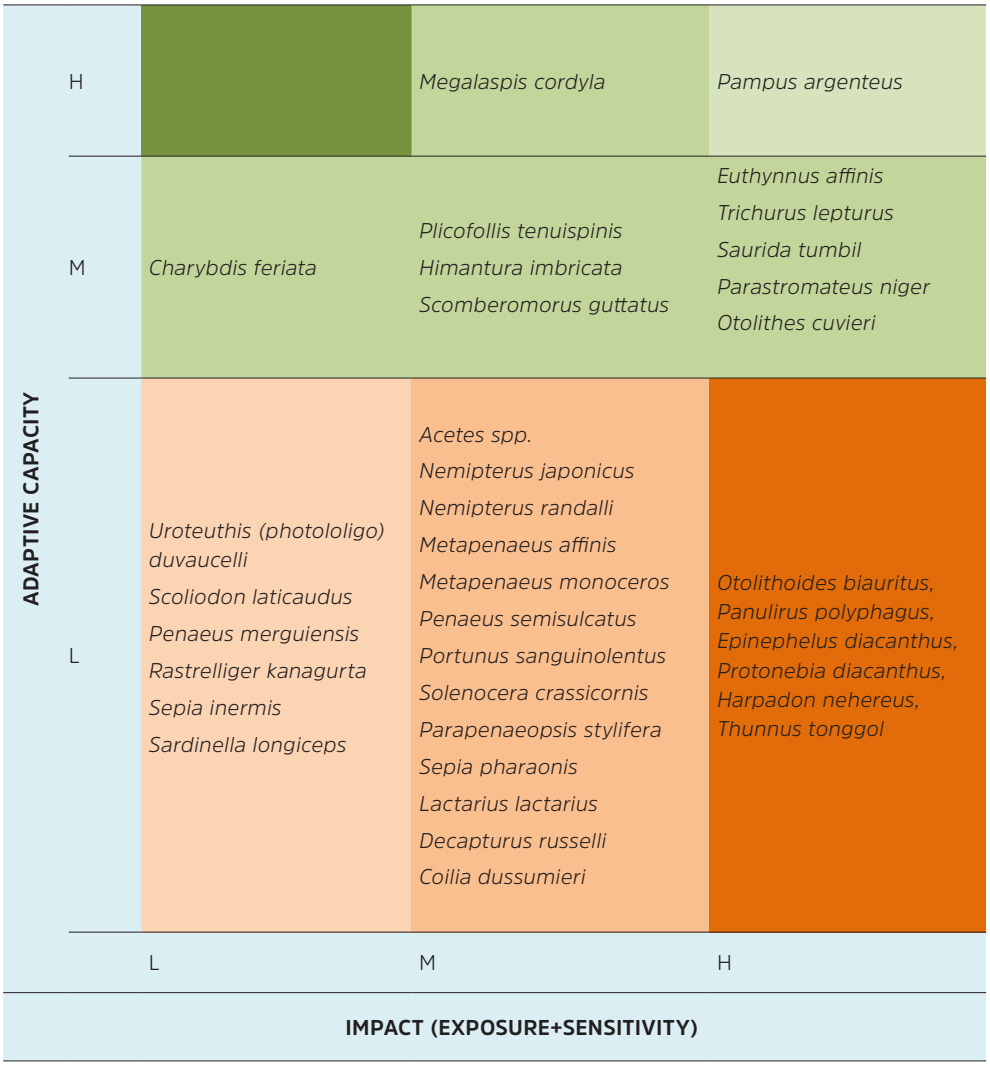


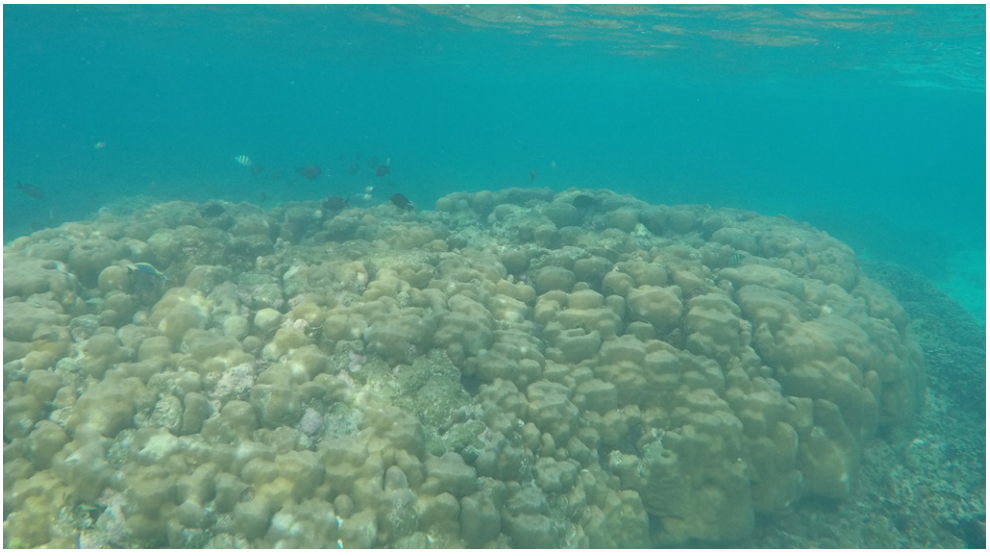
Figure 9.3. Vulnerability matrix of fish species along the northwest coast of India (Source: Zacharia et al., 2016)

10. Ecologically sensitive coastal habitats of Gujarat

Gujarat State, with a coastline of more than 1,600 km and the two gulfs, namely, Gulf of Kachchh and Gulf of Cambay, constitutes 16% of Indian coastline, sheltering diverse coastal ecosystems such as coral reefs, coastal wetland, mangroves, estuaries and mudflats.

Coral reefs

Gulf of Kachchh is a shallow-water marine inundation area above the Saurashtra peninsula, whose southern margin is bordered by one of the major coral reefs of India. Geological formations characterized the area from the middle Jurassic to Holocenera developed over a crystalline basement (Biswas, 1971). Other parts of the gulf have silt and clayey bottom with patches of fine sand (Hashimi *et al*., 1978). The topography is irregular at the mouth and central part of the gulf and consists of pinnacles and scraps ranging in size from 6 to 32 m (Nair *et al*., 1982). The gulf has 42 Islands in its margin, of which 34 have corals and most of them are partially submerged into water known as “Areal” islands and some are fully submerged and exposed during minus tides (Pillai, 1983). The coral reef of the Gulf



of Kachchh is one of the most northerly reefs in the world (Kelleher *et al*., 1995). Remote sensing studies made by DOD and SAC (1997) identified coral reefs of the Gulf of Kachchh mostly fringing type, alongside platform reefs and coral pinnacles covering 315 km^{-2} area. The gulf is characterized by high tidal fluctuations, which are comparatively low at the mouth and escalate towards the head due to the funnel shape and semi-enclosed nature of the area.

Gulf of Kachchh Marine National Park and Sanctuary

For conservation of ecologically important areas, Govt. of India initiated action through the state governments to create a network of Marine National Parks under the Wildlife (Protection) Act, 1972. The Gulf of Kachchh (GoK) Marine National Park and Sanctuary (MNPS) is the first Marine National Park in India, which has been established along the southern margin of the Gulf of Kachchh (22° 54" to 23° 14" N 68° 72" to 70° 14" E) during 1982 (Notification No. AKH-138-2-82-WLP-1081-126827-V2, dated 20.7.1982). Gulf of Kachchh is an isolated and one among the northernmost coral reefs besides the northern portions of the Red Sea and the Persian Gulf (Scheer and Pillai, 1983). Wildlife Institute of India has classified the Gulf of Kachchh MNPS as part of the West coast (8A) biotic province (Panwar and Mathur, 2002). The area was characterized by highly variable environmental conditions *viz.,* temperature fluctuations (15-30°C), salinity changes (25-40 ppt), high-suspended particulate loads and extreme tides (Rajasuriya *et al*., 2004). Among the four major coral reef ecosystems of India, only a very low number of hard coral species have been reported from GoK even though the region has the second-largest reef flat area (148.4 km^{-2}), (Pillai, 2010; SAC, 2010).

The occurrence of hard corals (Phylum: Coelenterata; Class: Anthozoa; Order: Scleractinia) was initially described at the Gulf of Kachchh by Gideon *et al*., (1957). The comprehensive work made by Pillai and Patel (1988) forms the authentic basis of hard coral taxonomy from this area, in which they have described 37 species of hard corals from 16 different reefs of the southern Gulf of Kachchh. Many research attempts followed this explored coral species diversity in the Gulf of Kachchh during different periods and added new species to the list (Patel 1976; Pillai *et al*., 1979; Chavan 1984; Scheer, 1985; Wafar 1986; Pillai 1987; Pillai and Patel 1988; Venkatraman *et al*., 2003; SubbaRao and Sastry 2005; Singh *et al*.,2006). Most of these studies were concentrated at easily approachable reefs like Pirotan Island, Poshitra Island, Boria reef and Narara reef. The recorded diversity is poor, with only 49 species of stony corals belonging to 25 genera, which include five species identified from the fossilized skeleton found on the islands (Satyanarayana and Ramakrishna, 2009), whereas the reefs north of it elsewhere have recorded almost double the number of species. The record of fewer coral associates may be attributable to the less number of explorations carried out in this reef area.

Quantitative and qualitative reef specific scleractinian studies in the region are scanty after Pillai and Patel (1988). A larger number of scattered islands (42 No), high tidal fluctuations coupled with turbid waters restrict the reach of the researchers to study the scleractinian diversity.

CMFRI (Sreenath, 2015) conducted a study on five reefs of the Gulf of Kachchh, *viz*., Chandri Island, Mithapur reef, Laku point, Savaj Island and Goose reef to evaluate the health status of coral reefs. *Porieslutea* was found dominant on the reefs, whereas *Dipsastrea favus* was found abundant. The average percentage of hard coral live cover of the surveyed reefs was 30.87%. As per the Coral Mortality Index estimated, most of the reefs were healthy except Goose reef which is categorized as "sick." Maximum bleached corals were noticed in the rock pool faces in the mid littoral zone of the Laku point reef and the highest dead coral cover has been recorded at the Goose Island reef. Adjacent to the Gulf of Kachchh MNP region, the presence of coral species has also been reported in the places along the northern gulf, *viz*., Mundra, Mandvi and Kandla (Deshmukh *et al*., 2000). Moreover, minor occurrences of hard corals also have been reported from intertidal regions along the Saurashtra coastline (Raghunathan *et al*., 2004).

The exposure to a stressful environment wiped away many of the less tolerant species from the region. The identity of current massive and sub-massive coral records has many ambiguities. A proper molecular-based study needs to be performed to record the total biodiversity of the area. As it is lined with many industrial giants, the shoreline requires heavy monitoring and control systems involving frequent sensors installed in the sea to provide early warning of pollutants, temperature and turbidity change. The impact assessments of new and currently ongoing projects should be made as strict and needed to be channelized through a single agency, which has NABL certified facilities.

Mangroves

Mangroves serve as a natural buffer zone against some of the worst natural disaster phenomena like cyclones and tsunamis and also help in preventing coastal erosion. Mangroves are known to be rich in organic sedimentation and act as a nursery ground for many of the commercially important fishes. Twelve species of mangroves have been reported from Gujarat *viz., Avicennia marina, A. alba, A. officinalis, Ceriops tagal, Rhizophora mucronata, R. apiculata, Aegiceras corniculatum, Sonneratia apetala, Exoecaria agallocha, Bruguiera gymnorrhiza, Acanthus illicifolis* and *Bruguiera cylindrica*. At present, the Gujarat state sustains one-fifth of the total mangrove cover of India. An area of 1,324 km^2 of mangrove area has been notified as forest and 56% of this lies in Kachchh.

As the coast line of Gujarat is under the influence of high tidal variation, studies on proper zonation of the tidal area and the pattern of mangrove growth in each zone should be performed before any transplantation processes. It will help in the identification of suitable species while they are introduced and planted during the afforestation process. The clearance of mangroves for industrial activities like salt production also leads to a decrease in mangrove coverage.

Coastal Wetlands

Wetlands are areas of land that are either temporarily or permanently covered by water. These are transient geographic areas, which cannot be called as terrestrial or aquatic. Wetlands support a plethora of biodiversity. The Millennium Ecosystem Assessment estimates conservatively that wetland covers 7% of the earth's surface and delivers 45% of the world's natural productivity and ecosystem services, of which the benefits are estimated at $20 trillion a year (Source: www.MAweb.org). Out of entire India, Gujarat has the maximum area classified as a wetland of 34.74 lakh hectares comprising 17.56% of the state's geographic area (SAC, 2010). Area of intertidal mudflats especially that of the Kachchh District, dominates in the coverage.

A very high tidal amplitude of 5 to 7 m in the region brings a large portion of the land areas under the intertidal mudflat region. The area amounts up to 22,604 km^{-2}. The intertidal area and low tide area have a luxuriant growth of marine algae and form an ideal feeding ground for small sea creatures, including

juvenile fishes. They also attract an enormous avian diversity, including several endangered migratory birds. Apart from the vast tidal mudflats of Kachchh, other identified coastal wetland areas in Gujarat are the southern Gulf of Kachchh, Gulf of Khambhat and Kerly Lagoon (SAC, 2010). Several other estuarine linked wetland areas, which have been less studied are Mahuva Malan-NikolBandhara, Goghla-Brancawaa–Sodambandhara creek system separating Diu from Gujarat, Miyani Creek, Kuranga lake, Gojines-Bhopat estuarine system, Gomati estuarine area, Poorna estuary, Narmada estuary, *etc*. Owing to recent climatic variability and persistent anthropogenic developments, wetlands of this area are in constant threat. Industrial pollution, land accretion, conversion to salt pans, lack of proper management actions leaves these ecosystems in a vulnerable state.

Eco-sensitive Zones

Ecological sensitive zones (ESZs) are those transition areas identified around the protected areas and notified by the Government of India to prevent damages caused due to developmental activities. The ESZs can act as a buffer zone between the two regions. The width of the ESZs can vary depending on the level of the existing development around the protected areas. Activities such as commercial mining, setting of sawmills, setting up of industries causing pollution, commercial use of firewood, establishment of major hydroelectric projects, use or production

of any hazardous substances, undertaking activities related to tourism like over-flying the National Park areas by any aircraft, hot-air balloons, discharge of effluents and solid waste in natural water bodies or terrestrial area, *etc.* will be prohibited in ESZs. During 2016, MoEF has approved six ESZs in Gujarat, which includes GoK Marine National Park and Sanctuary.

The Whale shark conservation

It has been more than a decade since the Union Government's Ministry of Environment and Forest granted full legal protection to Whale Sharks in Indian territorial waters by adding the species to Schedule-I of the Wildlife Protection Act, 1972 under subsection (1) of section 61. The whale shark, *Rhincodon typus* Smith, 1828, is the largest fish, which is reported to grow up to a length of 15 m and is the first fish to be protected by Indian Law. The fish is cosmopolitan in distribution in the tropical waters and has been reported from warm temperate waters. Until the early 1980s, the whale shark landings in India were mainly due to incidental catches and these sharks were either discarded or thrown back into the sea. Since the mid-1980s, the exploitation of whale sharks was a regular fishery (Ashok, 1996) and were commercially exploited off the Saurashtra coast for their meat, fins, liver, skin and cartilage (Pravin, 1998). Currently exploitation of whale shark is prohibited and listed in the Wildlife Protection Act, 1972.

Gujarat waters were believed to be the feeding ground of whale shark. It might be due to the abundance of plankton, which is the major food of this planktivorous giant, in the productive waters of Gujarat. One of only three filter-feeding sharks (the other two being the basking and megamouth sharks), the whale shark feeds on minute organisms, including plankton, krill, crab larvae, jellyfish, *etc*. Although they have approximately 3,000 tiny teeth (each less than 6 mm in length), the teeth are not used while feeding. Instead, the whale shark can sieve prey items as small as 1 mm through the fine mesh of the gill-rakers (Norman, 2015). Concerted efforts by the Govt. of Gujarat to create awareness among the fisher society and rescue the fishes that have been incidentally caught in the fisher's net led to the rescue of 412 whale sharks until 2014. Maximum incidences of Whale shark were during the winter period, which can be explained by the high productivity off the Saurashtra coast due to the mixing of water by winter convection. Scientific research on the ecology, reproductive biology, population dynamics and migratory behavior of whale sharks are in the initial phase. Multi-agencies approach, i.e., WWF, Department of Forest, Govt. of Gujarat and Tata Chemicals Pvt. Ltd., were involved in Whale shark conservation in the state. Though satellite tag studies have been performed on whale sharks elsewhere in the world, no conclusive results have been made available on the works done in India. Assessment of the age, growth rate and sex of the whale sharks are also important, which can be performed by more intensive research. In the view of ecological significance, local awareness, regional specificity and current fishery & conservation strategies, the whale shark can be considered as a State Fish in the state of Gujarat.

11. Subsistence marine fisheries of Gujarat

Ginger prawn (*Metapenaeus kachchhensis*) fishery in Kachchh

The Gulf of Kachchh is considered as highly productive ecosystem on the Northwest coast of India. *Metapenaeu kachchhensis* (ginger prawn) forms a seasonal fishery for the socio-economically backward part-time fishermen of that area as a significant source of livelihood. The Little Rann of Kachchh fed by the southwest monsoon provides a highly productive estuarine breeding and nursery ground for finfish and shellfish. This suitable environmental condition makes juvenile prawns migrate in large numbers to the estuarine area and forms a seasonal fishery in the region. The fishing starts in July, immediately after the end of monsoonal rains and continues up until the end of October based on the intensity of rainfall. Madherkhi, Tikar and Surajbariare are the major fishing sites, which are known for unique endemic ginger prawn fishery. The whole fishery was based on the exploitation of juveniles on a mass scale, which depends on the ample intensity of rainfall at the right time. Little deviance in the monsoon time, as well as precipitation level, can fail the fisheries. The craft used in the fisheries is a 'Malia' type of plank-built ribbed boat locally known as 'Odie' to facilitate easy beaching on the estuarine mud.

The bag net, locally known as '*Gunja*' used for harvesting the prawn, has a square mouth and it gradually tapers, like a cone, to an opening at the end. The '*Gunjas*' are operated both as passive and active gear. When the '*Gunjas*' are used as passive gear, they are just set against the tide based on the tidal amplitude. '*Gunjas*' was used as a dragnet, while two fishermen hold sticks that are tied to the sides of the net. Scissor net, a modified stake net, which is locally known as '*Katarjaal*,' is also used along the fishing grounds, free from the strong current. Fishermen set the gears along with the shallow areas by entering into the water barefoot, locally called '*Pag*,' and hence this is called 'Pagadia fishery.' After hot blanching in boiling brine and drying, the prawns are sealed in polyethylene pouches and transported to different parts of India by the marketing agents and processing plants. These juveniles of ginger prawn do not fetch a good price, unlike their adult counterparts and are only used for domestic consumption. During the fishing season, the total revenue of ₹6,000 million was realized from the fishery. The short-term ginger prawn fishery renders them a huge economic opportunity and decides the monetary fate of the family for the rest of the year. The fishery should be assessed and exploitation should be done sustainably; otherwise, it may lead to a complete collapse of the fishery due to the decrease of spawning stock biomass. The failure in the fishery may disturb the livelihood opportunity of the fishermen and hence proper awareness among the fishermen is required. The introduction of alternative livelihood options like cage and pen culture techniques, product diversification and value-added techniques, as well as establishment of a proper marketing channel, can improve the situation through better price realization.

Edible oyster (*Crassostrea graphoides*) fishery

The endemic fishery is restricted to Miyani and Navibander creeks located in the Porbander district of Gujarat. The Navibander creek is the estuarine part of a small seasonal river '*Bhadar'* with a narrow connection into the open sea. The creek harbours motorized fishing boats of the traditional small scale fishermen of Navibander fishing village. In the case of Miyani, the creek is connected to the Vartu canal, which supplies fresh water during the rainy season with a narrow connection to the sea. The Miyani creek is shallow and the upper part of the creek having rocky substratum provides the ideal habitat to the Oysters for settlement. The fishery of both areas is marginal and small scale in nature. The fishing starts after monsoonal rains in the adjacent coastal waters with small FRP boats using different gillnets and continues up to March – April. Once the wind prevails in early summer, reduction in fishing will start based on the intensity of oyster beds and consumer demand. The rock oyster, *Crassostrea graphoides,* is the dominant oyster available in both the creeks in a considerable amount along with other fishes and locally called as "*chheepla*." During monsoon, the oyster populations reduce due to high ingress of freshwater from the connected rivulets, which results in drop

in salinity of the creek and an increase in turbidity. During post-monsoon, once the salinity starts increasing, the spat settlement is in the rocky zone of the creek.

The harvesting of oysters starts during April and continues till the onset of monsoon. The oyster spread area is 0.6 km^{-2} in Navibander and 0.25 km^{-2} in Miyani. The oyster population per square meter is higher in Navibander (14 no. per m^{-2}) compared to Miyani (11 no. per m^{-2}). The seasonal fishery is from March to June as the oysters attain a harvestable size. Adults and sub-adults from the village were engaged in the harvesting of the oyster during low tide. For reaching the ground, oared mini FRP boat was used and the local dive bare skin to handpicks the oysters. A metal hammer was used to detach the oysters from the substratum. The diver selects the oysters underwater as per the size of oysters and only bigger ones are collected for consumption. In two hours, one person can collect oysters, which yield up to one kg of meat. The fishery is prominent and practiced during the ban period as a subsistence fishery. Most of the consumption is local, but sometimes some surplus amount is sold at Porbander market @ ₹350-500 per kg of meat. There is a huge scope of increasing production through oyster farming in the area by local fishers, which can lead to better marketing and earning sources in offseason.

Lobster fattening: Pit culture

Lobster pit fattening was prominent along the intertidal zone of Bhavnagar and Amreli district of Gujarat. The fishers in the designated locations were engaged in traditional practices of pit culture for spiny lobster (*Panulirus polyphagus).* The pit

culture sites were surveyed and data were collected through personal interviews, direct and indirect observation methods. Random villages were surveyed for the pit culture technique, including pit preparation, collection of young juvenile, transportation, feeding habits, stocking density, molting, growth rate and marketing. Observations indicated that most of the live lobsters collected from '*Bandhan*' or surrounding harbors weighed 100 gm or above, and attained a marketable size by the end of the third month of rearing. The average weight of the lobsters ranged from 250to 300 gm and fetched an average price of ₹1,000 to ₹1,200 per kg. The results of the growth and production of spiny lobsters in pits proved that it is one of the best traditional farming practices with least expenditure and helps in improving the socioeconomic status of the villages. This study, therefore, infers that the fattening of lobsters is advisable for pit culture and there is great commercial potential for the development of a pit culture of *P. polyphagus* in Gujarat.

Subsistence fishing using Light by small Hodi in Saurashtra

Capturing fishes using lights is an age-old practice in coastal waters. Chinese dip net in Kerala is the best example of the same. Some fishes exhibit positive phototaxis, and are attracted towards light. The small scale fishery in nearshore waters off Saurashtra coast was taking advantage of this peculiar phenomenon of the cephalopods. In recent days small FRP boat called Hodi is specially used for light fishing, which evolved from the earlier plank built wooden Hodi. The overall length of the Hodi ranges from 16 to 25 feet. All the boats are propelled with a small outboard petrol engine fitted to one side of the boat at the aft. The power of engines varies from 2hp to 5hp according to the size of the Hodi. Around 500 to 1,000 volt generator is used and kerosene is used as fuel for the generator. High power (100 watts) LED bulb is fitted in light-reflecting focusing box. In a single Hodi, 4-8 bulbs are fixed on the side with an inverted "L" shaped wooden frame. All these Light-based fishing operations are performed very near to the shore at the average depth range up to 40 feet. Every Hodi is mastered by one or two crew members according to the size of the boat, light power and abundance of the fish.

Light fishing, mostly seasonal, starts after the monsoon fishing ban with a peak from October to December and continues up to the end of February. The fishing voyage starts at 6 pm and ends at 7 am. One trip consumes about 3-5litre of petrol and 5-7 litres of kerosene. Mostly the target resources are squids (*Uroteuthes (P) duvauceli*) and cuttlefish (*Sepia pharonis*) along with others like croakers, groupers, snappers and flyingfish which are also attracted to the Light. Jigging, scooping and cast netting method of fishing are practiced to capture the cephalopods and fishes. Focused light attracts more squids and cuttlefish to the side of Hodi. Hand jigs are used to capture the squids and cuttlefishes from the side of boats, sometimes when the congregation is denser and spreads to a larger area cast nets are also used.

