

# **Post Graduate Diploma in Agricultural Extension Management (PGDAEM)**

**AEM 205 C**

**Sustainable Fisheries Development**  
*(3 Credits)*

**Block IV**

**Sustainable Marine Fisheries Development**



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## Unit 1

# Marine Fisheries Development in India

## Structure

- 1.0 Objectives
- 1.1 Introduction
- 1.2 Phases of fishery development
- 1.3 Objectives of fisheries development
- 1.4 Time line of fisheries development in India
- 1.5 Status of Marine Fisheries of India
- 1.6 Major issues in the marine fisheries sector
- 1.7 Sustainable development of Indian marine fisheries
- 1.8 Future strategies for Indian marine fisheries development
- 1.9 Let us sum up
- 1.10 Key words
- 1.11 Further Readings
- 1.12 Check your Progress (Questions and Answers/Hints)

## 1.0 Objectives

**After reading this unit, you should be in a position to**

- Define fisheries development and its objectives
- Understand developments in marine fish harvesting and processing sector
- Know fisheries development in India under different Plan periods
- Understand role of various agencies/organizations in fisheries development
- Understand the impacts of climate change and sustainability concerns on marine fisheries
- Understand the prospects for future development of marine fisheries

## 1.1 Introduction

Fisheries development concerns the processes leading to the progress in harvesting, processing, marketing and utilizing the yields from the natural resources of aquatic animals and plants for the benefit of the people and the country. Fishing has been one of the oldest methods of gathering food adopted by people living close to seas / rivers and was a small scale, sustenance level community based activity. Fisheries development has progressed considerably since World War II and the estimates of world marine capture fisheries production was 84.2

million metric tons in the year 2005 (FAO, 2006). While in the past, fisheries resources far exceeded the human capacity to exploit them, since the last two decades, technological changes have paved the way for a situation where increasing annual catches of fish is no longer a simple matter of increasing fishing effort. The rate of increase in fish production is increasingly becoming difficult to maintain as a consequence of many of the stocks having reached or even exceeded their limits of sustainable exploitation. Fish is a significant contributor to the livelihood, nutritional, trade and economic security of countries and hence concerns are being voiced about the rational development and management of fisheries where new terminologies like "sustainable development" and "responsible fishing" are currently being widely used.

## 1.2 Phases of Fisheries Development

Fisheries Development is influenced by a variety of factors such as the economic status of the country and the relevance of fisheries to the people by way of availability of fish as well as socio-political reasons. Broadly speaking, the following four development phases have been recognized for the fisheries sector:

- An **initial phase** of slow development characterized by the absence of any major fisheries or only a traditional fishery
- A **steady phase** with significant increase in catch rate and production
- An **over-development phase** characterized by declining catches and catch rates
- **Management phase** arising out of the above developments and aimed at regulating fishing and arresting the decline.

## 1.3 Objectives of Fisheries Development

- Increase export of fish and fish products
- Increase supply of fish to domestic market
- Increase level of fishermen's income
- Provide new employment opportunities in the fisheries sector
- Sustain the fishery

## **1.4 Time Line of Fisheries Development in India**

The development programmes for Indian fisheries have always aimed at increasing fish production and nutritional security, creating employment opportunities, improving welfare of fishermen and promoting exports. The first step for developing fisheries in India was mainly in response to the famine of 1898 where an immense need for cheap protein rich food was felt. The Royal Commission on Agriculture (1928) noted that nothing was being done to develop the country's fishing industry and recommended various actions to be taken to develop Indian fisheries sector. Grow More Food Campaign launched in 1940 recommended an organized thrust for development of fisheries. This resulted in a number of detailed studies on fisheries of British India besides commission of a separate department of fisheries in many provinces and also the provision of some assistance to the fish curing industry. Despite this, the full potential for growth was never realized. A Fisheries Experimental station was set up at Barrackpore, West Bengal, which later became the Central Inland Fisheries Research Institute (CIFRI). Training centers on fisheries were established in Barrackpore, Calcutta and Mandapam in 1945. Central Marine Fisheries Research Institute (CMFRI) was established in 1947 and since then it is carrying out pioneering research and development work in the field of marine capture fisheries with the objective of ensuring sustainability of fisheries resources and their ecosystem as well as livelihood security of the coastal fisher-folk.