An average of 25-40 kg mixed catch of squid and cuttlefishes are caught per Hodi in peak season. The whole catch of cephalopods were sold in price fixed by the moneylender cum traders. The price varies from ₹200 to ₹220 per kg. A full fledge hodi is costing around (₹1.1 to 1.5 lakhs) as the cost of FRP Hodi ranges from ₹35,000 to ₹45,000, Engine ₹50,000 to ₹75,000, generator costs from ₹20,000 to ₹30,000 and 4 to 8 bulbs each costing around ₹1,000. Operational cost per trip mostly comprises of petrol and kerosene used in a trip which costs around ₹800 to ₹1,000. Total earnings from one trip are around ₹3,000 to ₹4,000 from the fish sale. During the lean season, the same Hodi goes for hook and line fishing in the night in near shore area. The major catch in the line is Croakers having a price range of ₹100 to ₹120 per kg. The average catch per night is 15 to 30 kg using low-value squid as bait.

12. Sea cage farming and coastal mariculture in Gujarat

Fisheries and Aquaculture contribute about 5% in the agricultural GDP of India. Despite the contributions in the GDP of the Nation, the noteworthy point is that it has created direct and indirect employment opportunities for more than 14 million people. Indian seafood has great demand throughout the globe and the exports has grown to 7.08 billion USD in 2018. The ever increasing demand for fish as a protein-rich food source has resulted in widening the demand-supply gap. According to FAO, 80 million metric ton is the estimated demand for seafood by 2050 and with our present growth rate, we may not reach the production with the existing farming practices. To achieve such supply the production must multiply to several folds from the present production levels. Inland and brackish water aquaculture systems are suffering from lack of opportunities for expansion, pollution, productivity and other sustainability issues. Like many other parts of the world, the limitations are ever-increasing for enhancing the capture fisheries production with resource sustainability in India too. Aquaculture and its allied

Figure 12.1. Lobster fattening in open sea cages at Veraval

sub-sectors like mariculture have great potential to address this gap between supply and demand for seafood. Mariculture also helps the country to realize their socio-economic and ecological goals of the marine sector.

There exists a steady increase in the domestic demand of marine fishes for consumption, maybe due to the increased awareness of fish as a health food among the people and their increased purchasing power. It may lead to a sudden hype in demand for marine fishes. Since the marine capture fisheries are showing a stagnant or declining trend, there remains a huge gap in the demand and supply chains regarding seafood. The various possibilities offered by mariculture, especially cage farming, has only begun to be explored in India. Sea cage farming not only offers increased production of food fish but also forms a viable alternative for conventional marine capture fisheries, land-based aquafarming and various employment opportunities. Mariculture in sea cages and inland saline water bodies is a rapidly growing industry that can be promoted to the coastal fisher communities as a potential alternate lucrative business or as livelihood activity. Considerable high production potential attainable through various mariculture activities, especially cage farming, can play a significant role in enhancing the overall marine fish production in India, especially in Gujarat. Development of mariculture through cage farming can be taken up with central points of attention for sustainability and enhanced production by empowering the fisher folks through basic necessary scientific training associated with standard farm operations and management protocols.

An alternative technology/option needs to be explored for augmenting the ever-increasing demand of marine fish. Since the existing capture methods have exploited the resources indiscriminately due to various reasons like targetted fishery, socioeconomic pressure, etc., there is a necessity to exploit the resources sustainably. Under such circumstances, mariculture and cage farming has been identified as one of the methods for augmenting fish production from the sea. Cage farming originated in Southeast Asian countries and now it is one of the major culture activities all over the world. Mariculture is a relative latecomer in the food production industry in the world. The positive experiences in the production of salmonids in floating cages at high densities in European countries, marine finfish farming in cages, was successfully initiated in coastal waters of several Asian and Mediterranean countries as well. The main advantages of cages when compared to conventional land-based systems include low capital investments, simple management and low volume high-density rearing.

However, availability of space in suitable locations, prospects to perform sustainable farming and husbandry practices are significant in meeting the future global seafood demand (FAO, 2018). Mariculture industry was considered to be smaller

than the brackish and other inland aquaculture practicing industry in several countries till 2010. But, within the next five years, it achieved substantial growth by creating a cumulative economy with the combined value of both brackish and inland sectors globally (FAO, 2014). Globally, it proved in the past that the mariculture sector significantly contributed to the creation of a blue economy and direct and indirect employment. India's entry to marine fish farming in open seas is a relatively recent novel development. Currently, it is an emerging sector with great attention among the stakeholders and policymakers due to its significance in the economy, alleviation of poverty, increased employment opportunities and sustainability.

The first open sea cage in India was launched in the Bay of Bengal off Visakhapatnam coast during May 2007 as a research and development activity by ICAR-Central Marine Fisheries Research Institute. The initial version was 15 m diameter HDPE cage. Subsequently, for easy maneuvering and cost-effectiveness in terms of reduced labor, the size of the cages was being modified to 6 m diameter. Various farming trials, along the maritime regions of the Indian subcontinent, demonstrated the effectiveness and success of such cage types. The cost-effective GI cage design developed by ICAR-CMFRI emerged as a suitable model for low investment open sea farming operations for poor coastal fisherfolks. ICAR-CMFRI has developed and tested open sea cages of 6 m, 12 m and 15 m diameter for fish culture, 4m diameter for lobster farming and 2 m diameter cages for seed rearing made of GI and HDPE. In India, cage farming of finfish and shellfish is in the developmental stages. Experimental culture of Seabass, Mullets, Pearl spot, Grouper, Cobia, Pompano, Snapper and Spiny lobster are being carried out at

Table 12.1: The experimental culture and demonstration of open sea cage farming by CMFRI

Sl. No.	Maritime state	Locations of cage culture trial's	Species farmed
1	Gujarat	Sutrapada, Veraval, Vadadara Zala, Diu, Kachchhh	Lobster, Cobia, Pompano, Seabreams, Asian Seabass
2	Maharashtra	Kalamb, Satpati	Lobster
3	Goa	Polem, Talpona	Asian Seabass, Cobia
4	Karnataka	Karwar, Byndoor, Uppunda	Asian Seabass, Cobia, Pompano, Snappers
5	Kerala	Kozhikode, Kochi, Vizhinjam	Snapper, Asian Seabass, mullet, pearl spot, lobster
6	Tamil Nadu	Chemmencherry, Chennai, Mandapam, Kanyakumari	Asian Seabass, Cobia, Pompano, Lobster
7	Andhra Pradesh	Uppada, Kakinada, Srikakulam, Nellore, Visakhapatnam, Antarvedi, Nagaya Lanka	Asian Seabass, Pompano, Pearl spot
8	Odisha	Balasore	Asian Seabass

various centres of ICAR- CMFRI and its associated stakeholders with varying degree of success (Table 12.1).

Capture based mariculture

In India, marine fish farming expansion faces the problem of inconsistent supply of fry/fingerling. The Asian Seabass, *Lates calcarifer*, has been proven as an apt species for cage culture due to the availability of hatchery-produced seed by ICAR-CIBA & RGCA (MPEDA), market demand and fast growth. Other alternate species that have great potential are Cobia, *Rachycentron canadum*, Pompanos, *Trachinotus blochii* and *T. mookalee*, Orange spotted grouper, *Epinephelus coioides* for which hatchery technology has been initiated and standardized by ICAR-CMFRI. Various studies and

Figure 12.1. Lobster fattening in open sea cages at Veraval

observations by CMFRI indicated that dolnets of Gujarat and Maharashtra operating at different depths could capture juveniles of several high-value species. They are sold either at a very low price in local markets or used for drying. Also, there exists a good fishery for live juveniles of different species of lobsters, but a very few were utilized for fattening. If a small fraction of wild-caught seeds can be transported in live conditions they will form a very good seed source for CBA. It will be more lucrative for the fishermen at the same time, contributing to a several-fold increase in mariculture production by properly utilising existing resources. Among crustaceans, lobster rearing in open sea cages has been proved highly lucrative and remunerative. CMFRI has demonstrated the technical feasibility of lobster rearing in the cages at Veraval, Kanyakumari, Vizhinjam, Chennai and Mandapam.

Mud spiny lobster (*Panulirus polyphagus*) can be selected as a candidate species for sea cage farming as it is a highly-priced species which commands a good market price both in domestic as well as foreign markets. ICAR-CMFRI did several successful demonstrations of sea cage farming of lobsters along the Gujarat and Maharashtra coasts. The juveniles of the species are abundantly available along Gujarat and Maharashtra coasts and show a good growth rate under captive condition (1.17- 1.49 g day-1, Mojjada *et al*., 2012, Divu *et al*., 2017). Seed transportation is also easy as the animals can be transported in a semi-moistened condition rather than complete wet chain transportation. The species is hardy and shows better survival during transportation and culture. The species is considered an ideal species to capture-based aquaculture (CBA) as the young ones (< 100 g) are usually treated as by-catch and does not fetch a good market price. Fattening of small lobsters to exportable size (> 200 g) could increase the market price in a short period with minimal risks which make the culture practice profitable. The CBA of Lobster also helps indirectly in the conservation of the species, while giving high-profit turnover. If this practice expands in an unchecked way it will turn out to be a targetted fishery of lobster juveniles, which is not advisable.

Crab fattening

There exists a very limited understanding of wild mud crab resources along the Gujarat coast and its sustainable management plans. Conservation of the primary habitat of mud crabs, the mangrove forests, is essential to support their populations along the Gujarat coast. Gujarat state hosts the

Figure 12.3. Crab fattening demonstration mangrove pen unit at Okha region

second largest mangrove cover along the Indian continent (1,107 km -2 in 2015). Mangrove conservation and development have been given very high importance in the State, which results in an increase of 49 km-2 of mangrove cover since 2011 (FSI, 2017). Environmentally sustainable farming of mud crabs in coastal mangrove pens is seen as an important farming method in both conserving the existing mangrove forests from destruction and expanding the mariculture production areas.

There are three major species of mud crabs found along Gujarat coast under the genus Scylla, *S. serrata*, *S. olivacea* and *S. tranquebarica*, especially in the regions of Porbandar, Okha, Dwaraka and Kachchh. ICAR-CMFRI successfully performed various crab fattening initiatives along the Saurashtra coast. Mangrove pen and tank farming trials were successfully demonstrated at Okha and Porbandar regions, with the participation of the local progressive fishermen. The appropriate size mud crab juveniles (50-80 g) are available throughout the year in these regions (with a peak from May to September). The live seeds, caught from the seas, mangrove areas were stocked in the pens at a density of 5 no's m^2. A growth of 2.8 g d^{-1} was recorded during the culture trial period of 45 days, with an average survival of 50%. Partial harvesting of crabs can be done based on local /domestic market demand during weekends. Crab fattening can be used as an alternative vocation for the fisher women or fishermen whose settlements are in the vicinity of the mangrove forests along the Saurashtra and Kachchh coasts, where resources

Figure 12.4. Net-tube method of seaweed integration in cage culture system

Seaweed farming

Seaweeds are the renewable marine resources of value, growing well in shallow waters with suitable substratum. If available resources are harvested to its optimal level, it can employ a greater number of coastal fisherfolk in farming, harvesting and an equal number in post-harvest activities related to seaweed farming and/or collection. Women are also engaged in seaweed collection. Special efforts should be taken for its optimum exploitation and market expansion through the development of diversified product and their popularization. Seaweed mariculture offers an economically sustainable livelihood option for coastal fisher women, who, with minimum effort, can contribute significantly to the household income. A model has been developed and successfully tested at the Rameshwaram coast of India, where a person can earn ₹ 3,000–4,000 per month through seaweed cultivation. Gujarat coast is rich in seaweed biodiversity and has suitable areas for mass cultivation and necessary competitive human resources for the farming activities.

The quantity of seaweed presently harvested from nature does not meet the present demand from the industries. The gap between the demand and supply can be met only with the large scale farming initiatives of commercially important species of seaweeds. The seaweed polyculture, in association with molluscs and fishes, seems to have good prospects to increase the harvest and profits. The culture of seaweeds (e.g., *Gracilaria*) in pond and canal along with shrimp can help

Figure 12.5. Seaweed growth in net-tube after a week

to treat the effluent water. The problem of eutrophication in culture ponds due to feed waste and excreta released by fish/shrimp can be tackled by culturing seaweeds in such ponds. The Integrated Multitrophic Aquaculture (IMTA) is a popular method for sustainable mariculture, where seaweed farming introduced along the Indian coast in net tubes or rafts along with finfish and shellfish in sea cage farms. Such methods will help to reduce the harmful environmental impacts due to aquaculture activities along with additional income to the fishers.

Diversification of shrimp aquaculture with marine finfish in coastal saline ponds

Aquaculture is the world's most diverse farming system in terms of species, methods and farm environments. FAO guides member countries regarding diversification of aquaculture as the demand for aquatic plants and animals for food and other uses increases.

Asian countries contribute nearly 90 percent of the global production of culture fisheries. Diversification with fish species is not happening in shrimp aquaculture because of the high-value commands for shrimp in the export market. Shrimp farming is exhibiting an increasing growth trend in all the major shrimp- producing Asian countries. However higher growth in shrimp production, is accompanied with higher instability in production due to various production risks associated with ecosystem complexities and disease incidences (FAO, 2018). Indian shrimp farming is displaying a spectacular growth leading to an all-time high in exports

Figure 12.6. Pompano nursery for intercropping of marine finfish in coastal mariculture ponds

of USD 7.08 billion during the financial year 2017–18 (MPEDA & NABARD, 2018).

India blessed with a coastline of 8,129 km, has vast stretches of estuaries/ backwater lagoons. The government of India identified coastal aquaculture as one of the high potential area for increasing the fish and shellfish production. It is considered that after the Green revolution it's time for the blue revolution to exploit the huge potential in the aquaculture sector. Indian brackish water aquaculture is largely dependent on *Peneaus monodon* and *Litopenaeus vannamei*. *L. vannamei* gains momentum from 2008 because of its low susceptibility to the disease WSSV and high tolerance of culture condition. Other candidate species include *P. indicus*, *P. merguiensis* and *P. semisulcatus*.

Gujarat has a greater potential for sustainable coastal aquaculture expansion. Valsad, Navsari, Surat and Bharuch are among those districts at Gujarat state which contribute the major share (95%) in state shrimp production. Shrimp farming in Gujarat was initiated during 1991-92, having an average production of 337.80 kg/ ha and increased to 1,840 kg/ ha in 2008-09.

The shrimp culture commenced with the culture of *P. monodon*, but soon it faced major production issues as it was the decade of WSSV. Later, second attempt was made in 2010 after the introduction of exotic strain *L. vannamei*, which increased the production to an average of 7,000 kg/ha in 2016. In a country-level comparison, India, Indonesia, Thailand and the Philippines have shown moderate

Figure 12.7. Pompano harvest in an intercropped coastal mariculture pond

growth in the production and export of shrimp eventhough these countries also faced the set backs due to WSSV.

Diversification of the species and farming methods, have been suggested for assuring production and steady income to aqua farmers and to the country. It has been pointed that replacing, supplementing, or rotating shrimp with culture of other high- value fish species like Asian sea bass (*Lates calcarifer*), grouper (*Epinephelus* spp), mullets (*Mugil* spp.) and milkfish (*Chanos chanos*) may ease the risks in mono-cropping of shrimp. Although increasing number of species are being farmed in aquaculture and diversification possibilities are high in some cases like coastal saline water bodies. Further diversification is constrained by limitations in technology, profitability, regulations, sustainability and enabling environments including community acceptance.

As it was found that monoculture of a species is not a good idea with concern to disease occurrence, inter-cropping or integrated aquaculture practices have been suggested by various scientific studies. Diversification of species and culture systems, along with a more or less even distribution of production, could provide resilience in the present face of a changing climate and other external drivers. Also this will add economic, social and ecological insurance to the existing aquaculture systems. However, diversification is not without risks and may not always be a viable means to increase total culture production. In addition to the economic costs, there will be associated development costs, including evaluation and mitigation of environmental and social impacts and establishment of species-specific bio-security frameworks for such diversification efforts. Diversification is a strategy that decreases risk, capitalizes on opportunities and provides resilience. Diversification in aquaculture often means substituting one species, strain, or other farmed type for another. Resilience is not likely to come from adding more stocks, but from replacing a susceptible stock with an available best alternative.

Shrimp farming can be integrated with some recently developed possible marine finfish species such as Silver pompano (*Trachinotus blochii*). This fish species exhibits vast culture potential in India due to its good meat quality, adaptability, captive breeding, low cost of production and high market demand. The ICAR-CMFRI successfully standardized the broodstock development technique at Mandapam in 2008 and induced breeding in 2011. Later, through various pilot projects carried out in Andhra Pradesh, Tamil Nadu, Karnataka, Kerala and Gujarat proved its suitability as a candidate species for co-culture or inter-cropping in low saline shrimp ponds. In Gujarat, these fish species were cultured on a trial basis in shrimp *L. vannamei* ponds and the results were inspirational. Here silver pompano was inter-cropped with shrimp. The farming practice will reduce the

incidences of diseases for the shrimp culture stocks. Also, pompano was found suitable for culture in the winter months along the Gujarat coast, which facilitates the extended cropping season during which shrimp crop cannot be carried out. It was suggested through scientific studies that three years of cyclic farming of shrimp and finfish (4 crops of shrimp and four crops of pompano) in alternation could be suitable and beneficial for the prevailing climatic conditions of Gujarat and also similar for other states.

Mariculture site selection on GIS platform along Gujarat coast

Mariculture is assuming greater importance for augmenting, not only seafood production but also provides sustainable alternative livelihood avenues and employment opportunities for the coastal folks. High- income generations were also recorded from farming of diversified finfishes and shellfishes like seabass, cobia, snappers, seabreams, spiny lobsters, etc. The long coastline, enterprising nature of the local people, a wide area of the continental shelf, pleasant weather conditions, the EEZ of Gujarat has a potential future for sea-cage farming in the country.

Open sea cage farming technology developed by the ICAR-CMFRI is identified as one of the possible means to increase fish production in the country. It has been projected that in India we need to produce about 18 million t of fishes by 2030. As per NFDB, our fish production has to rise from 4 million t to 12 million t in the next 14 years. Enhancing fish production from the inland sector has limited scope due to limited land availability, pollution and many other reasons.

The major portion of the additional seafood production demand has to meet perpetually from mariculture. The NFDB has projected that even if 1% of the inshore waters will be used for cage farming. Blue Revolution Mission initiated for the integrated development of the fisheries and aquaculture sector to achieve the desired seafood production goal. As the sea is the only source to improve the Indian marine food production, any unplanned use of public water bodies would create serious environmental, socio-political conflicts among the stakeholders along the coast.

As of today Government of India and state administrations have already given thrust on open sea farming under National Protein Mission and Blue Revolution Schemes by adopting the technology perfected by ICAR-CMFRI along both the coasts of the country. Mariculture is turning out as one of the leading industries in the country for the coming days. Thus, there is an urgent need to identify the potential sea farming sites, thereby preparing a Marine Spatial Plan for Mariculture

(MSPM) by using technological advancement like GIS and remote sensing to make sustainable and judicial use of open water bodies to expand sea cage farming in Gujarat as well as other maritime states in India.

Geographical information system (GIS) is a powerful tool capable of organizing, analyzing and displaying large, spatially explicit datasets. GIS is occasionally used in fisheries to support or illustrate fisheries assessments or as a supplement to general environmental analysis. There are several marine spatial issues expected, while expansion of mariculture, which must be understood prior to develop a sustainable growth model and mitigate conceivable supplementary problems among marine space users.

The territorial waters of Gujarat were examined for the mariculture suitability for the creation of a sustainable blue economy. About more than 13 lakh hectares were preliminarily identified, which is potentially suitable for developing mariculture in territorial waters. The identified sites are equivalent to around 15% of the total available Indian subcontinent water resources, including reservoirs, rivers, canals, inland ponds, flood plain lakes and brackish water resources and are been marked on a GIS platform. The findings based on satellite remote sensed data, it depicts the production potential of Gujarat to create a substantial maritime blue economy through farming fish in the open sea.

The farmers, entrepreneurs and promoters evaluate the potential open sea offshore farming sites based principally on accessibility, biological and technical feasibility and most importantly on cost concerns. Due to ocean dynamics, the establishment of sea cage farms in open waters involves complex and difficult procedures. Hence, it is essential to select a proper site that is ideally suitable in terms of ease of operation, minimal risks and economic feasibility and management as mariculture sites.

Based on the optimal ranges of physico-chemical variables, sea cage farming sites were broadly categorized into most suitable, suitable, less suitable, relatively unsuitable and unsuitable regions along the Gujarat coast by ICAR-CMFRI, which can be utilised initially for commencing the mariculture activities by the Government of Gujarat.The active fishermen along the Gujarat coast are highly trained workforce who have extensive knowledge about the sea conditions, boat handling, net mending and maintenance, fish harvesting, etc. Such a domain people can easily be trained in the field of mariculture through various targeted efforts. Sea cage farming will empower the fishermen through enhanced employment opportunities, social security and food security.

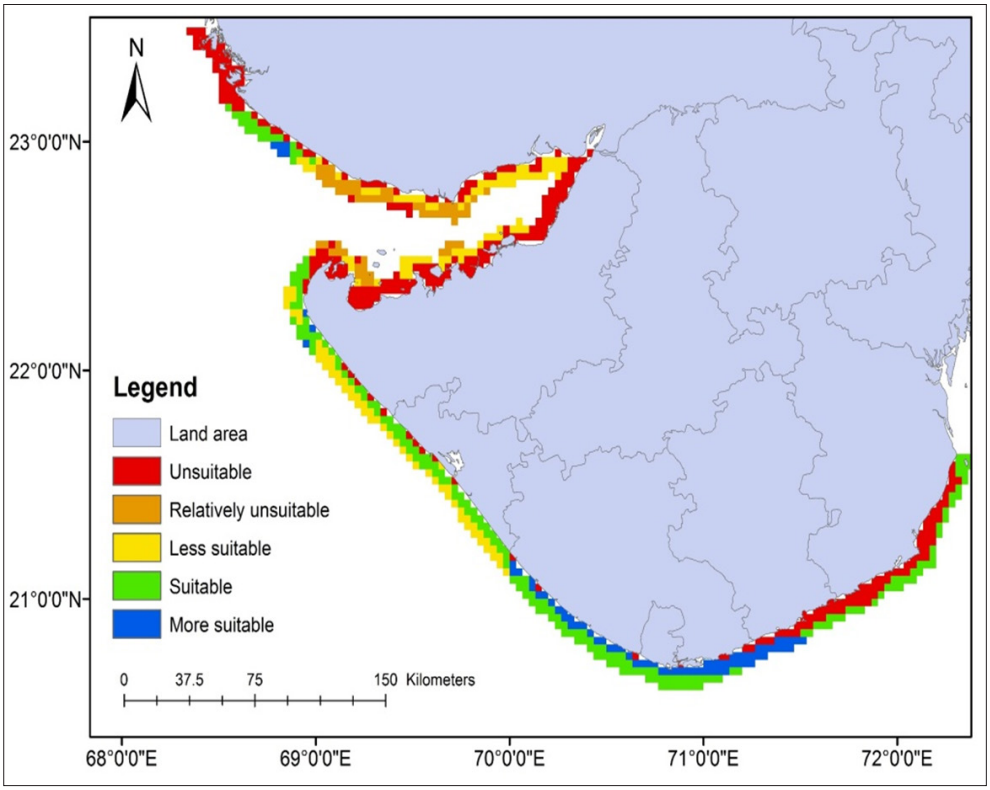


Figure 12.8. Preliminary mariculture site suitability map for Gujarat on GIS platform.

ICAR-CMFRI has pioneered sea cage farming technologies and the institute as a strong workforce, expertise in the field of cage culture technology all over the country (Rao, 2009). The main constraint in commercializing mariculture in India is the lack of a mariculture policy for the demarcation of designated farming sites. This issue needs to be tackled with collective efforts from the Union Government, concerned scientific organizations and states with the formulation of the policies suited for sustainable mariculture for each region/state. The ICAR-Central Marine Fisheries Research Institute is playing a phenomenal role in the country on mariculture research and developments. Due to the efforts made by the institution, National Mariculture Policy (NMP-2018) is under the consideration of Government of India with, the vision to double the fish production and thereby the farmer's income. The policy proposes special mariculture zones/ clusters and offshore technology parks for

marine aquaculture. To support mariculture development the Government has promoted Fisheries Infrastructure and Aquaculture Development Fund (FIDF) with a fund magnitude of more than 3 billion USD.

Recommendations and advisories for sustainable ecosystem-based mariculture development in the territorial waters of Gujarat

- As per the recommendation of the FAO and World Bank, an Ecosystem Approach to Aquaculture (EAA) with proper management measures should be adopted while expanding any mariculture practices.
- Results derived through the preliminary GIS-based mariculture site selection procedure need to be considered as a strategic policy implementation support system by the concerned administrators and managers.
- Diversification of the existing possible farming locations from the susceptible species to the best available alternate ones.
- Successfully tested and proven technologies only must be adapted for comercialisation.
- Encourage the private sector participation with necessary administrative govt. controls.
- Positive and negative environmental impact assessment studies must be carried out regularly.
- Seed dependency over the wild caught seeds of any commercially important species for farming must be regulated/avoided. Steps must be taken to establish marine finfish/shellfish hatcheries / satellite hatcheries for the state by the Government.
- A regulatory body is essential to execute and monitor the mariculture activities and each involved personnel must be defined with clear roles and responsibilities for the smooth running of the chain of operations of control.
- As Gujarat is the first state in India to have preliminary GIS-based maps of potential mariculture sites all along the 1,600 km coastline, Since it is a preliminary study result, based on the secondary and satellite data, in-situ ground validation is advised for each location before proceeding with the expansion of any sea farming activity.
- Cluster or zone-based detailed studies are essential and encouraged for the implementation of the policy based on multiple stakeholder involvement, especially taking the concern of local fisherfolk.
- Site/location-specific studies/projects should be encouraged and the data-based should be maintained for future research and development activities. The same can be used for the formulation of effective and efficient policies as and when required upon the consultation with concerned stakeholders.

13. Marine fisheries allied industries in Gujarat

Gujarat continuously tops in marine fish landings of India in the last few years. Allied fishing actives are the main pillars to support state fish production. Allied fishing industries in Gujarat include boat building, fish net making and mending, ice factories, processing industries, dry fish yard, etc.

Boat building yards

Boat-building yards are located mostly in Junagadh district. Most of the yards are located in Veraval and Mangrol, which supplies boats to the entire state. The number of boat building yards in the state was 24 and 39 in 2005 and 2010, respectively and these yards are generally in the premises of harbor. Initially, boat-building yards were located in Junagadh district only, but now it's slowly spreading to other parts of the state. Mostly, Wooden and Fiberglass Reinforced Plastic (FRP) boats are constructed and every year, hundreds of boats come into the fishing system from these yards.

Fishing net making and mending yards

Fishers generally purchase fishing nets from either state government cooperative suppliers or private suppliers. Gujarat Fisheries Central Co-operative Association

Limited is supplying different types of fishing net and net making material to fishers at nominal prices. In small fishing villages like Kotada, Chorwad, Madwad and Sutrapada, the net mending yards are owned by communities or fishermen cooperatives and in larger fishing villages like Veraval, Mangrol, Porbandar and Jafarabad, yards are mostly owned by individuals. The net mending activities are carried out either by fishermen themselves or specially trained workers.

Ice factories

An adequate supply of good quality ice is a fundamental requirement for the fishery. Block ice is generally used for all types of fishing activities and ice factories are located near to the harbor area. The dependence of fishery on ice supply increased due to an increase in the number of fishing days. The number of ice factories in the state was 178 and 292 in 2005 and 2010, respectively. The ice factories are located in all the major fishing villages and large numbers of factories are in Junagadh, Porbandar and Jamnagar district.

The traditional block ice maker forms the ice in cans or blocks, which are submerged in a tank containing circulating sodium or calcium chloride brine. The dimensions of block and temperature of brine are usually selected to give a freezing period of between 8 and 24 hours. The block weight can vary from 100 to 150 kg, depending on requirements; 150 kg is considered the largest size of block one man can conveniently handle. The capacity of the ice factories varied from 10 to 20 t per day. Ice is transported to harbor by *Chakda* (a hybrid vehicle in Saurashtra region of Gujarat) and loaded to the vessel a few hours

before the commencement of the fishing trip in small multiday vessels, a day before in large multiday vessels. Most of the single day vessels do not carry any ice. Ice is crushed before loading in the vessel in the harbor. Small vessels crush the ice using a hammer while larger vessels use ice crushing machine.

Processing plants

The number of processing plants in the state was 90 in 2010. Processing plants are buying fishes directly or through a middlemen. Fishes were subjected to pre-process before processing. Pre-processing includes de-heading, de-gutting and peeling in shrimps. After pre-processing, material brought to the processing section where different products like crab stick, crab claw, fish finger, dressed fishes, shrimps, cephalopods, etc., are prepared. Processed products are packed and kept in freezer and cold storage before export to different places. Mostly pre-processing and processing activities are carried out by women.

Freezing and cold storage plants

Freezing and cold storage plants are either located closely with processing plants or run separately. The number of freezing and cold storage plants in the state was 73 and 42 in 2005 and the same increased to 74 and 228 in 2010, respectively.

The processed products are kept in the freezer at–40° C for a few minutes before being stored in the cold storage. Different types of freezer used in the state are plate freezer, blast freezer and Individual Quick Freezer (IQF) depending on the type of products to be frozen. Unlike freezing plants, most of the cold storages are separate from the processing plant. Cold storages are mostly owned by exporters who purchase the product from the processor and store the product at -18° C until the products are exported. Fishes are mainly exported to China and Japan, shrimps to the USA and Europe and cephalopods to Europe and Middle East countries.

Fish drying and curing yards

Fish drying and curing is one of the oldest methods of fish preservation that still exists along the Gujarat coast. Fish drying and curing yards are mostly located at Jafarabad, Rajpara, Nawabandar, Veraval, Porbandar and Jamnagar. Bombayduck, shrimps, sole fish, croakers, ribbonfish, elasmobranchs, lizardfish, etc. are the major groups used for drying and curing. Sun drying is followed by all the fish drying yards of the state and any advanced drying machines/technology are yet not in practice.

After de-gutting, fishes are dried either on a floor mat or hung on the ropes. After 3 to 5 days of drying, fishes are packed for exporting. During drying, about 80% of water in the fish disappears. Women traditionally play a major role in these activities. Low value dried products such as *Acetes* and lizard fishes are send to poultry and fish feed factories whereas, high value dried fishes like Bombayduck, ribbonfish, shark and rays are utilized for human consumption. Dried fishes from Jafarabad are mainly marketed to Mumbai, West Bengal, Delhi and Kerala. Some parts of this also move into the local market of Gujarat. The dried Bombayduck,

locally known as '*Sukel bumla*' or '*Dantaniya bumla'* fetch a price of around ₹3,000 per 20 Kg. Dried Bombayducks sold in bulk are locally known as "*Bhara*."

Fishmeal plants

Damaged by-catch and rejected fishes, which generally get low prices, are used for fishmeal production. The fishmeal plants are located in Junagadh and Porbandar districts of Gujarat. The number of fishmeal plants in the state was 29 and 31 in 2005 and 2010, respectively. The fishmeal is recognized as a valuable animal protein supplement and a source of vitamins, minerals and unknown growth factors. Fish meal is added to the diet as high-quality supplements to obtain efficient diets, particularly for aquafeed, fish feed and poultry feed. Low-value by-catch and fish waste from processing plants are used as raw material for fish meal.

The main channel of marketing is from a fish meal plant to aquafeed companies, poultry feed manufacturers and importers of fish meal. The fish meal produced is exported mainly to Australia, China, Egypt, Japan, middle east countries, South Korea, Saudi Arabia, Pakistan, Spain, South Africa, Thailand, Vietnam, New Zealand and also to the local markets.

14. Existing legislation relevant to marine fisheries of Gujarat

The Gujarat Fisheries Act, 2003, is the primary legislative Act, enacted to provide protection, conservation and development of fisheries in inland and territorial waters of the State of Gujarat. This Act is in line with the Marine Fisheries Regulation Act (MFRAs) of other states.

Prohibitions are made for destructive fishing, fishing by poisoning of water, introduction of exotic fishes, erection or use of destructive fishing gears, construction of weirs, dams and bunds, release of industrial waste, sewage, or effluent, regulating the dimension and kind of nets to be used and the mode of using them, prohibiting all fishing in specified waters for a period not exceeding two years, etc.

Chapter-III deals with the Regulation of fishing in the specified Area. It regulates, restricts or prohibits certain fishing activities considering the need to protect the interest of different sections of people/fishers engaged in fishing, particularly the traditional fisher's, the need to conserve fish and to regulate fishing on a scientific basis, need to maintain law and order in the sea and shore, etc. as stated below:

- fishing by such class or classes of fishing vessels and for such period as may be specified in the notification;
- catching of such species of fish and for such period as may be specified in the notification,
- use of such fishing gears as may be specified in the notification,
- mariculture,
- collection of biological specimen and
- number of fishing vessels which may be used for fishing

The Act prohibits fishing in a specified area by the vessels that are not licensed under the Act and describes modalities for issuance of a license. It states that the owner of the vessel intended to be used for fishing shall register the vessel

under the Act detailing the port or harbor from where it is intended to be used. The Act makes it mandatory on the part of a registered fishing vessel to furnish certain returns on fishing periodically in the prescribed format and period notified by the Government. It empowers the Registration Officer to inspect any fishing vessel at any time to verify whether the returns are furnished. The Act also makes it mandatory for the registered vessels to carry life-saving and communication gadgets on board.

Enforcement Officers are empowered enough to implement the provisions of the Act to search and impound fishing vessels operating in contravention to the provisions of the Act. The Licensing Officer can suspend or cancel the fishing license in such cases. Provisions are made to appeal to the decision of the Registration Officer under various sections. Penalties for offenses done in contraventions of the provisions of the Act by the registered vessels, as well as individual companies, are also detailed. The procedures of adjudication are also detailed in the Act. The Government of Gujarat has enacted rules on most of the provisions of the Gujarat Fisheries Act 2003.

Provisions/clauses under the Gujarat Fisheries Act, 2003 for marine fisheries management

Protection of fish:

1. Prohibition against destructive fishing methods like using explosives.
2. Prohibition against destruction of fish by poisoning of water. Prohibition on release of any poison to capture fish.
3. Prohibition against introduction of exotic fish
4. Regulation of fishing:

    a. No fishing within the radius of 100 m downstream a river mouth in the sea.
    b. No fishing from June to September, in an area of 100 km upstream of the sea in the river.
    c. No discharge of effluents, which may be harmful to the fish.
    d. Regulating the dimension and the kind of nets to be used and the mode of operation; in case of bag net (Dol, Golva, Gunja and trawl net), at least 40 mm mesh size at the cod end.
    e. Trawl net needs to maintain more than 40 mm of square mesh-size at the cod end.
    f. Prohibition on the operation of any dragnet (Mahijal, Chhatijal).
    g. Gillnet–need to implement more than 150 mm mesh size.
    h. Prohibition on the exploitation of species protected under the Wildlife Protection Act 1972

i. Prohibition on the capture of egg-bearing/brooder fish/juvenile fish.
j. Prohibition on use of any gun, spear, arrow, or the like in any water for fishing.
k. Prohibition on electric fishing.
l. Prohibition of introduction of any fish which may be harmful to species of fish, without obtaining prior permission.
m. Registration for fish culture activity with a fee of ₹100/- per annum.
n. Registration fee towards sale/trade of fish/fish seed:
    i. wholesaler: ₹1,000/- per annum
    ii. retailer: ₹50/- per annum
o. No objection certificate (NOC) required to transport/trade the fish
p. Prohibiting fishing in territorial waters from 10th June to 15th August during the closed season.

Regulation of fishing in specified area:

1. Regulation of fishing within a specified area in consultation with FSI/CMFRI/GAU.
2. Every person in the mechanized fishing vessel shall obtain a token from the Registration Officer before leaving for fishing and hand over the same while returning to the coast as is done in the southeast coast.
3. Berthing of fishing boats in a specified area of fishing harbor only
4. No fishing at berthing place/channel/port area
5. Non-mechanized fishing vessels shall fish within five nautical miles from the shore with hook & line, gillnetting, etc. (whichever approved by licensing officer).
6. Fishing by mechanized vessel need to operate beyond five nautical miles
7. Adapt to Catch Reduction Devices (CRD) in all trawling vessels.
8. No industrial pumping of seawater without approval from the authorities
9. Prohibition on destruction of mangroves.
10. No collection of biological specimens/ornamental fishes/live or dead marine products/fossilized corals/oysters/selling of shells without permission.
11. A ban on exploitation of protected species, whale shark, turtles and whales and other protected species listed under WPA, 1972
12. The licensing officer shall report on the straddling of the whale shark, turtle and whales to authorized forest officials.
13. Promotion of mariculture, installation of artificial reef devices and stock enhancement programs
14. Protection of the interest of traditional fishers.
15. Maintaining law and order situation in the territorial waters and onshore
16. Carrying any person as crew in contravention of the condition mentioned in the fishing license shall be punishable under the law.
17. Specimen signatures of officers (licensing, registration, enforcement, adjudicating) and Commissioner shall be furnished to coast guard from

time to time.

18. Ban on fishing of undersized fish information circulated by the Commissioner
19. No purchase/processing/transporting of undersized fish.
20. Ban on fishing operation during cyclonic/weather warning conditions and required to report back at the port during said time.
21. Prohibition of Ghost fishing
22. Prohibition of throwing old/used or unused nets/thermocol sheets/old floats/used tins& bottles/brunt oil/used cotton waste/used green coconut in the harbor.
23. Restriction on open defecation on-board in the sea shall use onboard toilets.
24. Mark clear visible registration number on the side of the fishing vessel
25. Cancellation of licenses and Diesel subsidy card, in case of repeated apprehension (more than one) by Pakistani marine security agency.
26. Registration fee of ₹1,000/- in case of boat building yard/processing plant/ ice factory/other related industries with the application.
27. Prior permission required for fishing in the specified area and time by the owner of the vessel from Gujarat or another state
28. A prescribed fee payable for grant and renewal of License and registration:

    a. Mechanized above 15 m/50 HP/25 gt: ₹15,000/-, 12,000/- and 10,000/-
    b. Mechanized up to 15 m/50 HP/25 gt: ₹6,000/-, 5,500/- and 5,000/-
    c. Motorized/beach landing craft: ₹1,500/-, 1,200/- and 2,500/-
    d. Non-mechanized above 8.5 m/3gt: ₹1,000/-, 750/- and 1,250/-
    e. Non-mechanized up to 8.5 m/less than 3 gt/FRP canoe/Dugout canoe/: ₹550/, 450/- and 625/
    f. Tin boat/FRP/ Wooden tarapa: ₹500/-, 450/- and 375/-
    g. Pagadia fishing: ₹200/-, 100/-

31. A license granted shall be valid for three years from the date on which it was granted unless it is suspended or canceled earlier and may be renewed from time to time for three years on payment of such fees as may be prescribed.

32. No license can be issued without availing of insurance by the crew

33. No grant of License unless having life-saving and fire-fighting appliances on-board

34. Life jackets on-board (approved by Mercantile marine department), two lifebuoy, foam type fire extinguisher in the engine room, two buckets with sand, transistor radio, VHF radiotelephone communication equipment for two-way communication (vessel operating more than 48 hrs and more than 50 NM), SART, aneroid barometer, magnetic compass, telescopic mast and sail

colored in fluorescent orange, sufficient food, water and clothing.

35. Top of wheelhouse/canopy painted with orange color with black colored registration of the vessel and orange-colored canvas with black square or circle to identify from air.

36. Suitable flares for use at times of distress

37. Maintenance of vessel and fishing logbook on-board

38. Emergency sail in all mechanized vessels, Flag victor

39. Ban on fishing in the spatial closures

40. Registration of Vessel: The grant of certificate of registration shall be valid for five years from the date of issue unless it is canceled earlier and maybe renewed from time to time for five years on payment of such fees as may be prescribed above.

41. Inspection for the certificate of registration and issue of license time to time

42. Cancellation, suspension and amendment of License: the holder of a license has, without reasonable cause, failed to comply with any of the condition subject to which the license has been granted or has contravened any of the provisions of the Act or the rules made or any notification issued thereunder, then without prejudice to any other penalty to which the holder of the license may be liable under this Act, the Licensing Officer may, after giving the holder of the license a reasonable opportunity of being heard, suspend or cancel the license

43. Authorization of Enforcement Officer:

If the Enforcement Officer has reason to believe that any fishing vessel is being or has been used in contravention of any of the provisions of this Act, or of any rule or order made or any notification issued thereunder or of any condition of the License issued under section 10, then he may –

(i) enter and search such vessel and impound such vessel and seize any fish found in it,

(ii) keep the impounded fishing vessel in such place and such manner as may be prescribed,

(iii) dispose of the fish so seized and deposited the proceeds thereof in such manner as may be prescribed and

(iv) make a report of the contravention to the Court if the offense is punishable under clause (b), (c), (d) or (e) of sub-section (1) of section 21 and in other cases, to the Police Officer in charge of a police station.

15. Views on seasonal fishing ban: perception of fishers

The seasonal fishing ban is one of the most important instruments under the MFRA for the management of marine fisheries and has been implemented in the coastal states, though with varying periods and duration. Uniform fishing ban all across the coastal states; differently for the west and east coasts of the country, coordinated by the Central Government. This measure increased the efficiency of fishing ban implementation while reducing the conflicts between the states to a greater extent. The present period of fishing ban is from 1st June to 31st July (61 days) along the west coast and 15th April to 14th June (61 days) along the East Coast. Gujarat has already been practicing a community-supported fishing ban for 67 days from 10th July to 15th August. The fishing ban has been implemented in the state effectively.

The Veraval RC of ICAR-CMFRI gathered the fishers' perception and suggestions on the fishing ban. The study revealed that the fishers operating trawlers, gillnetters, dolnetters, etc., feel that the fishing ban is good for the fishery resources as it allows breeding and growth of the young ones though they felt that the loss of job and livelihood is a concern. A mixed opinion was obtained regarding the period and duration of the ban. Nearly 50% of trawler operators, 31% of gillnetter and 25%

of dolnet operators responded in the interview that the period and duration of fishing are not appropriate. Most of the trawl, gillnet and dolnet operators in the Saurashtra and south Gujarat suggested that the fishing ban may be implemented from April-May to August-September. The major section of the fishers opined that the fishing ban should apply to all types of boats and the rule should apply to the areas beyond the territorial waters also.

The fishers were also unanimous in saying that the fishing ban should be applied in a similar form to the neighboring states as well. The fishers were affirmative towards having seasonal area/gear restrictions to fishing to conserve/protect specific groups of fishes facing the threat of overfishing. Issues of coastal pollution, juvenile fishing, purse seine fishing, etc., were also put forth by the trawl fishers. Fishers across the gear types suggested revision of the MFRA and the provisions of the MFRA should be made known to the fishers. The fishers gave their views and suggestions spanning resource conservation measures, the safety of fishers and enforcement of the MFRA, etc.

The ICAR-CMFRI conducted annual stakeholder consultations at Veraval during 2014, 2015 and 2016 with the active participation of fishers belonging to most of the category of fishing fleets like trawlers, Gillnetter, dolnetters, small scale fishers, etc., besides consultations on the draft National Marine Fisheries Policy in 2015. In all these consultations, the perceptions of the fishers on several aspects like landing trend of major resources, management interventions in place and their effectiveness and compliance, etc., were sought. Most of the fishers expressed that the seasonal fishing ban should be continued with a protracted period and strict enforcement. The detailed opinion on ban season by stakeholders is reflected in Annexure 3.

16. Swot analysis for the marine fisheries of Gujarat

Regular stakeholder interaction meetings were conducted in the region to consider the fisher's opinions, validate the research outputs and the inclusion of their views for suggesting fisheries management measures. The Strengths, Weaknesses, Opportunities and Threats (SWOT) attributes were identified from the stakeholders through the interaction meets. The status of the marine fisheries sector of Gujarat is represented in Figure 16.1.

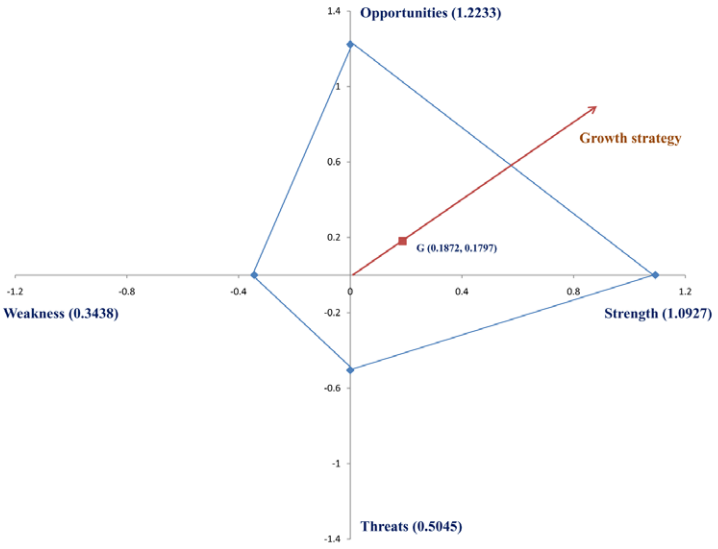


Figure 16. 1. SWOT plot for the marine fisheries of Gujarat (Strengths and Opportunities are better than Threats and Weakness in the region)

Strengths

- Longest coast length (1,600 km), wide continental shelf (1, 64, 000 km^2), Abundant marine fishery resources, a wide variety of fishing craft (27,347) and a large number of fish landing centres (123).
- Leading state in marine fish production in the country for the past five years
- Fishing dominated by mechanized fishing vessels, which contributes to the commercially priced fishery resources
- Export earnings and export-oriented units.

Line trawling along the coastal waters of Gujarat

Line trawling is the recent fishing practice coming up along the northwest coast of India, mainly by Maharashtra fishermen and recently start by Gujarat fishermen. A group of fishing boats did the fishing (number of boats varies from 50 to 120) along the coastal waters of 30-60 m in depth. The overall length (OAL) of the fishing crafts was ranging from 46 to 54 feet with an engine capacity of 88 to110 HP. Each fishing craft carries 10 to 12 fishing gears per trip and the preferably mid-water pelagic trawlnets and occasionally bottom trawlnets. The major portion of the catch comprised tiny shrimp, followed by croakers, ribbonfishes, lizard fishes, threadfin breams, catfishes, etc. The sweeping of a wider area can cause mass exploitation of the fishery resources, destruction of the fishing grounds and ecologically sensitive habitats. It may take huge time to rejuvenate the fishery and biodiversity along the fishing grounds swept by these trawlers. As the fishing is operating very near to the coastal waters, the traditional/subsistence fishermen will get affected by poor catch rates. Further, the continuation of line trawling may lead to chances of inter-state conflicts among the fishers.

- Unique and one among the highly productive marine ecosystems in the world
- Vast fishery infrastructure facilities, i.e., fish freezing and processing plants, ice factories, dry fish units, peeling sheds, boat-building yards, gear mending units, *surimi* plants and curing units, etc.
- Healthy fishery ecosystem, mainly dominated by demersal fishery resources and high trophic categories

Weaknesses

- Lack of compliance with rules and regulations
- Overcapacity of fishing fleet in the fishery
- Inadequate information on resource status and dynamics
- Unhygienic practices during harvest and post-harvest
- Low prices to fish catch due to lack of cold chain, low quality and poor handling of fish catch
- Complexity in fisheries, i.e., multi-species, multi-gear, multi-stakeholders
- Low literacy status and poor economic background of the fisher community
- Lack of fishing vessel monitoring and surveillance system
- Over-exploitation of most of the commercially fishery resources
- rules and regulations are outdated and need revision in connection with recent changes and modifications in the fisheries sector

Opportunities

- Co-management and Public Private Partnership in the area of fishery management
- Modification of fishing gears and crafts
- Expansion of fishing towards untapped fishing grounds and potential resources
- Promotion of open sea cage culture, coastal mariculture and shrimp farming, etc.
- Promoting value-added and diversified fishery products
- Establishing cold chains to attain better prices to the catches
- Expansion of export markets by complying their standards

Threats

- Open access and Unregulated fisheries lead to conflicts in the sector and depletion of resources
- Detrimental fishing practices like pair trawling, light fishing, etc.
- Overexploitation of commercially important fish stocks
- Climate change and natural calamities
- Detrimental fishing practices are threats to critical marine coastal habitats

- Poor quality and low standards of fishery products and byproducts

Issues in Marine Fisheries sector of Gujarat

- There should be a ban on purse seine fishing along Gujarat and Daman & Diu region; otherwise the fish stocks will deplete soon.
- Pair trawling along the inshore waters off the coast, which is a harmful fishing practice to the fishing grounds and ecologically sensitive habitats.
- Gross-root level issues while implementing relief measures to the fishermen during the fishing ban season.

Pollution and litter in the coastal and marine ecosystem and their impact

The intensity of marine litter pollution studied along Gujarat coast using a rope quadrate (10 x 10m) of operated in triplicate from each station with 100 m interval on a line transect. The sorted marinelitter samples were weighed based on different categories to know the relative composition and recorded as g m^{-2} and numbers m^{-2}. The mean values of marine litter found to be 90.56 g m^{-2}. It was noticed that the surveyed sandy beaches were with enormous quantities of plastic litter (>100 g m^{-2}). Plastics and fishing nets registered highest from the beaches. The results showed that litter became an integral part of beach ecosystem. The accumulation of plastic litter inthe dolnets was collected and weighted from each haul to understand the intensity of plastic pollution in dolnet fishing grounds. The accumulated marine litter was varied from 0.49-

5.36 kg during experiment hauls. The highest quantity of marine litter observed was 5.36 kg, which was around 35% of the catch found in to the nets. An incidence of macro-plastic ingestion wasexamined in the common dolphinfish, Coryphaena hippurus and long-tail tuna, Thunnus tonggol in the region (CMFRI, 2017). A total of 1267 guts across 12 fish species were examined and 402 guts were found positive for microplastic fibers. The frequency of occurrence was found to be higher in the species located in close vicinity of the coast, which can be attributed to the fact that plastic load in marine benthic environment is indirectly proportional to the distance from the coast. The abundance of microplastic fibers in guts vary from single strands to over 100 strands in one gut with width and length ranging from 9.8 um to 35.40 um and 1.23 mm to 5.96 mm respectively (Rajan Kumar et al., 2018).

Rajan Kumar, Shikha Rahangdale, Vinaykumar Vase, D. Divu, Kapil S. Sukhdhane, Tarachand Kumawat, P. Abdul Azeez and Subal Kumar Roul 2018. Abundance of microplastic fibers in guts of edible crustaceans from north-west coast of India. National Conference on Marine Debris (COMAD 2018), Book of Abstracts and Success stories, Marine Biological Association of India, April 11-12, 2018, Kochi, p. 54-55.

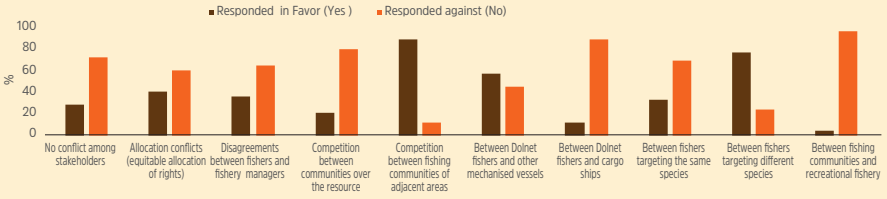
CMFRI 2017. Annual Report 2016-17. Central Marine Fisheries Research Institute, Kochi. 292 p

- Fishermen identity cards issued by Govt. should be treated on par with other identity cards like Aadhar, EIC and ration card, etc.
- Provide immediate relief assistance to fishers during accidents and natural calamities and the fishermen should be insured.
- There aren't any developments in infrastructure in the last 25 years. Schools and hospitals need to be established near the fishing villages. Fishers should get land near the seashore for aquaculture
- Harbor extension projects should be done for the major fishing harbors in the region to handle the increased number of fishing boats in the fishery
- Frame and implement strict monitoring protocols and rules to prevent pollution by factories/industries. Pollution is mainly affecting the small scale, marginal and subsistence fishers as the catches from the inshore areas are declining.
- All the harbors in Gujarat can be properly maintained structurally and upgraded. The hygiene in the landing centres should be well maintained as per the standards of the European Union or international importing markets.
- The fishermen of Kachchh district expressed their need to have fish landing jetty and there should be regulations on pollution by companies and there should not be any factories near inshore fishing areas.
- Impact of climate change on marine fishery resources, ecosystem and fisher's livelihood needs detail study and close monitoring.
- Illiteracy and lack of awareness among fisherfolk community
- Inclusion of fishers while framing the MFRA and the rules.
- Fishers from other states and foreign countries should not be allowed to fish in their area, especially during the ban period, so that they get better catch after the monsoon.
- Inadequate on-board handling facilities, quality control standards and poor marketing infrastructure.

Fisher's perception of conflicts in Dolnet fishery along Gujarat

Fishers play a major role in contributing to fisheries management, particularly in the" Bottom-up approach" which is being increasingly recognized as an imperative mechanism for facilitating the successful harnessing of fishery resources, maintenance of power relations between the stakeholders and Governance, and addressing the SDG Goals of zero hunger, poverty elimination, and sustainable production and consumption. In this context, a study on the conflicts encountered by dolnet fishers of the major dolnet operating centers of Navabandar and Jafrabad of Gujarat State with other stakeholders (Inter-sectoral and Intra-sectoral) has been attempted to suggest useful implications for the policy-making agencies.

Inter-sectoral conflicts were observed to take place in two connotations, namely dolnet operators of Gujarat coast in conflict with the line trawlers of Maharashtra as well as other mechanized trawlers and gillnetters of the State. Competition for resources between fishers targeting different species (74%) and fishers targeting the same species (52%) was yet another type of inter-sectoral conflict observed. Intra-sectoral conflicts, on the other hand, were found to occur between dolnet fishers of adjacent areas of the State (84%) for their fictitious claim over fishing grounds. The majority of fishers have responded that they traditionally rely on local customary mechanisms to address conflicts. Most of the conflicts are resolved through local fisher associations and advisory unions, rather than resorting to institutional approaches such as government, courts, or tribunals.



17. Recommended management options

Regulations on the registration of new fishing vessels

The marine fishery is a free and open access system in Gujarat, which has resulted in intense competition for the common resources among a variety of sub-sectors, i.e., traditional, motorized and mechanized. To ensure the socio-economic security of artisanal fishers, who operate motorized craft and struggle to compete with the mechanized sector fishers, sector-wise fleet optimization is the better solution. Hence, to stop unsustainable increase in fishing effort, especially of mechanized units, the following measures are recommended:

a. There may be mandatory registration and licensing of all motorized and mechanized boats operating along the Gujarat coast. An unregistered and unlicensed boat should be removed from the fishery.
b. Registration of new fishing craft may be done only after considering the optimum fleet size recommended by GoI.
c. Implementation of registration and licensing of fishing vessels periodically.
d. Converting and modifying fishing craft.

Fishing effort and fleet capacity

In recent years, increasing fishing fleet capacity is rampant, which leads to an increase in the fishing effort along Gujarat. To realize maximum economic returns, fishers have adopted new designs in fishing crafts and gears to suit specific situations. Trawlers, dolnetters and gillnetters have increased in overall length (OAL) to undertake multi-day fishing voyages in recent days. Trawl nets with suitable modifications targeting specific resources came into existence viz., shrimp trawl net, ribbonfish trawl net and cephalopod trawl net. Modifications were made to winches to haul dolnets and increase in horsepower of engine and number of cylinders. The important changes that have taken place in the last few years for the boats with outboard motor and introduction of in-board motor fitted in large vessels operating gillnets and trawl nets; winches and other deck equipment. Strict monitoring, surveillance and verifications are required to regulate the number, size and scale of operation and capacity of craft and gear. The following measures are recommended:

a. Mechanized fishing vessels shall not be used for fishing in the territorial waters, which are designated for the artisanal fishermen (within five nautical miles from the shore). A stringent monitoring mechanism needs to be in place to safeguard the interest of small scale fishers and the resources in coastal waters from massive harvesting capacity of mechanized fleets.
b. The present fishing grounds are under intense exploitation pressure and further increase in effort may increase the vulnerability of fish stocks and lower the share of profit per fishing trip. Therefore, it is necessary to limit the fishing intensity along coastal regions by diverting the surplus effort to under/un-exploited far distant fishing grounds. Incentives for the conversion of existing vessels for deep-sea fishing should be considered.
c. The fishing craft length and engine capacity may be regulated by fixing and capping the size and power of trawlers, dolnetters and gillnetters by imposing upper limits. Innovations and modifications of fishing crafts and gears in terms of design, operation, mode of propulsion, engine horsepower, fishing methods, type of gears, etc. should be carefully scrutinized and vetted by a competent technical authority before granting permission.
d. All boat-building yards, net mending units, fishing allied industries and landing centres and fishing harbors should be brought under the purview of the GMFR Act and should be registered and monitored under the Act.

Implementation of mesh size regulations

In the state of Gujarat, mesh size regulation exists for trawl nets, dolnets and gillnets (Table 17.1). However, these regulations are seldom followed by the fishermen resulting in huge catches of small and juvenile fishes by trawlers and dolnetters. Studies conducted jointly by CMFRI and CIFT revealed that the average amount of fish that escapes because of the use of a stipulated 40 mm cod-end mesh instead of the usual mesh for trawls is a meager 8.1 kg/haul. The amount was roughly 20% of the catch. The average loss per haul in monetary terms is ₹23 only, which is about 1.3% of the total revenue realized per haul. However, on using a 40 mm cod-end mesh, there will be an increase in unit value of the fish caught by 24%. It may happen because of the absence of small fishes in the catch, raising the unit value of the catch. On the other hand, the implementation of legal mesh size would pave the way for certification of the fisheries as sustainable and fetches the higher value for the catch.

Table: 17.1: Details of recommended mesh sizes for the different fishing gears (MFRA, Gujarat, 2003)

Gear	Mesh size	Major resources in the gear
Trawl net / Dol net / Golva	40 mm sq. mesh size of cod end	Demersal fishes
Gillnet	5"	Silver pomfret, Black pomfret and other fishes
Gillnet	10"	Large croakers, polynemids, Seerfishes, Tuna and other fishes
Gillnet	3.7"	Mullets

Inspection of mesh sizes of different fishing gears at the landing centre/fishing harbor during departure and arrival of a fishing boat by the regulatory authority.

a. Imposing penalty if violated the recommended mesh size for different fishing gears.
b. Cancellation of registration and license of the boats found to breach the Act twice
c. Create awareness and encouragement to use by-catch Reduction Devices (BRDs), TEDs and Juvenile Excluder – Shrimp Sorter Devices in trawls.
d. Educating the fishermen on the perils of juvenile fishing and growth overfishing in economic terms and stock status

Diversification of fishing vessels

There is scope to increase the production of unexploited deep-sea resources, especially the oceanic tunas, billfishes, along with sharks and deep-sea oceanic cephalopods by diverting fishing effort to distant untapped fishing grounds and deeper waters. It will considerably ease out the fishing pressure in the inshore waters and resolve the conflicts between different sectors. The suggested options are:

a. Encourage and support conversion of trawlers to tuna longliners by suitable modifications/upgradations.
b. Promote and introduce multipurpose / combination vessels, which are mostly engaged in passive fishing by a variety of gears viz., large mesh gillnets, hooks and lines and squid jigs.
c. Provision of government support and subsidies for small scale fishers, especially those fishing for oceanic species of tunas to upgrade their fishing crafts and acquire iceboxes/fish preservation facilities in their traditional crafts

Conservation strategies

The length at first capture of the majority of species is smaller than the size at first maturity, indicating that the majority of resources are caught before they mature and spawn at least once in their lifetime. For example, in Silver pomfret, the length at first maturity of females is 27.5 cm, while the length at first capture is only 8.2 cm (Ghosh *et al*., 2009), which indicates the stress on spawning stock which could be addressed by increasing their size and age of exploitation. Moreover, the indiscriminate removal of spawners of large and long-lived fishes poses a serious threat to the population, due to recruitment overfishing. A concept of Minimum Legal Size (MLS) can be considered to ensure the healthy stock status of commercially exploited resources by considering logic criteria based on size at first maturity (SFM) or length at which 50% individuals in a population of a given resource attain maturity (LM_{50}%). The following measures are recommended:

a. Strict adherence to Minimum Legal Size during landing and marketing of finfish and shellfish. As the complete exclusion of juveniles from gear is unlikely, the juveniles (Juvenile/total catch) catch of a particular species in a given gear needs to be set after scientific consultation.
b. Punishment and levies imposed on fishers, boat owners and traders who are violating the clauses of MLS regulations.
c. Monitoring of minimum export size for the highest value and export demanded resources like lobsters, prawns, seerfishes and tunas.
d. Assessment of spawning stock biomass of individual resources and retaining or conserving a certain proportion for the replenishment of the stock. Fishing should be prohibited in the areas of spawning migrations during spawning season
e. Creating awareness among fisherfolk on the rescue and releasing back of endangered resources like whale sharks, turtles and marine mammals, etc. to conserve their population.

Observation of closed season and establishment of Marine Protected Areas (MPAs)

The motorized Gillnetter operate during the monsoon ban season and are actively engaged in fishing for gravid females of ghol, koth, dara, pomfrets, lobsters, etc. Similar situation exists for dolnet fishery in some centres, wherein juveniles and spawners of commercially important resources are exploited in considerable quantities during monsoon months. Therefore, to ensure sustainable yields from these overexploited stocks, rebuilding and replenishment of stocks and ecosystem rejuvenation, closure of gillnet and dolnet fishing during monsoon months are suggested. It will allow spawners to reproduce at least once before exploitation. The suggested measures are:

a. Strict monitoring and implementation of trawl ban from the middle of June to the middle of August.
b. An operational ban on outboard Gillnetter and mechanized dolnetters during the ban season to replenish fish stocks and resolve social conflicts
c. The artisanal fishers engaged in fishing during monsoon months along the inshore coastal waters should be regulated and compensated.
d. Using a consensus approach, suitable eco-zones which act as shrimp/fish nurseries should be identified and declared as MPAs or no-fishing zones. The waters off the southern coast of Saurashtra along the districts of Amreli and Bhavnagar are excellent breeding and nursery grounds for *ghol*, *koth* and lobsters and these areas may be declared as MPAs and no-fishing zones.

Sea safety

The safety of the fishermen at sea is of utmost importance and requires due consideration. The suggested options are:

a. Compliance of equipping lifesaving appliances (LSA) and firefighting equipment on-board in all the fishing vessels. The living conditions of fishers in the vessel also should be improved.
b. Fishing vessels should be appropriately marked as per FAO specifications for their identification based on the International Telecommunication Union Radio Call Signs (IRCS) to ensure the safety of fishers at sea during the distress conditions.
c. Introduction of Vessel Monitoring System (VMS) for the fishing vessels using satellite tracking technology.

Reinforcement of management information system

The GMFR Act stipulates that every owner of fishing vessels should furnish detailed information in the prescribed proforma *viz.,* name of the vessel and owner, registration number, type, overall length, tonnage, engine HP, gears used, number of crew, fishing area and fish caught, etc. Knowledge-based fisheries management relies on the availability of reliable and adequate data on the resources and their dynamics, including the economics of fishing operations. The scientific data available with research institutes like CMFRI should be supported and validated by an effective real-time fishing data feedback system with active participation and co-operation from the fishermen and fishing vessel operators. The following measures are suggested:

a. Introduction of log sheets for the collection of fishery and fishing operation information details such as fishing gears used, fishing area/ground, fishing effort, catch and species composition should be made mandatory for all

motorized and mechanized fishing craft and the details should be made available to fisheries inspectors when demanded.

b. Fisheries Information System (Potential Fishing Zone (PFZ) advisories, market information and e-commerce portal, fish identification and biological information, etc.) should be integrated with unified fishing vessel registration system, which can be developed for effective control, monitoring and management of marine fisheries making use of the advances in Information Technology.

Participatory Approach Management (PAM)

The active involvement of stakeholders in decision making and its implementation, is an important and effective management tool for the fisheries sector. Fisheries co-operatives play a crucial role in this context and the onus of protecting harvested resources and social security of the fishermen is vested in them. In Gujarat, only 1.4% of the fishermen are members of cooperative societies. Frequent interactions with scientists/technical human resources are required to understand the biological and environmental basis for the sustainability of fish stocks and get information about the schemes and policies existing in the sector. This, in turn, will implement the management measures/options smooth and effective. The awareness on the benefits of conservation of fish stocks is low among the fisherfolk, which has to be strengthened with the help of extended services of Central and State fisheries institutions/agencies and NGOs with a participatory and co-management approaches. The following measures need consideration:

Strengthening of extension services

a. FAO-Code of Conduct for Responsible Fisheries (CCRF) and the GMFR Act has to be popularized among all the stakeholders. In the feedback of recent surveys conducted by CMFRI, the unawareness among respondents about FAO-CCRF and GMFR Act was quite evident.

b. Fisherfolk should be educated and trained in the usage of advanced technologies like electronic devices and wireless communications. The study reveals that only a quarter of the fisherfolk were using PFZ information and echo sounder for locating fish shoals.

c. Formation of new fishers' cooperative societies needs to be promoted and the existing ones should be further strengthened for the benefit of the small scale fisheries sector.

d. Setting up of State/District/Panchayat level Scientific Advisory and Management Committees (Councils) with the participation of experts and other stakeholders for advising the Government on various issues related to resource exploitation, conservation, marketing and management of the fishery resources as is already implemented in the state of Kerala

e. A model fishing village/harbor may be set up for the demonstration of participatory or co-management.
f. Establishment of a harbor-based task force including fishers and local administrative bodies to identify such conflicts and pursue the issue to the concerned organization to ensure quick remedial measures are recommended as an effective and quick conflict resolution mechanism.

Strengthening fish marketing networks

Gujarat was a non-fish consuming state with a per capita fish consumption of only 3.72 kg/year in 1991. However, in recent times this has changed with an increase in per capita fish consumption to 10.34 kg/year in 2005. Better domestic markets and value chains need to be established to cater to consumers with fish and fish products due to the changes in the dietary habits of the people in the state. An efficient internal market network has to be established and developed based on the principle of optimum utilization of the resource, hygienic handling, processing and maintaining standards, diversification of value-added products and efficient marketing. The following options are suggested:

a. Fisherfolk need to be encouraged technically and supported financially for greater involvement in fish trade and other micro-enterprises in the field of the post-harvest sector.
b. Intermediaries/middlemen involved in trading and marketing of fish and fishery products may be minimized to guarantee maximum returns to the fishermen from consumer rupee and the marketing chain should be as small as possible.
c. Infrastructure facilities like ice plants, cold storages, potable water availability, fish hold, processing and freezing plants and electricity have to be strengthened for proper storage, marketing, processing of the harvested resources with minimal post-harvest losses/wastage.
d. Registered fish stalls/outlets with proper hygienic standards should be authorized to vend fishes outside the fish landing centre. Setting-up of suitable labs/agencies for checking the quality of fish sold in domestic markets needs to be promoted.

Certification, HACCP implementation and value addition technologies

Seafood industries need to get upgraded with the advent of new regulations by the European Union (EU), which intends to prevent, deter and eliminate illegal, unreported and unregulated (IUU) fishing. Every health certificate of the consignment has to be accompanied by a “catch certificate” signed by the competent authority designated by the Govt. of India and whose signature is approved by the EU. HACCP is a product certification system used in the fish

processing industry to identify potential safety hazards, so that key actions, known as Critical Control Points (CCPs) can be taken to reduce or eliminate the risk of the hazards. Right from the time of capture to preservation and storage, strict scientific procedures are recommended, which can reduce the post-harvest loss and add extra value to the fishery products. Trained fishermen's groups may be involved in the preparation of value-added products. The waste generated during processing can be used for developing by-products like fish silage, fish manure, fish meal, etc., for cattle feed/plant manures, etc. The management options suggested are:

a. Setting up of authorized agencies/organizations for certifying sustainable fishing methods and eco-labeling fish and fishery products.
b. Stakeholders have to be sensitized about the emerging non-tariff barriers (standardization, testing and labeling and certification requirements) in global fish trade and the need for adoption of sustainable fishing activities.
c. All fish processing units need to strictly implement HACCP and other guidelines as required by the importing countries, which have to be regularly inspected, signed and verified by the competent authority from time to time.
d. Hygienic conditions and suitable infrastructure facilities should be ensured at the fishing boats and harbor/landing centres, fish markets and during transportation of fish.
e. Fishermen groups have to be trained in on-board fish handling, value addition and utilization of wastes during processing.

Impacts of climate change on marine fisheries

Marine fishery resources and coastal fishers around the world are under threat by climate change. Climate change events like sea-level rise, an increase in sea surface temperature, increased storminess and an increase in the frequency of cyclones can have an impact on the distribution and productivity of fish stocks. Climate change impacts like cyclones, storms, coastal erosion and reduction in the number of fishing days at sea can affect the coastal communities. Conservation of marine ecosystems and adoption of climate change adaptation and mitigation plans assumes paramount importance and there is an urgent need to create awareness and implement contingency plans along coastal regions. The possible options are:

a. Challenges arising from climate change-induced sea-level rise and its other impacts on the fisheries sector should be sensitized to all the stakeholders.
b. Fishers should be warned well in advance on the cyclones and storms by the Meteorology department and they should have easy access to satellite weather data and images.
c. The government should prepare sufficient contingency and mitigation plan for relief from weather-related disasters

d. Plantation/afforestation of mangroves for the protection of coastal areas needs to be initiated
e. Energy-efficient and fuel-saving fishing technologies (LPG/solar energy sources), which reduces CO_2 emissions have to be promoted.

Marine Habitat Restoration

The introduction of artificial reef modules will restore marine habitats and increase the production of marine finfish and shellfish resources and creating new biodiversity habitats as nursery and feeding grounds. Artificial reefs are known to aggregate fishes and are deployed for the benefit of small coastal fisher communities displaced by the motorized/mechanized sector. The reasons behind the aggregation of fish are many and vary between different fish species. Hence scouting time for fish can be reduced. The following options are suggested:

a. Artificial reef modules in varying sizes and shapes have to be provided to the fishermen community in limited numbers for use only by fishermen fishing by hooks and line.
b. Coastal waters usage policy has to be formulated.
c. Industries dumping their effluents without proper treatment into the sea should be severely dealt with and "Effluent Treatment Plant (ETP)" for effective recycling has to be made mandatory for the existing and new industries.

Capture Based Aquaculture (CBA) and Mariculture

CBA is perhaps the best alternative to augment the low catch rates and poor economic returns in the marine fisheries sector. Juveniles of high valued commercial species viz., lobsters, *ghol*, *koth* and pomfrets caught alive by traditional fishermen operating various types of encircling nets in inshore can be farmed to marketable sizes in floating cages by feeding them with trash feed/formulated feed. Additionally, live broodstocks caught by various gears can also be maintained in floating cages in nearshore areas, which will facilitate hatchery and seed production. The suggested methods are:

a. Demonstration and promotion of CBA in floating cages or pens among the fishermen communities. The expertise available with CMFRI in open sea cage culture can be well utilized for this.
b. Small cages have to be supplied at subsidized cost by the National Fisheries Development Board through the Fisheries department of the state government.
c. Diverting the fisher's youth to other fisheries-related activities like coastal mariculture or value addition through persistence awareness workshops, skill development, and capacity-building programs will reduce the economic dependence on harvest and lead to a reduction of conflict over limited resources.

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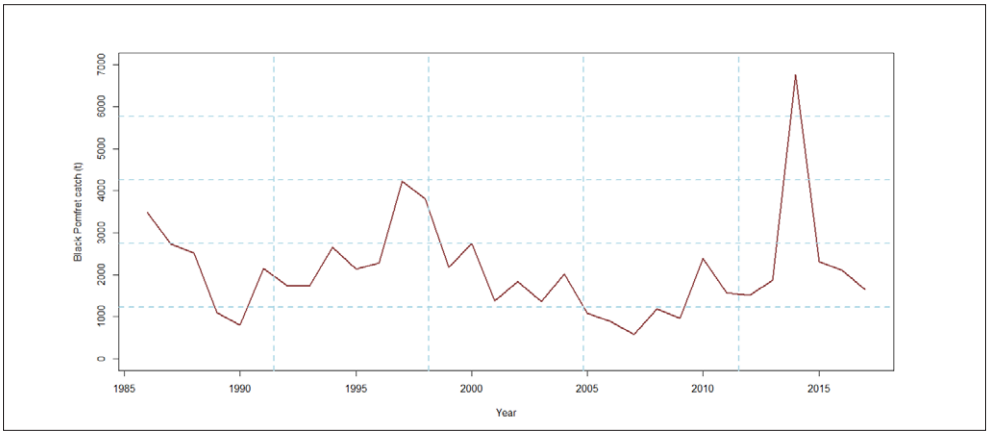
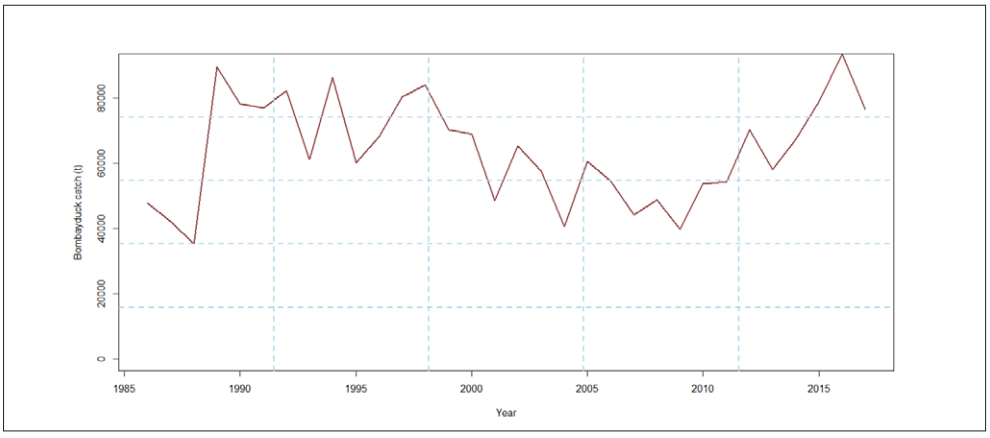
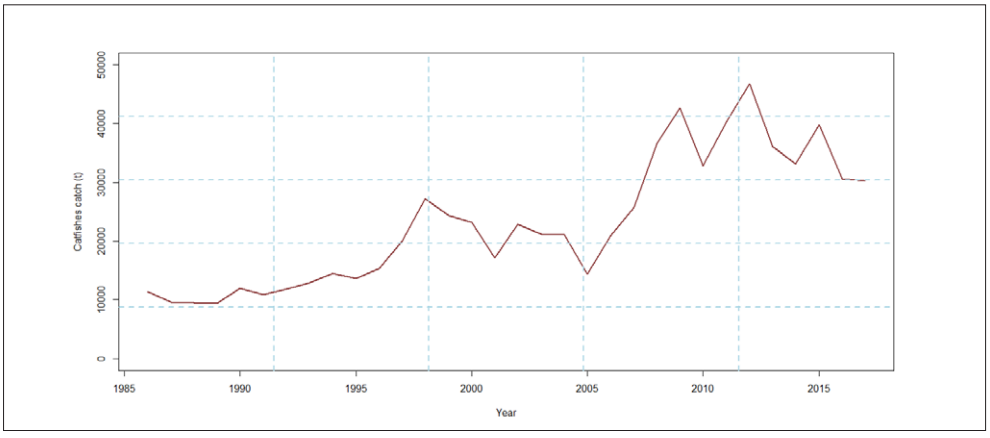
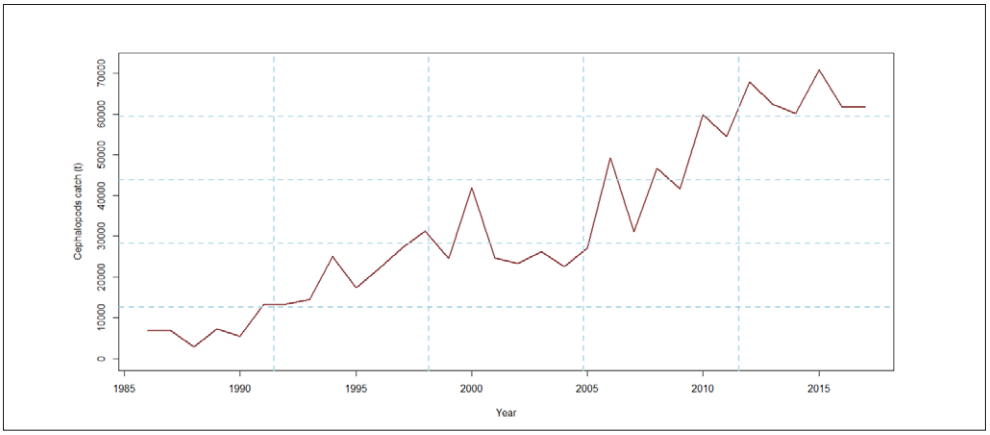
Annexure-1

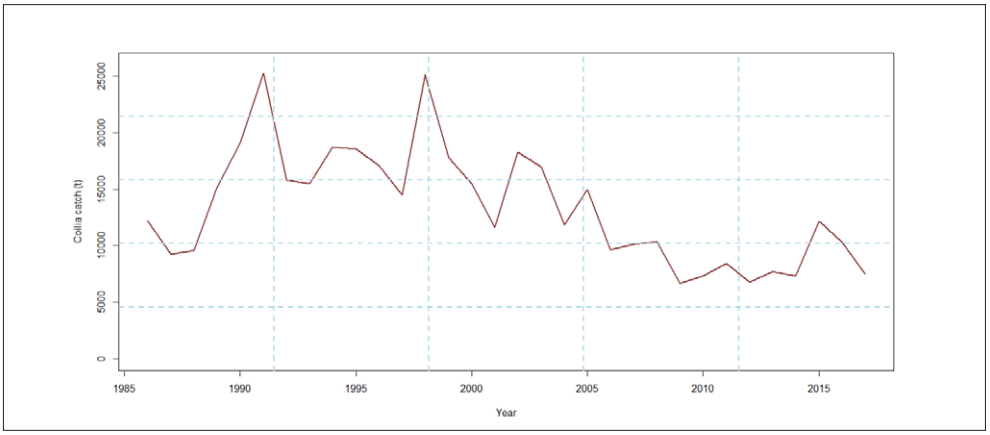
Catch trend of commercially important fishery resources

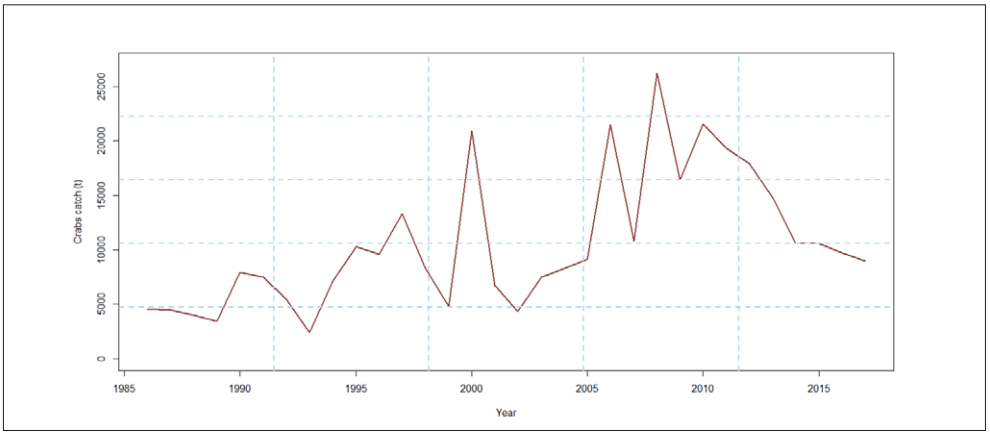


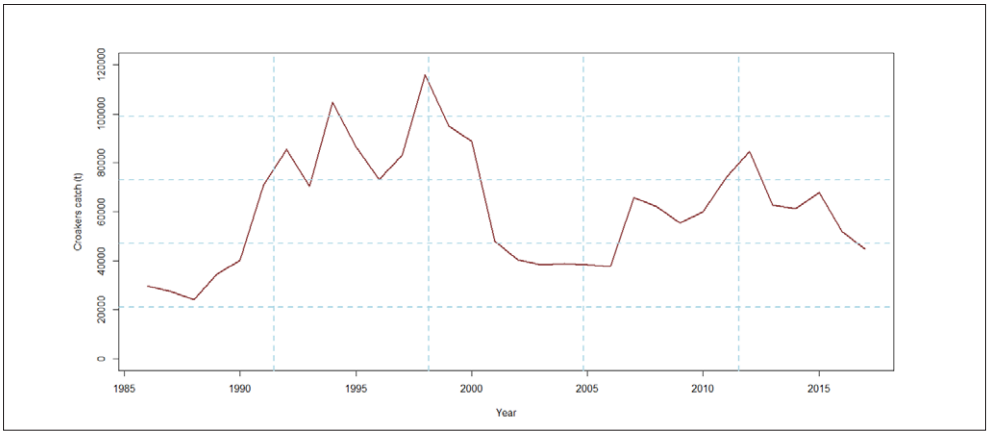


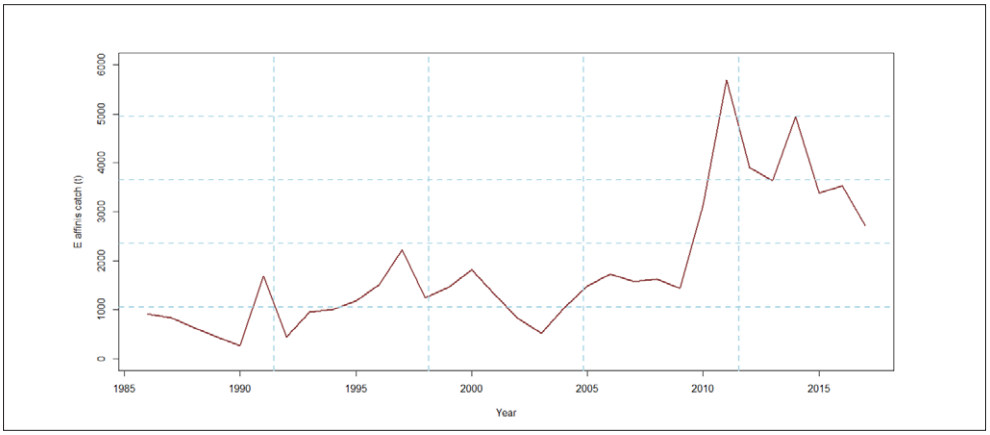


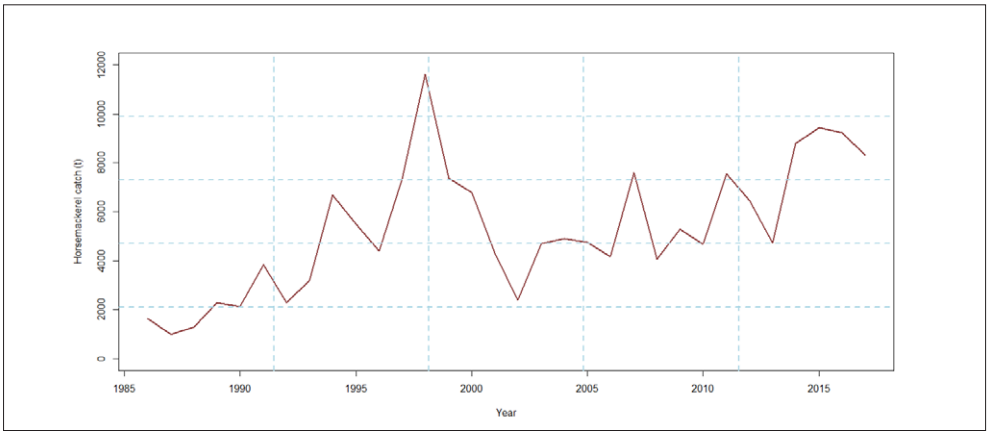

Cephalopods catch (t)
0
10000
20000
30000
40000
50000
60000
70000
1985
1990
1995
2000
2005
2010
2015
Year

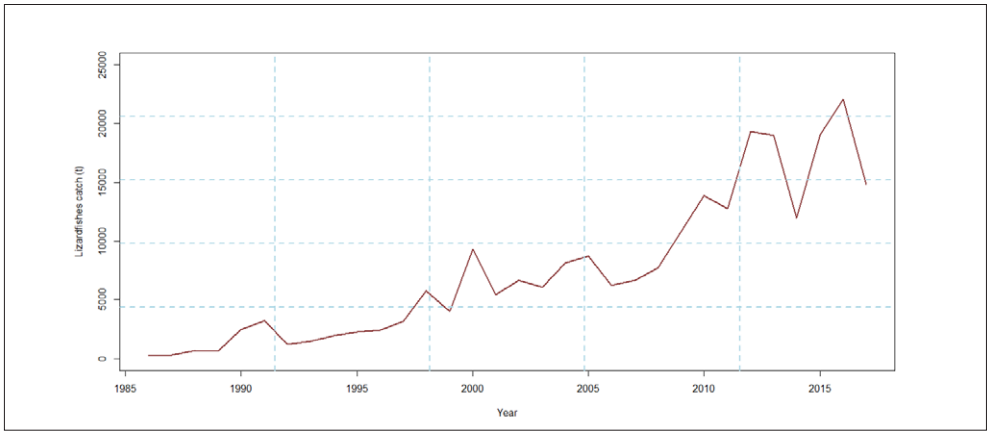

Coilia catch (t)
0
5000
10000
15000
20000
25000
1985
1990
1995
2000
2005
2010
2015
Year

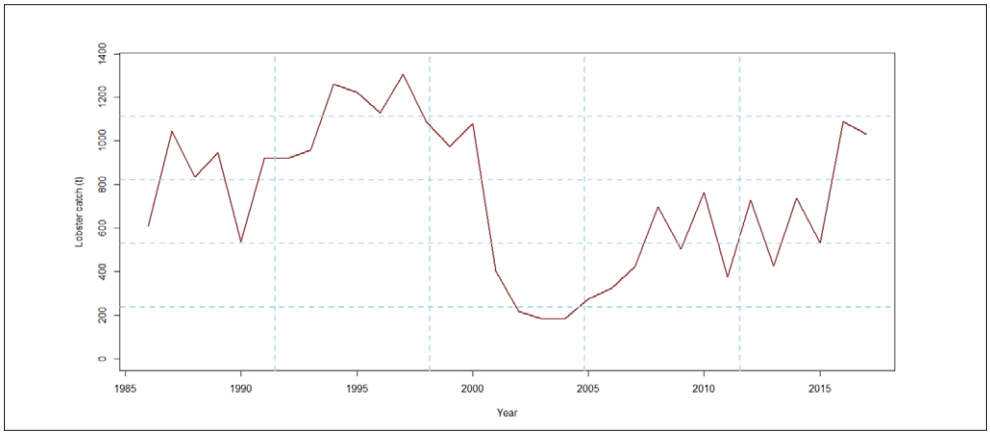

Crabs catch (t)
0
5000
10000
15000
20000
25000
1985
1990
1995
2000
2005
2010
2015
Year

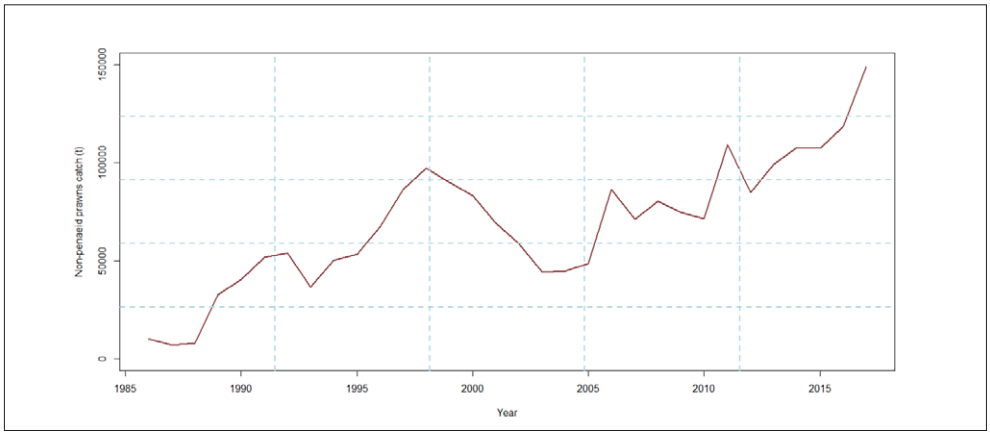

Croakers catch (t)
0
20000
40000
60000
80000
100000
120000
1985
1990
1995
2000
2005
2010
2015
Year

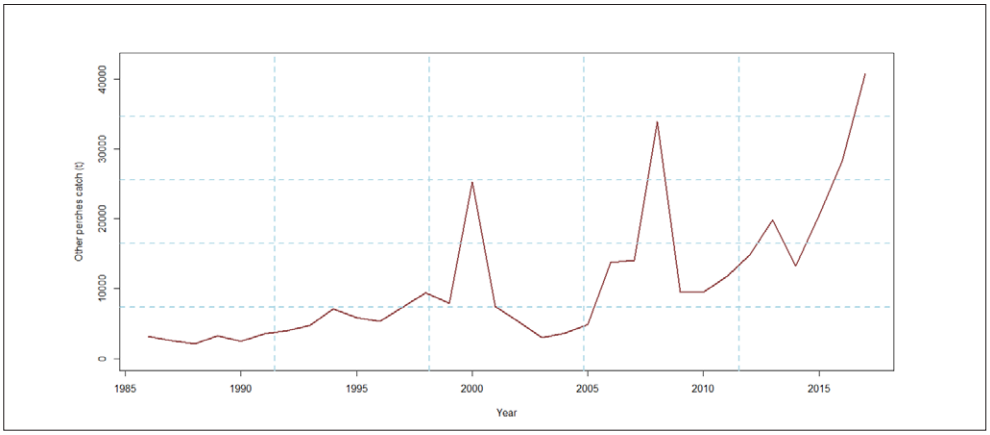

E affinis catch (t)
0
1000
2000
3000
4000
5000
6000
1985
1990
1995
2000
2005
2010
2015
Year

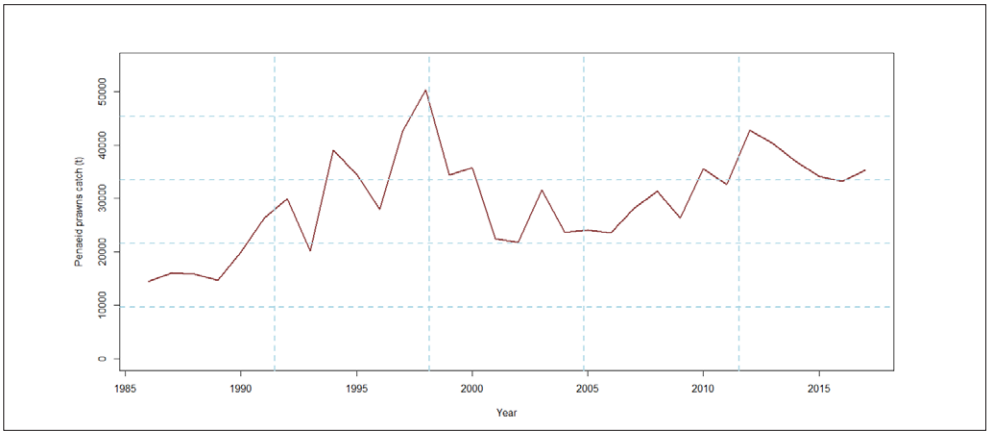

Horsemackerel catch (t)
0
2000
4000
6000
8000
10000
12000
1985
1990
1995
2000
2005
2010
2015
Year

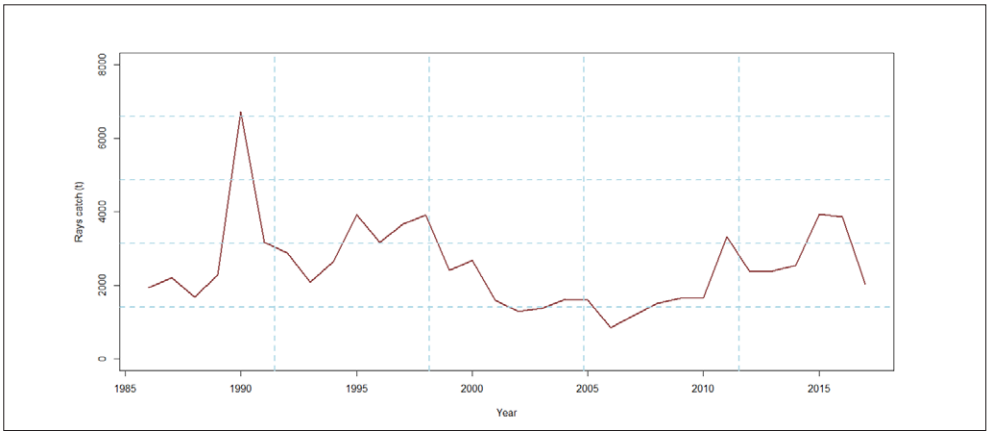

Lizardfishes catch (t)
0
5000
10000
15000
20000
25000
1985
1990
1995
2000
2005
2010
2015
Year

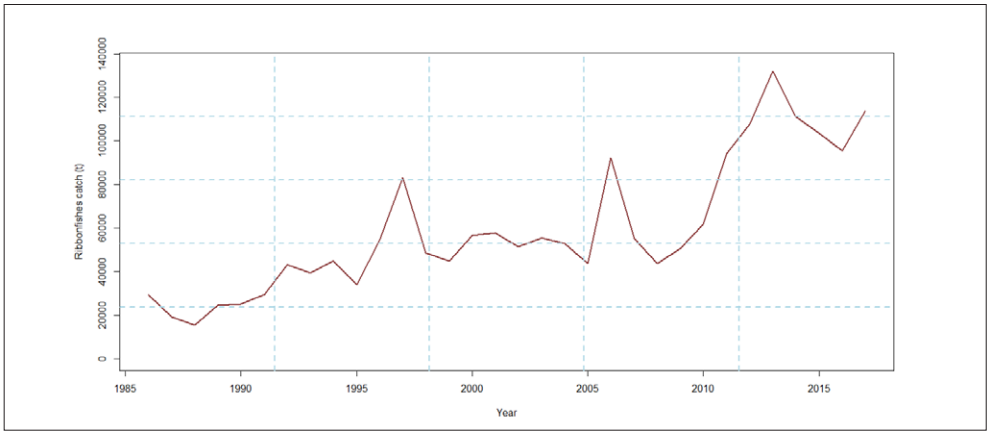

Lobster catch (t)
0
200
400
600
800
1000
1200
1400
1985
1990
1995
2000
2005
2010
2015
Year

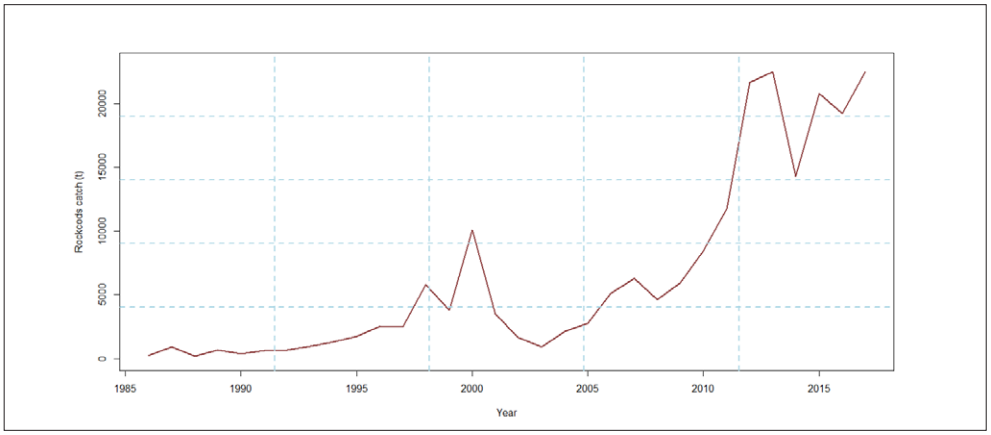

Non-penaeid prawns catch (t)
0
50000
100000
150000
1985
1990
1995
2000
2005
2010
2015
Year

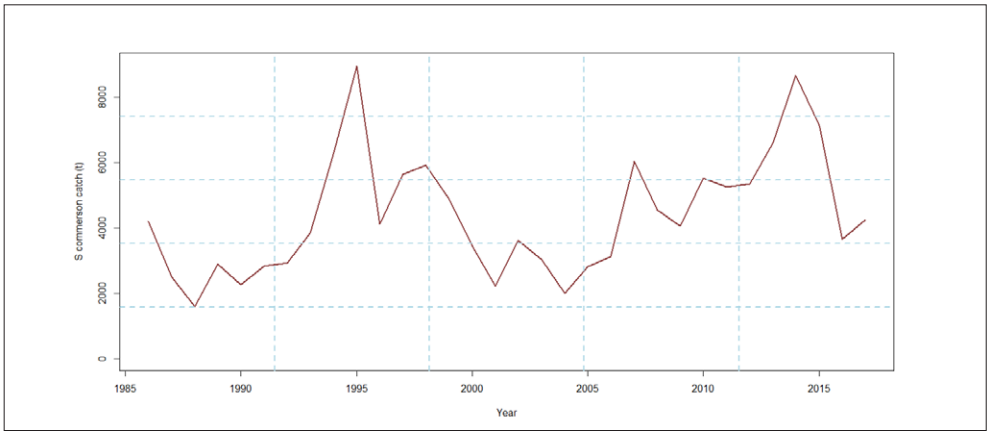

Other perches catch (t)
0
10000
20000
30000
40000
1985
1990
1995
2000
2005
2010
2015
Year

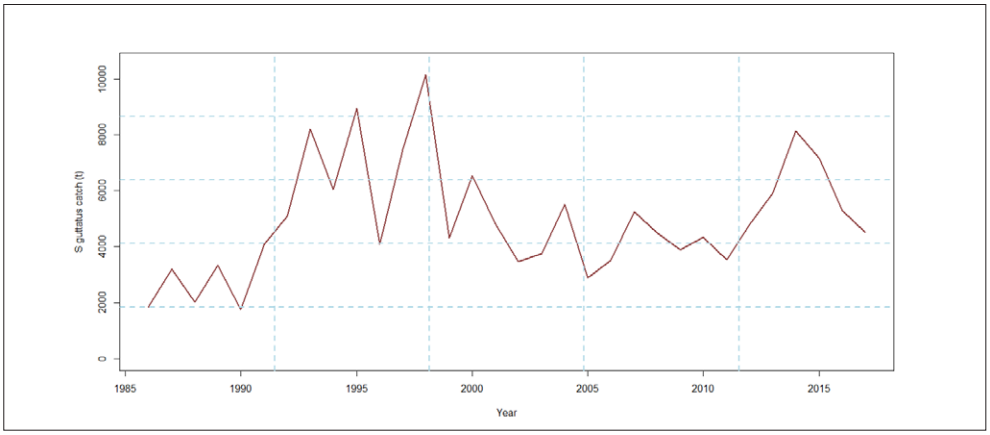

Penaeid prawns catch (t)
0
10000
20000
30000
40000
50000
1985
1990
1995
2000
2005
2010
2015
Year

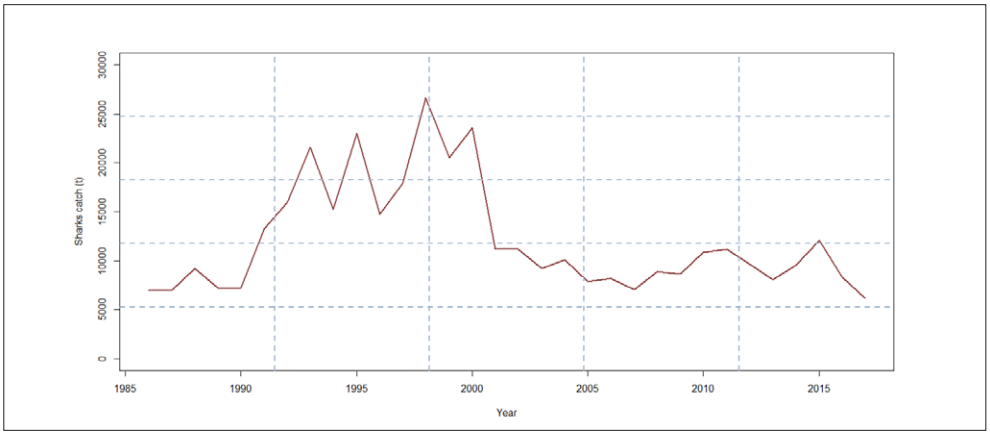

Rays catch (t)
0
2000
4000
6000
8000
1985
1990
1995
2000
2005
2010
2015
Year

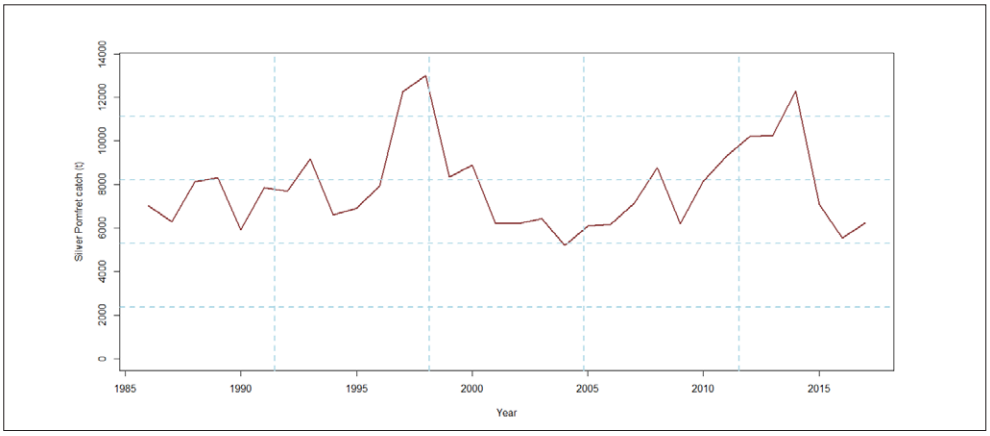

Ribbonfishes catch (t)
0
20000
40000
60000
80000
100000
120000
140000
1985
1990
1995
2000
2005
2010
2015
Year

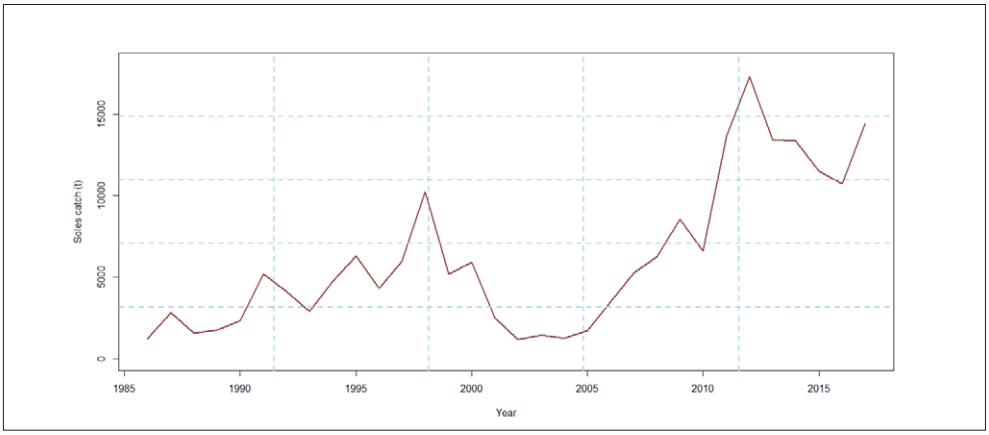

Rockcods catch (t)
0
5000
10000
15000
20000
1985
1990
1995
2000
2005
2010
2015
Year

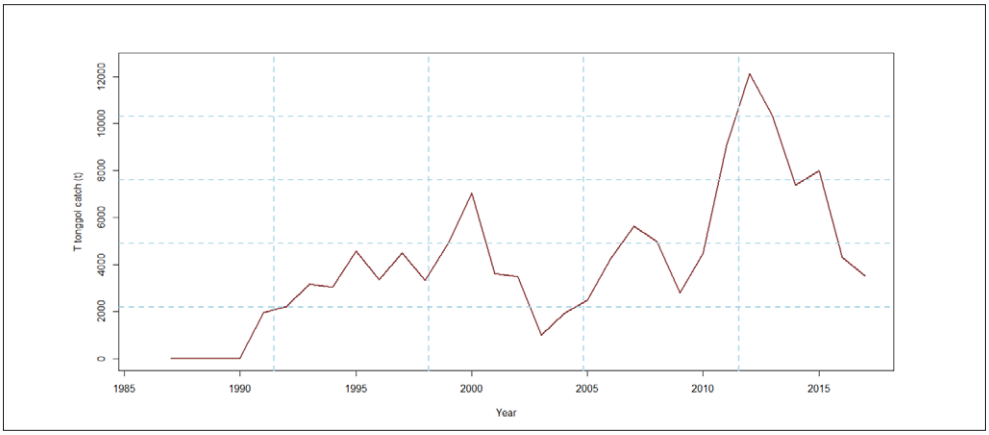

S commerson catch (t)
0
2000
4000
6000
8000
1985
1990
1995
2000
2005
2010
2015
Year

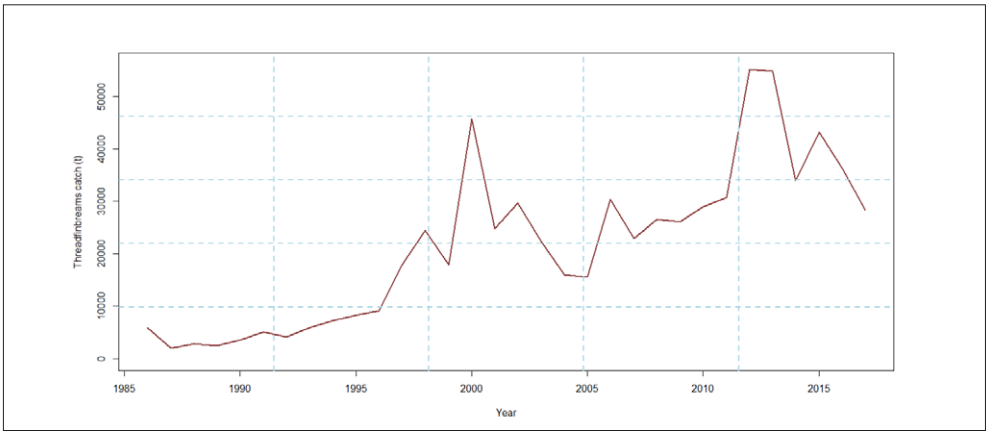

S.guttatus catch (t)
0
2000
4000
6000
8000
10000
1985
1990
1995
2000
2005
2010
2015
Year

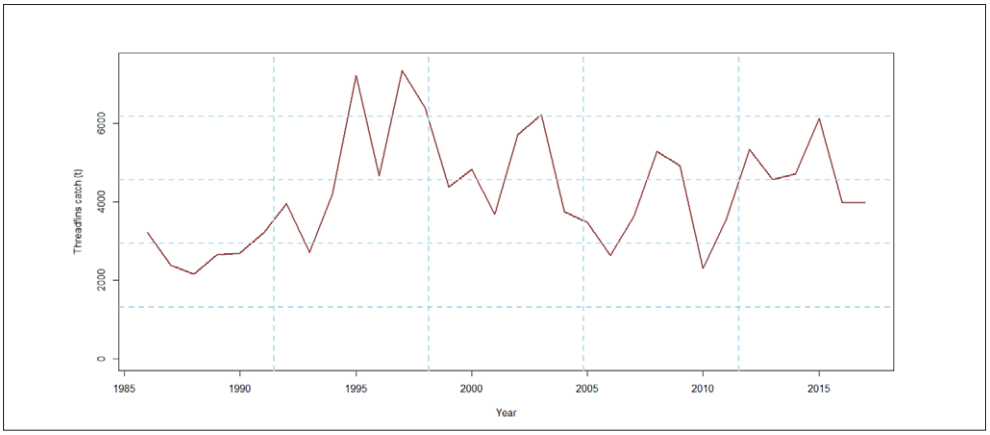

Sharks catch (t)
0
5000
10000
15000
20000
25000
30000
1985
1990
1995
2000
2005
2010
2015
Year

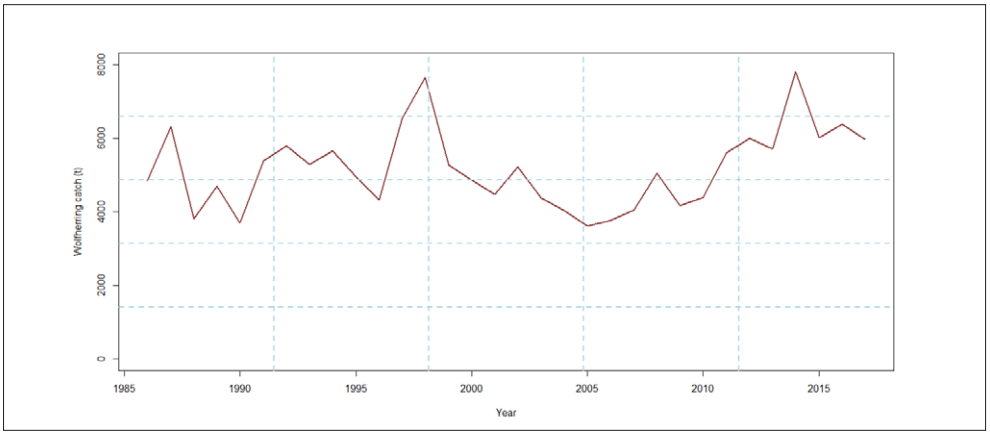

Silver Pomfret catch (t)
0
2000
4000
6000
8000
10000
12000
14000
1985
1990
1995
2000
2005
2010
2015
Year


Soles catch (t)
0
5000
10000
15000
1985
1990
1995
2000
2005
2010
2015
Year


Tonggol catch (t)
0
2000
4000
6000
8000
10000
12000
1985
1990
1995
2000
2005
2010
2015
Year

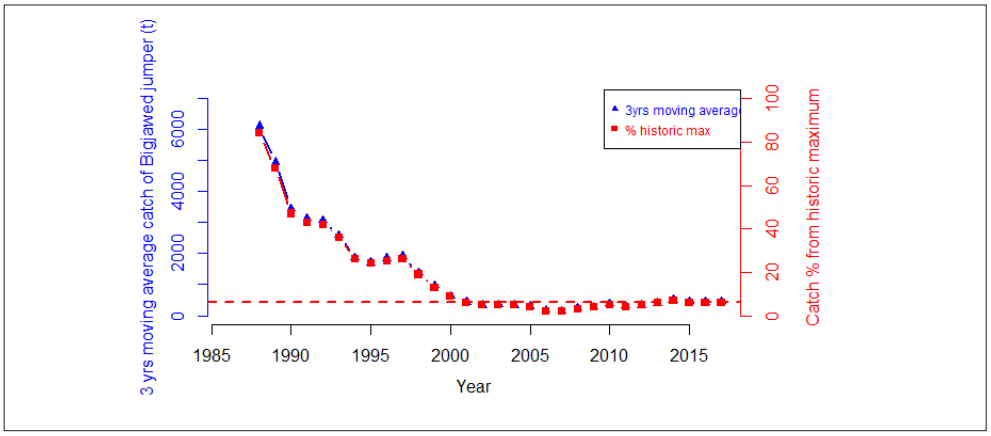

Threadfinbreams catch (t)
0
10000
20000
30000
40000
50000
1985
1990
1995
2000
2005
2010
2015
Year

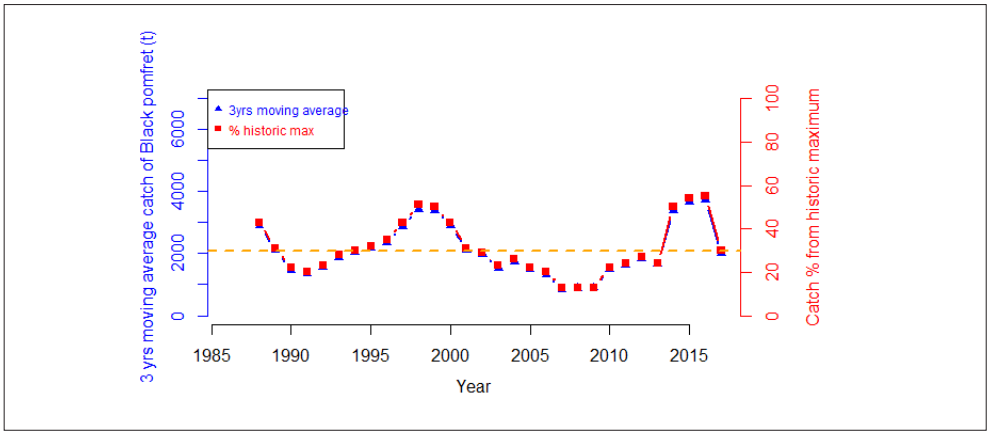

Threadfins catch (t)
0
2000
4000
6000
1985
1990
1995
2000
2005
2010
2015
Year

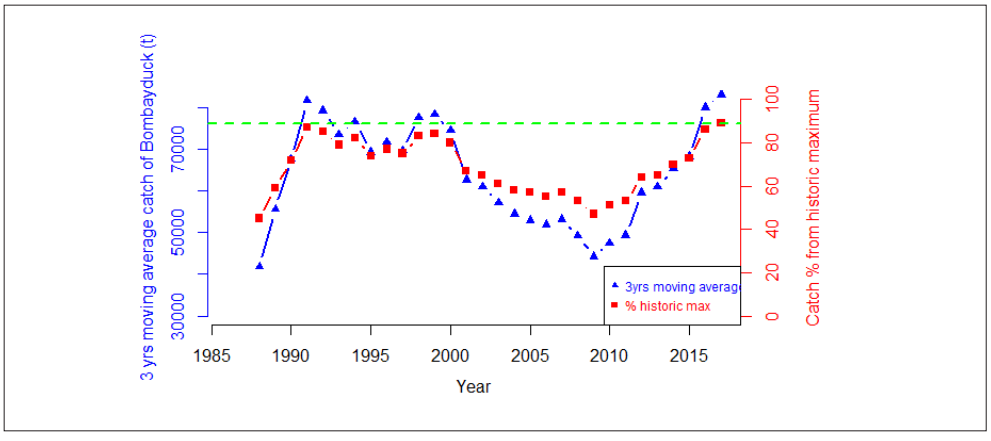

Wolfherring catch (t)
0
2000
4000
6000
8000
1985
1990
1995
2000
2005
2010
2015
Year

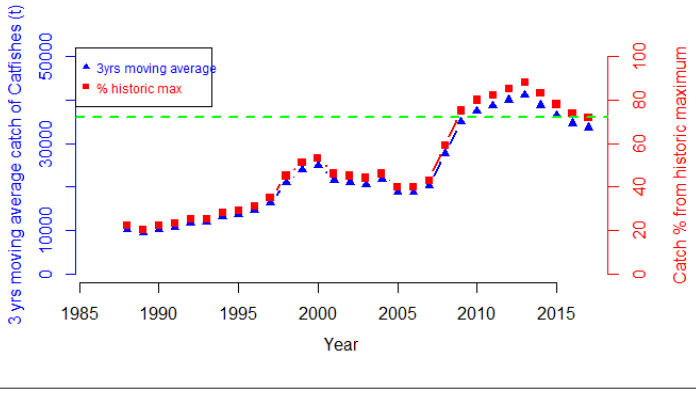
Annexure-2

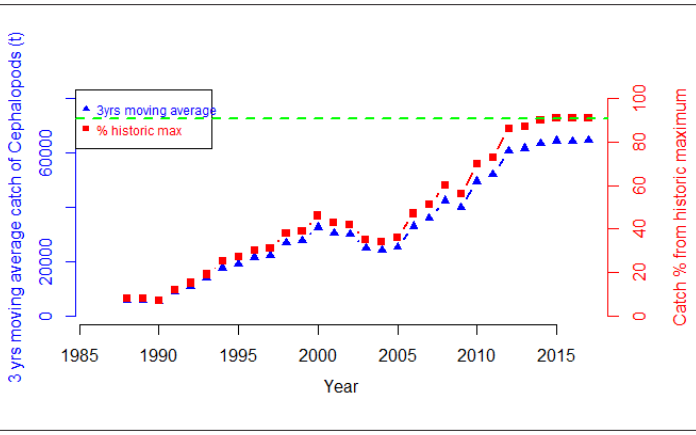
Trend of Rapid Stock Assessment of commercially important fishery resources

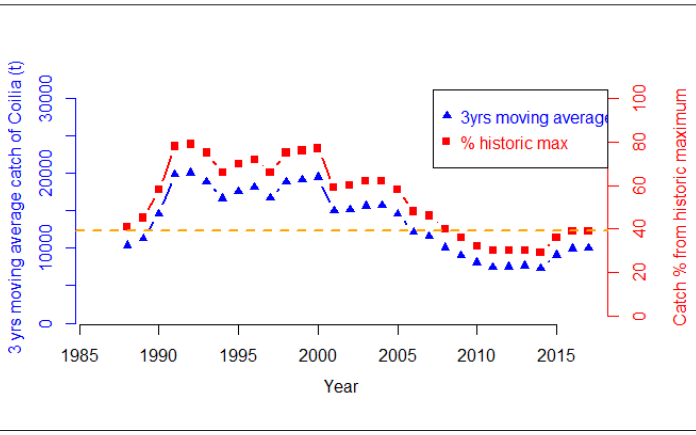


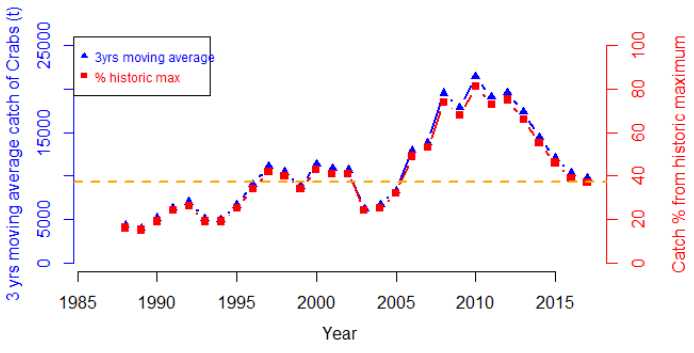


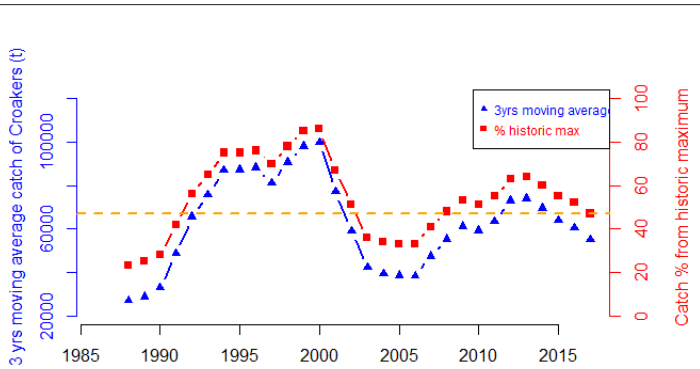


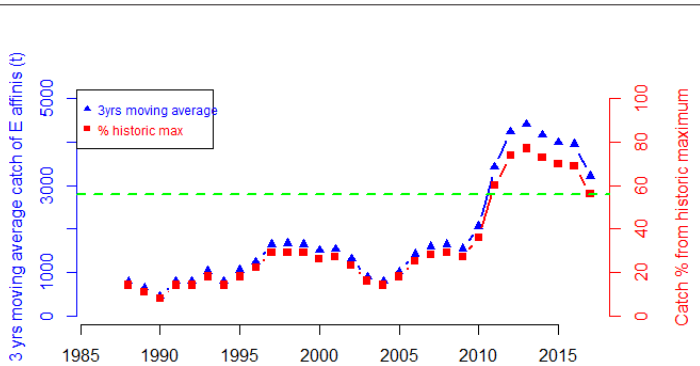

3 yrs moving average catch of Catfishes (t)
0
10000
30000
50000
3yrs moving average
% historic max
1985
1990
1995
2000
2005
2010
2015
Year
Catch % from historic maximum
0
20
40
60
80
100

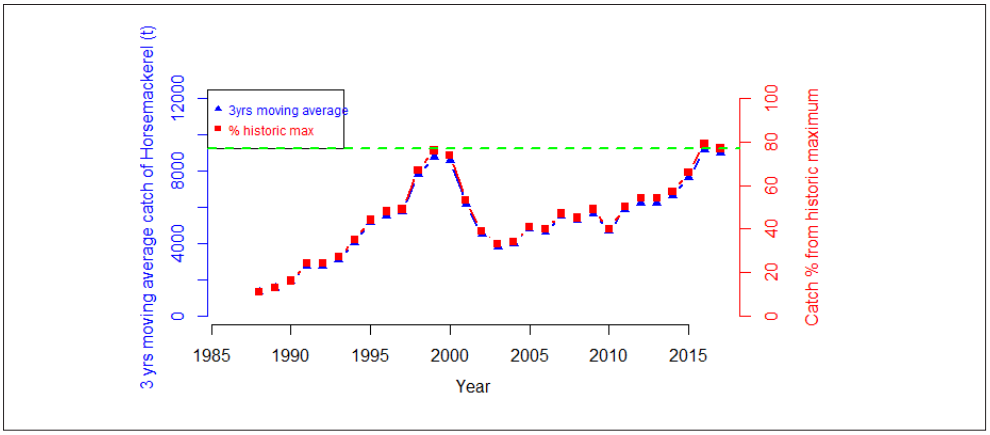

3 yrs moving average catch of Cephalopods (t)
0
20000
60000
3yrs moving average
% historic max
1985
1990
1995
2000
2005
2010
2015
Year
Catch % from historic maximum
0
20
40
60
80
100

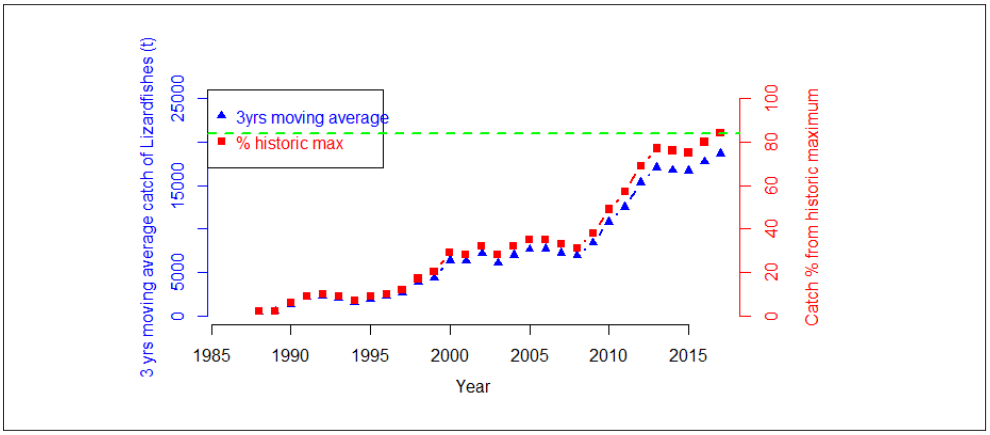

3 yrs moving average catch of Coilia (t)
0
10000
20000
30000
3yrs moving average
% historic max
1985
1990
1995
2000
2005
2010
2015
Year
Catch % from historic maximum
0
20
40
60
80
100

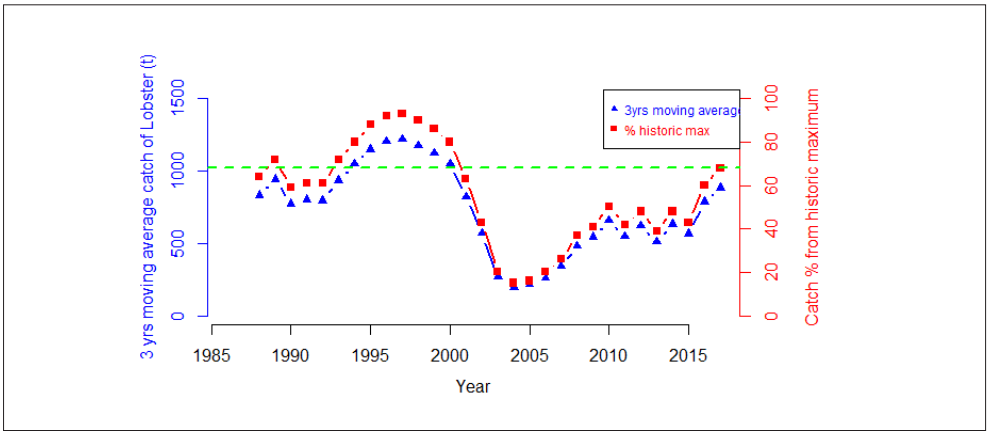

3 yrs moving average catch of Crabs (t)
0
5000
15000
25000
3yrs moving average
% historic max
1985
1990
1995
2000
2005
2010
2015
Year
Catch % from historic maximum
0
20
40
60
80
100

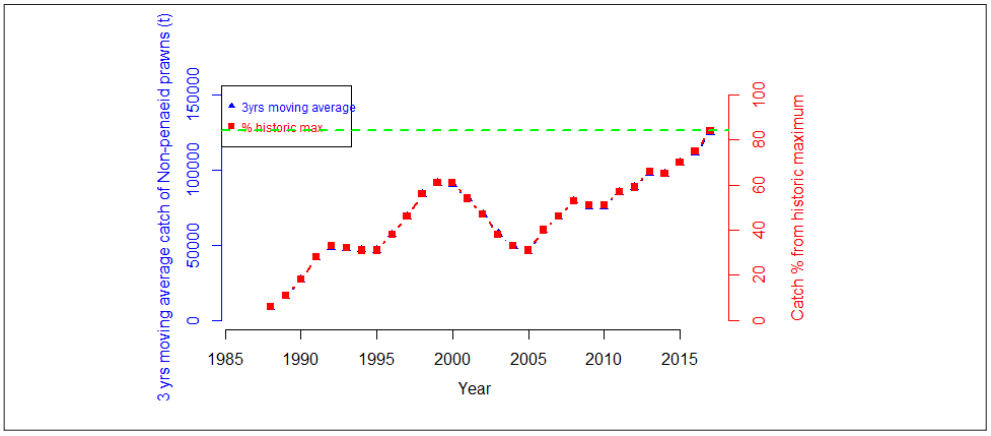

3 yrs moving average catch of Croakers (t)
20000
60000
100000
3yrs moving averag
% historic max
1985
1990
1995
2000
2005
2010
2015
Year
Catch % from historic maximum
0
20
40
60
80
100

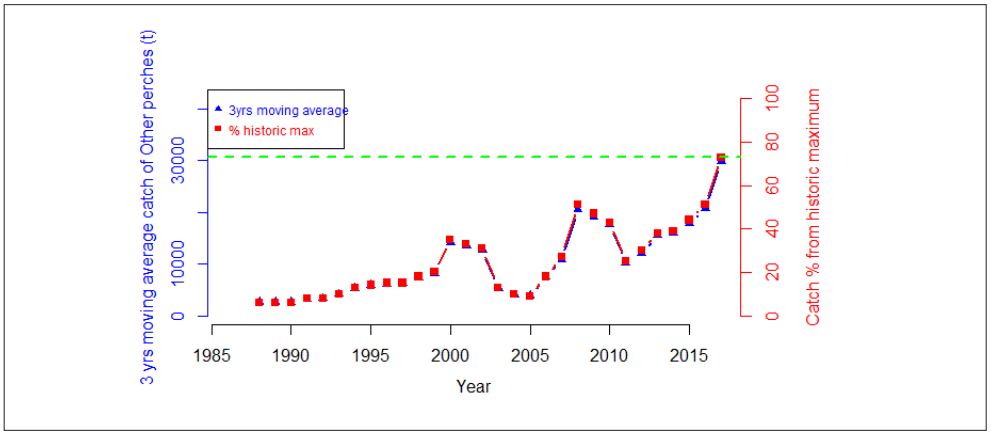

3 yrs moving average catch of E affinis (t)
0
1000
3000
5000
3yrs moving average
% historic max
1985
1990
1995
2000
2005
2010
2015
Year
Catch % from historic maximum
0
20
40
60
80
100

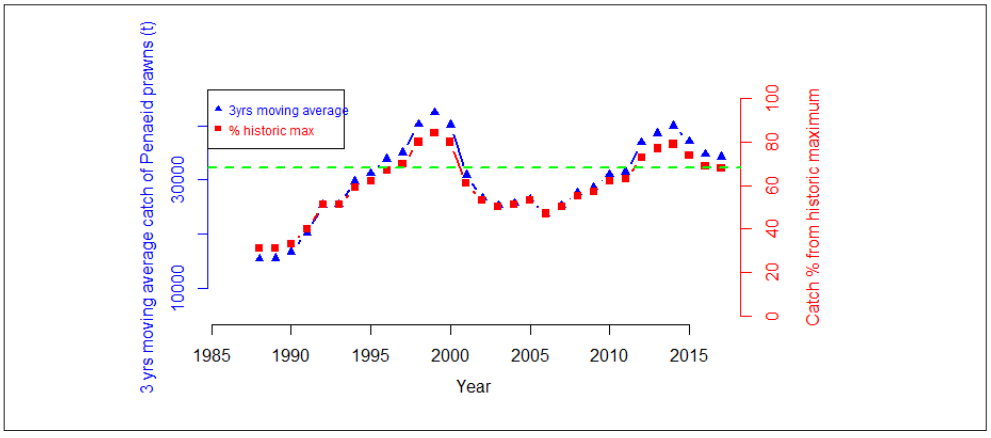

3 yrs moving average catch of Horsemackerel (t)
0
4000
8000
12000
3yrs moving average
% historic max
1985
1990
1995
2000
2005
2010
2015
Year
Catch % from historic maximum
0
20
40
60
80
100

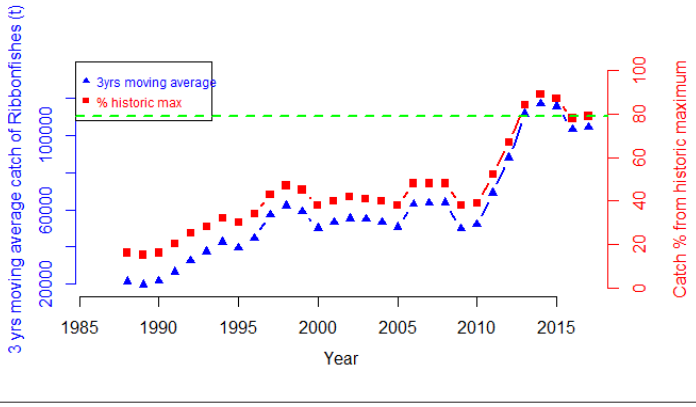

3 yrs moving average catch of Lizardfishes (t)
0
5000
15000
25000
3yrs moving average
% historic max
1985
1990
1995
2000
2005
2010
2015
Year
Catch % from historic maximum
0
20
40
60
80
100

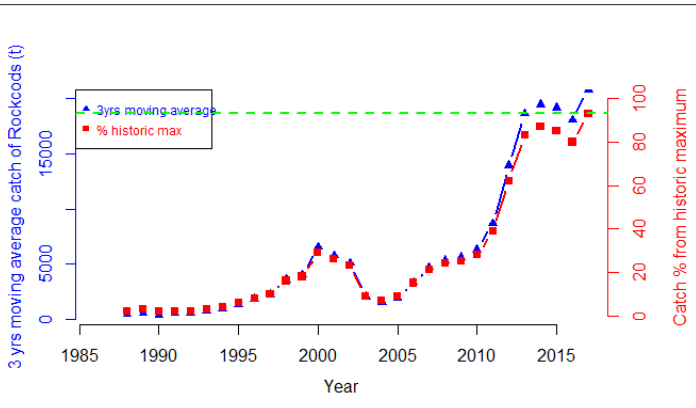

3 yrs moving average catch of Lobster (t)
0
500
1000
1500
3yrs moving averag
% historic max
1985
1990
1995
2000
2005
2010
2015
Year
Catch % from historic maximum
0
20
40
60
80
100

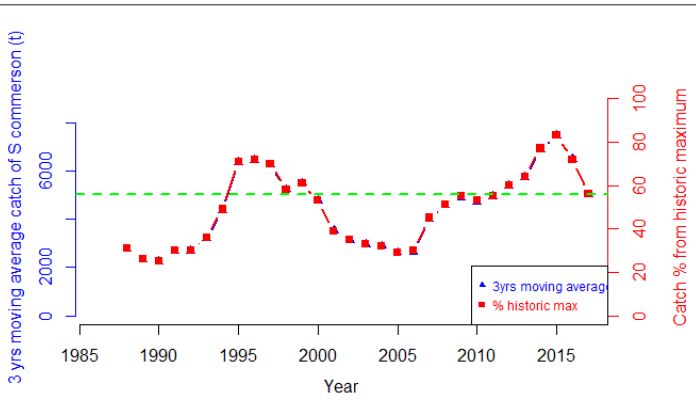

3 yrs moving average catch of Non-penaeid prawns (t)
0
50000
100000
150000
3yrs moving average
% historic max
1985
1990
1995
2000
2005
2010
2015
Year
0
20
40
60
80
100
Catch % from historic maximum

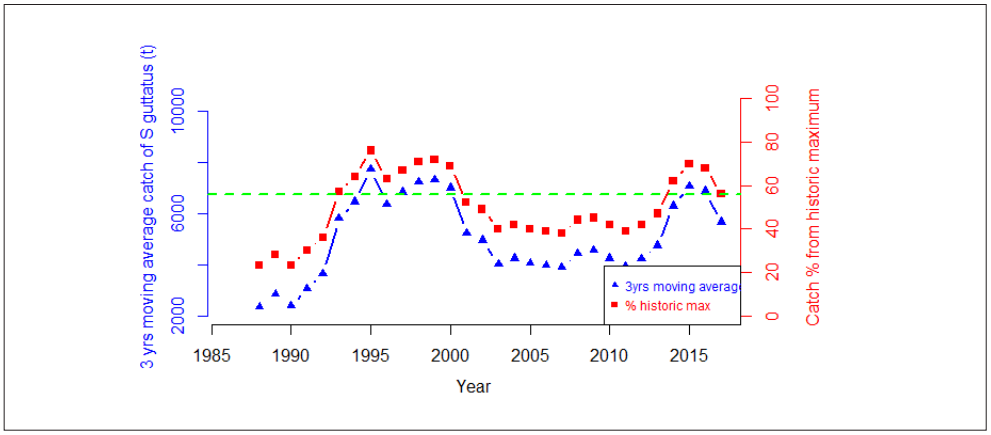

3 yrs moving average catch of Other perches (t)
0
10000
30000
3yrs moving average
% historic max
1985
1990
1995
2000
2005
2010
2015
Year
0
20
40
60
80
100
Catch % from historic maximum

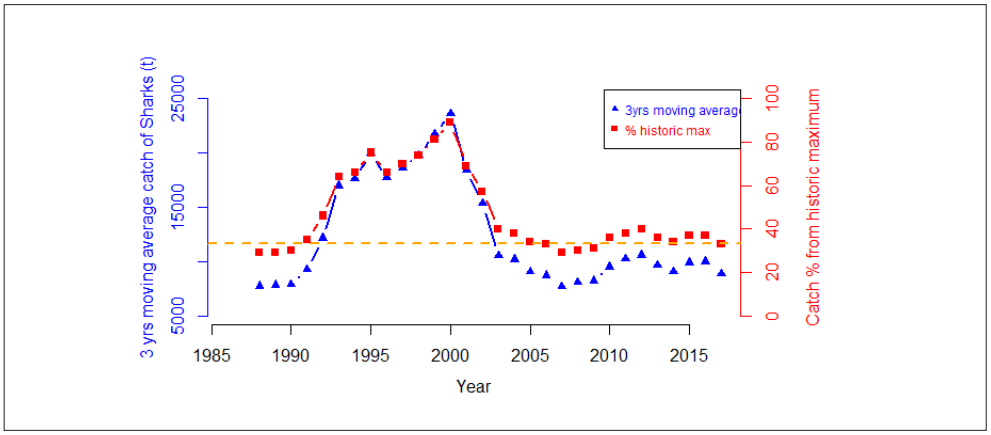

3 yrs moving average catch of Penaeid prawns (t)
10000
30000
3yrs moving average
% historic max
1985
1990
1995
2000
2005
2010
2015
Year
0
20
40
60
80
100
Catch % from historic maximum

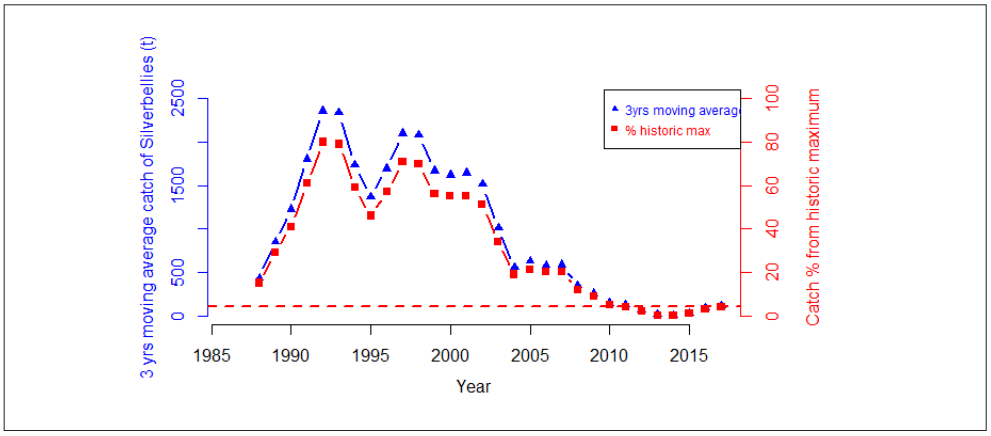

3 yrs moving average catch of Ribbonfishes (t)
20000
60000
100000
3yrs moving average
% historic max
0
20
40
60
80
100
Catch % from historic maximum
1985
1990
1995
2000
2005
2010
2015
Year

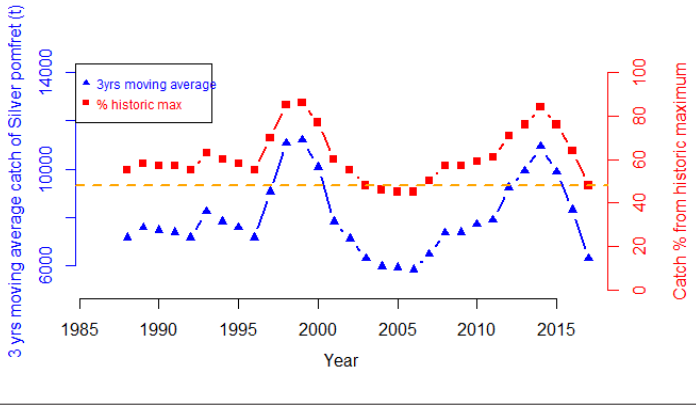

3 yrs moving average catch of Rockcods (t)
0
5000
15000
3yrs moving average
% historic max
0
20
40
60
80
100
Catch % from historic maximum
1985
1990
1995
2000
2005
2010
2015
Year

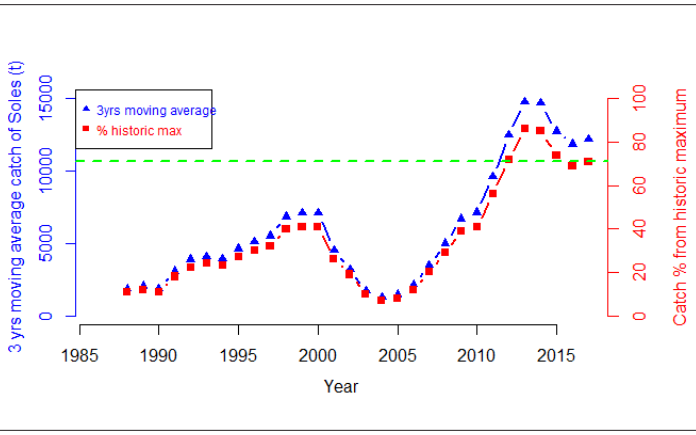

3 yrs moving average catch of S commerson (t)
0
2000
6000
3yrs moving average
% historic max
0
20
40
60
80
100
Catch % from historic maximum
1985
1990
1995
2000
2005
2010
2015
Year

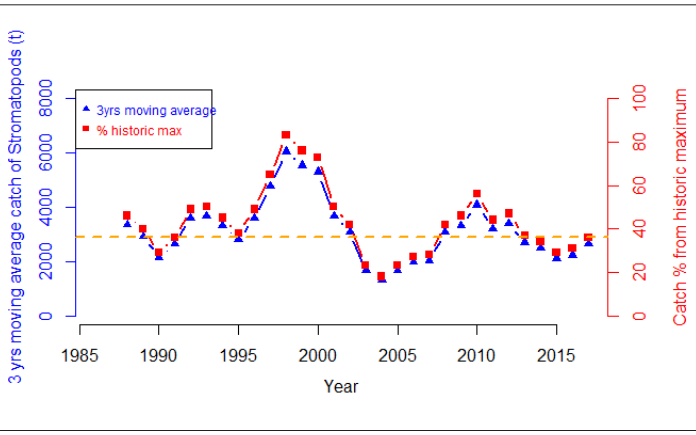

3 yrs moving average catch of S guttatus (t)
2000
6000
10000
1985
1990
1995
2000
2005
2010
2015
Year
0
20
40
60
80
100
Catch % from historic maximum
3yrs moving averag
% historic max

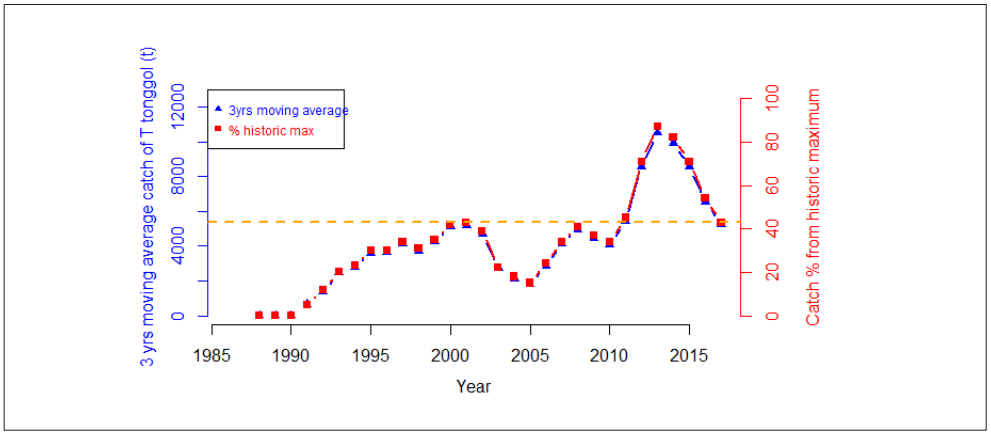

3 yrs moving average catch of Sharks (t)
5000
15000
25000
1985
1990
1995
2000
2005
2010
2015
Year
0
20
40
60
80
100
Catch % from historic maximum
3yrs moving averag
% historic max

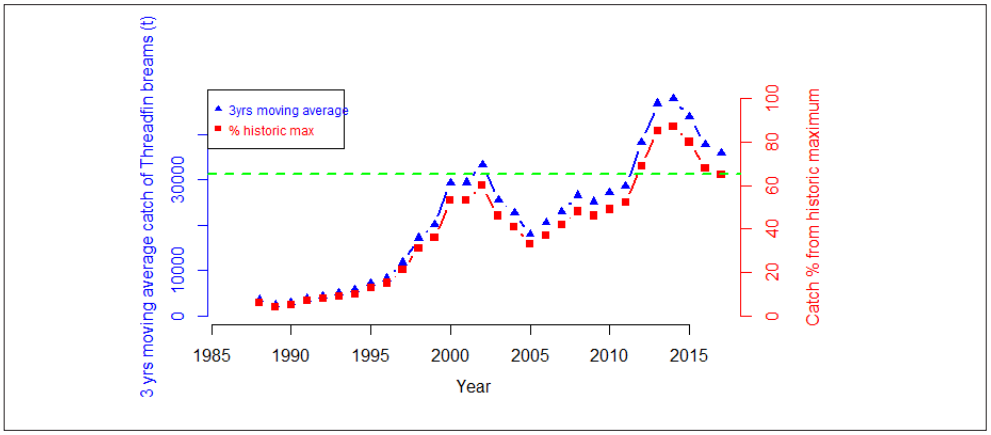

3 yrs moving average catch of Silverbellies (t)
0
500
1500
2500
1985
1990
1995
2000
2005
2010
2015
Year
0
20
40
60
80
100
Catch % from historic maximum
3yrs moving averag
% historic max

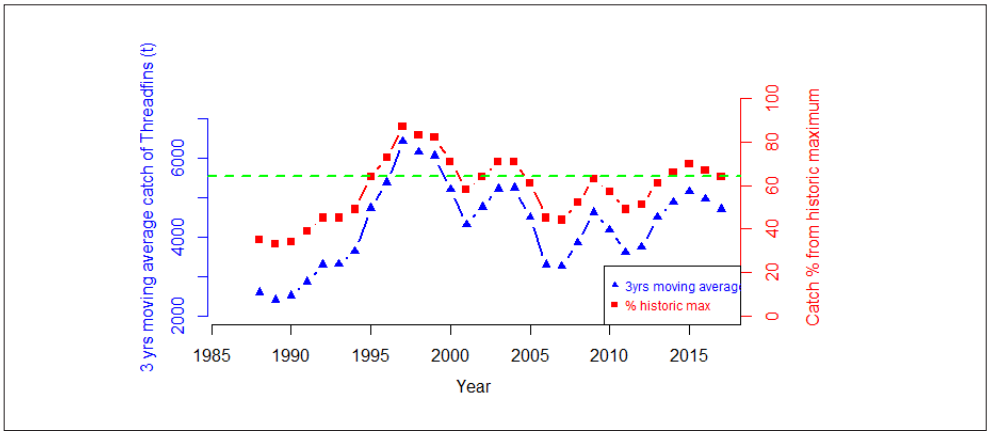

3 yrs moving average catch of Silver pomfret (t)
6000
10000
14000
3yrs moving average
% historic max
0
20
40
60
80
100
Catch % from historic maximum
1985
1990
1995
2000
2005
2010
2015
Year

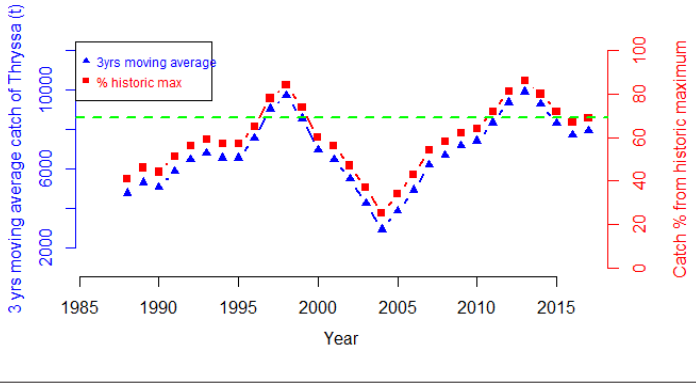

3 yrs moving average catch of Soles (t)
0
5000
10000
15000
3yrs moving average
% historic max
0
20
40
60
80
100
Catch % from historic maximum
1985
1990
1995
2000
2005
2010
2015
Year

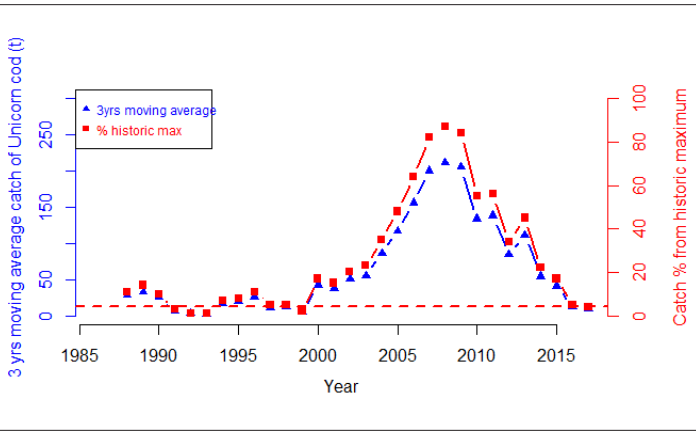

3 yrs moving average catch of Stromatopods (t)
0
2000
4000
6000
8000
3yrs moving average
% historic max
0
20
40
60
80
100
Catch % from historic maximum
1985
1990
1995
2000
2005
2010
2015
Year


3 yrs moving average catch of T tonggol (t)
0
4000
8000
12000
3yrs moving average
% historic max
1985
1990
1995
2000
2005
2010
2015
Year
Catch % from historic maximum
0
20
40
60
80
100


3 yrs moving average catch of Threadfin breams (t)
0
10000
30000
3yrs moving average
% historic max
1985
1990
1995
2000
2005
2010
2015
Year
Catch % from historic maximum
0
20
40
60
80
100


3 yrs moving average catch of Threadfins (t)
2000
4000
6000
3yrs moving averag
% historic max
1985
1990
1995
2000
2005
2010
2015
Year
Catch % from historic maximum
0
20
40
60
80
100

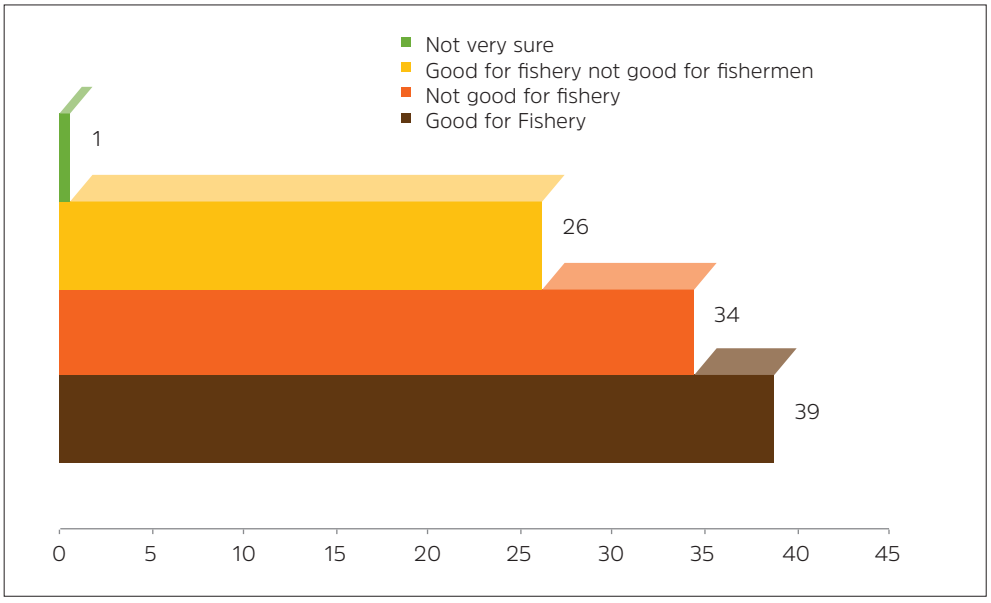

3 yrs moving average catch of Thryssa (t)
3yrs moving average
% historic max
2000
6000
10000
0
20
40
60
80
100
Catch % from historic maximum
1985
1990
1995
2000
2005
2010
2015
Year


3 yrs moving average catch of Unicorn cod (t)
3yrs moving average
% historic max
0
50
150
250
0
20
40
60
80
100
Catch % from historic maximum
1985
1990
1995
2000
2005
2010
2015
Year

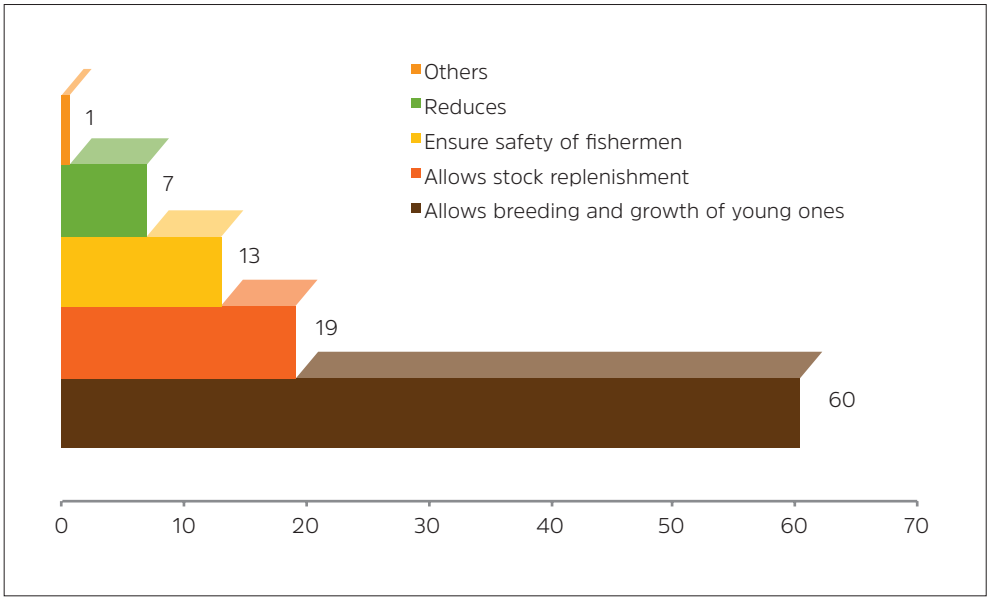
Annexure-3

Stakeholder feedback on Seasonal Fishing Ban Survey

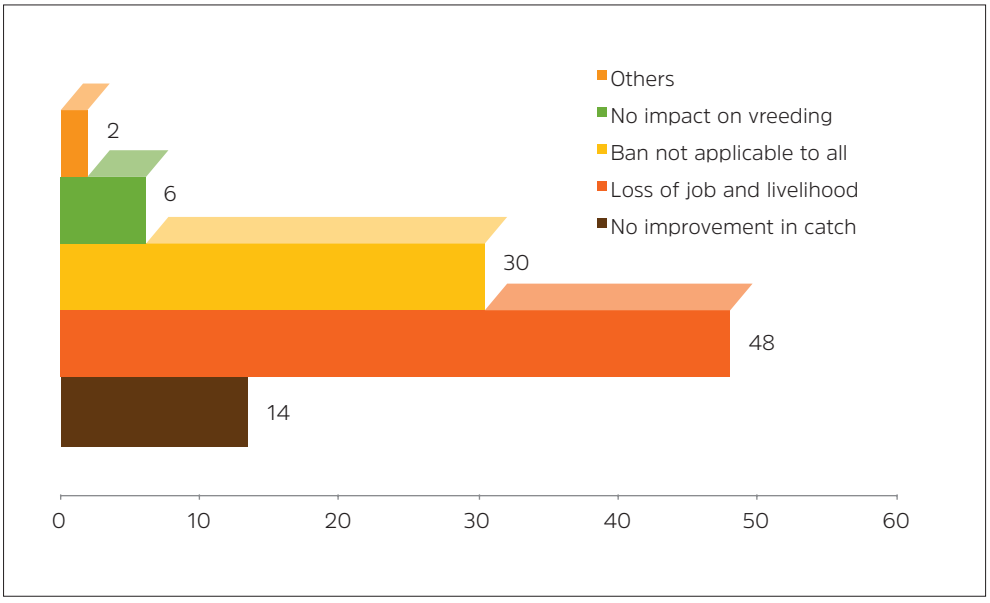
What is your opinion about the impact of the present seasonal fishing ban?



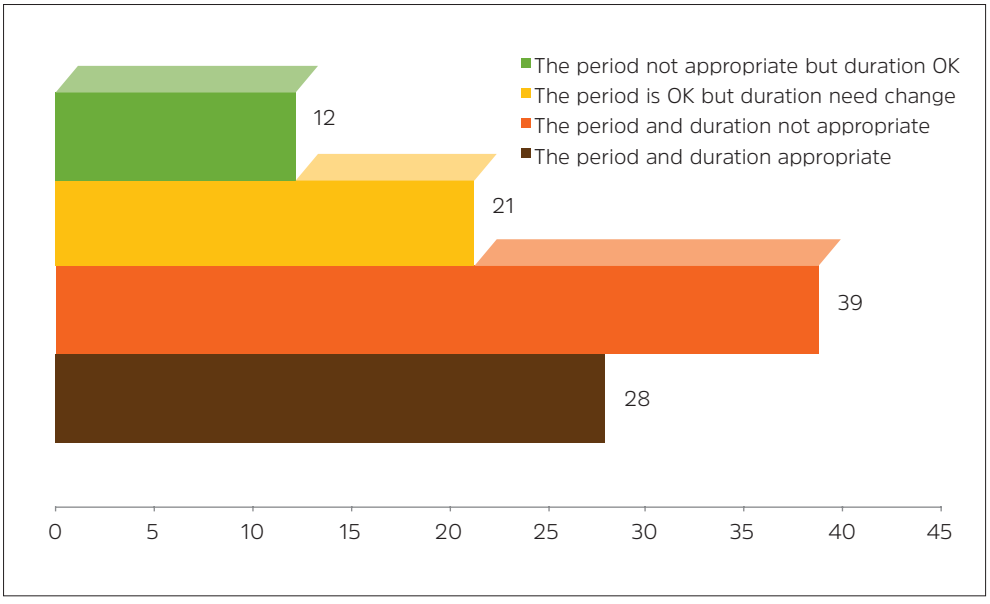
If good for fishery, what are the good impacts?



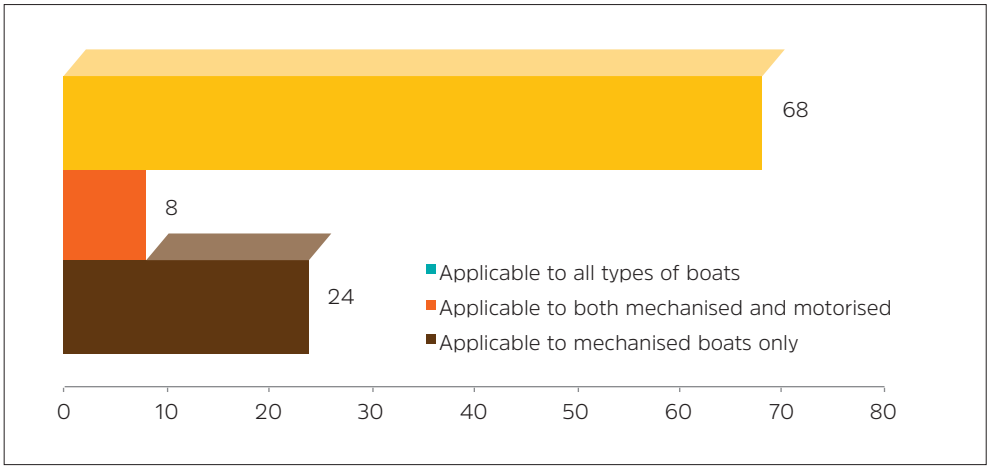
If bad for fishery, what are the adverse impacts?



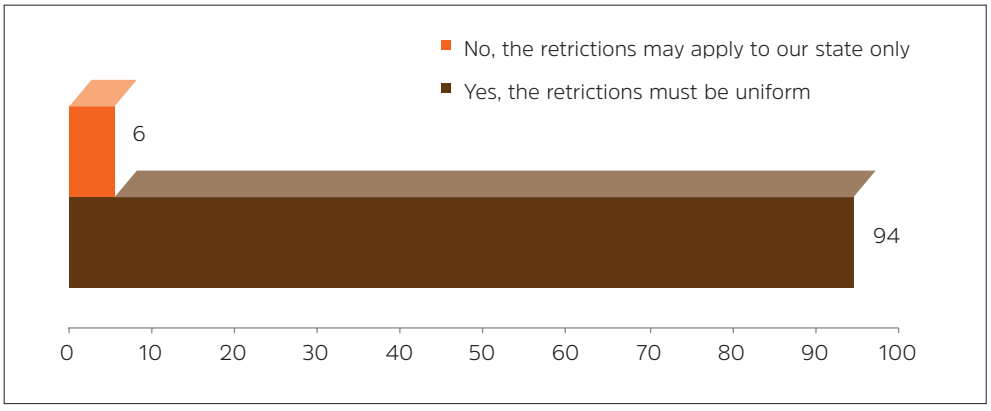
View about the period and duration of the present seasonal fishing ban?



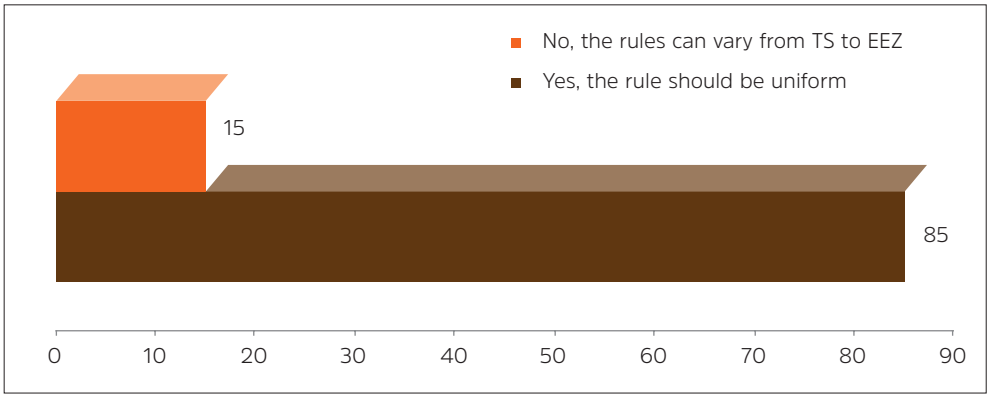
What should be the coverage of application of the ban?



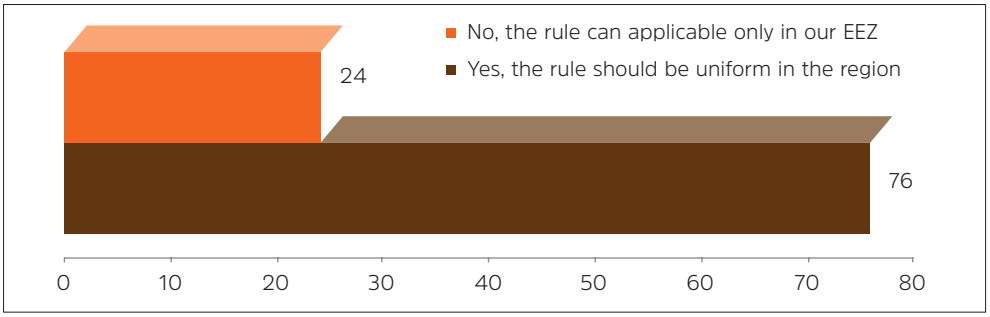
Should the same rule of application be followed by the neighboring state?



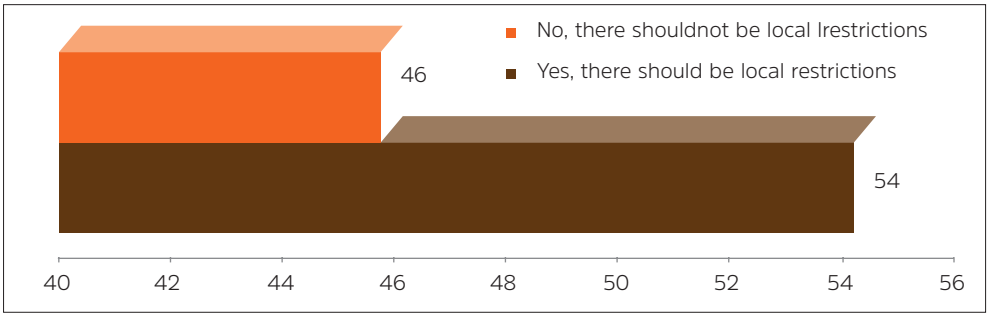
Should the ban be applicable to all the vessels operating beyond territorial waters?



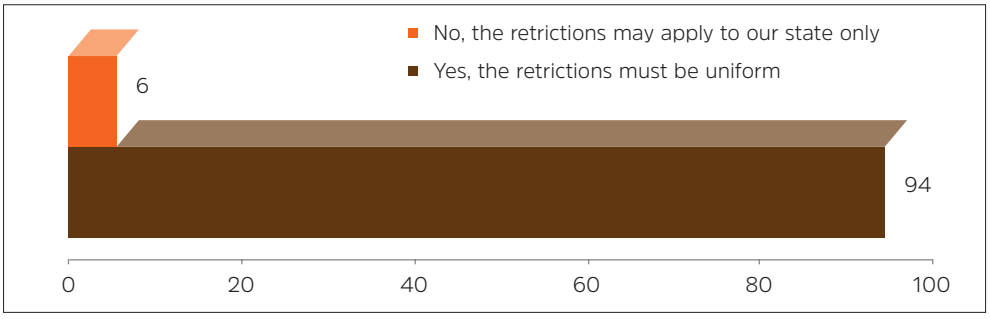
Should the rule applicable to neighboring country for effectiveness?



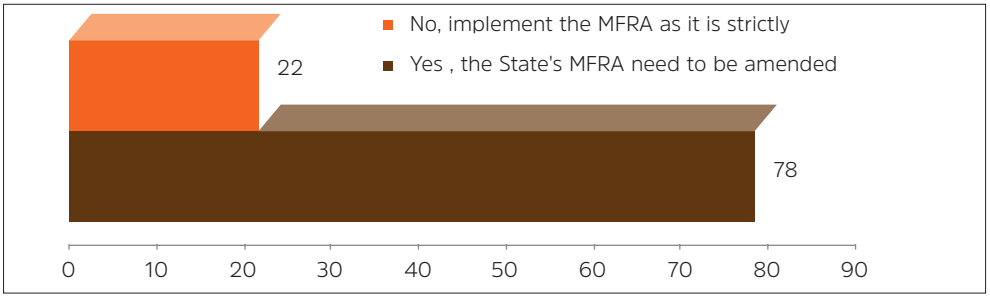
Is there any need for local, seasonal area/gear restrictions within your maritime state?



Should there be similar restrictions in the neighboring states?



Do you need to re-look into the MFRA and incorporate necessary changes?



Annexure-4

Stakeholder Consultation - 2017

The Veraval RC of ICAR-CMFRI conducted its annual stakeholder consultation on the Fishery Management Plan (FMP) project on 6th May 2017 at the Conference Hall of the Centre. Nearly 50 stakeholders comprising of fishers across the sub-sectors, exporters, domestic traders, NGO representatives, officials of the DoF, Gujarat, MPEDA, EIA, MPEDA-NETFISH, scientists of ICAR-CIFT, etc participated in the consultation. Mr N. R. Patel, Deputy Commissioner of fisheries, Gujarat, Mr Jagdish Fofandi, President of the Municipal Corporation and an exporter, R. A. Gupta, Deputy Director, MPEDA, Veraval, Dr Shivraman, Scientist-in-Charge, ICAR-CIFT, Veraval, etc., were the prominent participants other than the leaders of the fishermen's associations. The results of the projects were presented through power point presentations and the stakeholders were encouraged to raise their queries/concerns/suggestions. The stakeholders raised many queries/suggestions/concerns on the data collection, production figures, trend etc. Besides, elaborate discussions took place on the recommendations of the draft Policy Brief such as the Modernization of Token system; Mesh size regulation; Catch reporting; Fishing area limitation; Light fishing; Line trawling; Optimum fleet size; Regulation in EEZ; Sea safety measures; Monitoring, control and surveillance system; Vessel monitoring system; Value addition; Amendment in Gujarat Fisheries act 2003 etc.

Stakeholder Consultation–2018

The Annual stakeholder consultation meeting was conducted on Marine fish landings and the research achievements for the year 2018 and SWOT Analysis on for the Gujarat Marine Fisheries Policy Brief of the state held in the presence of fishermen, association leaders, seafood processors, administrators, scientific staff and various stakeholders of Veraval on 29/05/2018 in the Conference Hall of Veraval RC of CMFRI. Dr. Divu D., Scientist In-Charge of VRC of CMFRI welcomed all stakeholders for their participation in the meeting and urged their active participation during the interactions. He explained the purpose and agenda of the meeting, mainly on detailed presentation on data and technical discussions on draft policy of marine fisheries of India PI of the Gujarat Fisheries Management Project presented a detailed presentation on marine fish landings of Gujarat for the year 2017 and salient research

achievements by the centre during the same period. Fishermen expressed that the size of fishes is day by day decreasing, especially resources like ribbonfish, cuttlefish, pomfrets, groupers, scieanids, perches etc. Fishermen were opined on misconceptions on breeding season of the fishery resources and ban season along the region. They demand prolong ban season (3-4 months) to be implemented along the state. For the development and maturity of fishes, a ban is imperative. The CMFRI studies on breeding season of the most resources were during winter monsoon, which was in agreement with the fisher group. Some of the stakeholder explained that in most of the foreign countries targeted fishing is prevailing with a specific mesh size to avoid immature fishes in the catch. In the previous year 2016, the fishermen voluntarily stop fishing 2 months before the ban season, which may lead to ample catches the next year 2017.

Fishermen were raised poor quality issues of the catches and low prices. The Scientists, ICAR-CIFT, EIA and MPEDA were addressed the technical issues, research gaps and measures to improve the value chain in Gujarat. Seafood processors complained of the shortage of raw materials to feed the 120 plus seafood processing plants. They suggested that the government should have leasing policy to promote the brakishwater aquaculture with preference given to fishermen to promote production and reduce fishing pressure on resources. The scientists presented that the number of fishing crafts in the sector is increasing periodically, which may hamper the sustainable status of the exploited stocks and suggested to have an optimum fishing fleet. But the fishermen explained government should have alternate livelihood and economic policies to support the fishermen. We have presented the output of Minimum Legal Sizes (MLS) for the 45 commercially exploited resources, and then fishermen don't want to comply with MLS management measures due to the non-selectivity (trawling) in the fishing method which is out of their control. Instead MLS fishermen suggested to have extended ban season and declare spatial closured for fishing. Fishermen are aware of the seriousness of the juvenile fishing happening along the state, but don't want to comply with MLS measures. After the presentation we have conducted SWOT Analysis exercise for the marine fisheries of Gujarat to get strengths, weaknesses, opportunities and threats in the sector. Followed a prioritization of SWOT based on ranking and weightage. Based on the status of SWOT, we are planning to have Strategic Plans (SPs) and Research Projects (RPs) to deal the weaknesses and threats in the sector.

Acknowledgement

This policy document, with advisories to sustainably manage the marine fishery wealth of Gujarat, is the result of the research work carried out by the scientists at the Veraval Research Centre of ICAR-CMFRI.

The authors sincerely acknowledge Director, ICAR-Central Marine Fisheries Research Institute for the constant encouragement, support and motivation provided throughout the preparation of the document. The research carried out by the earlier scientists of the Research Centre forms the foundation of this document and their valuable inputs are sincerely appreciated and thankfully acknowledged. We especially thank Dr. Sunil Kumar Mohamed, HoD, MFD and Dr. T. V. Sathianandan HoD, FRAD, Dr. Dineshbabu A. P., Principal Scientist, Dr. Grinson George and Dr. Muktha Menon, ICAR-CMFRI for their constructive remarks, guidance and technical contribution.

The excellent inputs, suggestions, critical comments provided by managers, department officials and policymakers of this region are gratefully acknowledged. The fishermen, fisherwomen, boat owners, union and society leaders and representatives from the post-harvest sectors actively participated in the stakeholder meetings and discussed the fishery pattern, existing problems and practical solutions to manage the fishery of this region. We sincerely place on record their appreciation for all the valuable information, fruitful discussion and timely inputs.

The critical comments and suggestions made by Heads of the Departments, ICAR-CMFRI have enriched the content and presentation of this document. The authors are grateful for all invaluable inputs provided by the Policy Cell of CMFRI, which has resulted in the compilation of this document.

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Notes

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