The first All-India Fisheries Conference (1948) convened in New Delhi recognized the importance of fishing industry and focused its attention on the need to develop fisheries industry. On these lines, it was decided to seek foreign co-operation to create necessary infrastructure for modernizing the fisheries sector. Thus in 1952, a tripartite agreement was signed by the Governments of Norway, India and the United Nations, with the objective of mechanizing the Indian fisheries sector and popularizing diversified methods of fishing such as trawling, purse seining and pole-and-line fishing. This resulted in the Indo-Norwegian Project (INP), which was set up at Quilon (Kerala state) in 1953 where the process of modernization/mechanization of marine fisheries was initiated. In the fifties, small-mechanized boats with bottom trawl nets were introduced. The establishment of Central Institute of Fisheries Technology (CIFT) during 1957, gave a foundation for research in the aspects of design of various fishing crafts, gears, fishing techniques, methods of handling and post-harvest processing and utilization. Since 1963, the activities of INP were directed to exploratory and experimental fishing while CIFT took up research work on designing of new craft types. The development of fishing harbours also played a key role in marine fisheries development of India, starting from 1954 when the Government of

India solicited the services of Technical specialists in FAO to locate best possible sites for fishing harbours in the country. Since 1965 the Port Trust Authorities have played a key role in implementing fishing harbour projects. Currently there are about 2251 traditional landing centers, 33 minor and six major fishing harbours. These serve as base for 104,270 traditional non-motorized craft, 75,591 small scale beach landing, motorized craft, 58,911 mechanized craft (mainly bottom trawlers, drift gill-netters and purse seiners) and 120 deep sea fishing vessels of >20 m OAL. Thus the development of harbours and landing jetties, motorization of artisanal crafts and rapid expansion of mechanized fishing have contributed towards a significant increase in fish production, employment generation and revenue earnings.

#### ***1.4.1. Developments in craft and gear /fishing technologies***

Timber such as teak (*Tectona grandis*) and jungle jack (*Artocarpus hirsuta*) were the most common materials used in vessel construction until the 60s. Non-availability of quality timbers at reasonable price, difficulties in maintenance of wooden crafts and government policy of forest conservation spurred studies by CIFT and the Bay of Bengal Programme (BOBP) on alternative materials for vessel construction such as plywood and Fibreglass Reinforced Plastic (FRP) which have emerged as viable alternatives and contributed to development of the sector. Adoption of fisheries technologies developed by CIFT such as synthetic fibre fishing gears, development of different gears like four-seam trawl and bulged-belly trawl which could increase the catching efficiency by about 30%, methods such as stern trawling, out-rigger trawling, mid-water trawling purse-seining, long lining and introduction of specialized gill nets for lobster fishing have played a significant role in the fisheries development in India. Fish detection gadgets introduced in large boats with facilities for proper gear handling for enhancing their efficiencies have also added a new dimension for enhancing the catch per unit effort of specific gear and craft. Multi-day fishing rather than daily fishing; mother ship and carrier boat operations wherever practical, are the fuel saving practices that are being implemented in fleet operations along the Indian coasts today. Recent advances in technology have also provided fishermen with equipment such as Global Positioning System (GPS) to reach the potential fishing grounds accurately; detect the presence of fish and monitor the success of capture process acoustically (echo sounder, sonar, gear monitoring systems) thereby minimizing the search time and fishing time and hence saving energy. Information on Potential Fishing Zones (PFZ) based on inputs from National Remote Sensing Agency (NRSA) for sea surface temperature (received from NOAA satellite AVHRR imageries) and ocean colour (from OCEANSAT) are being provided to fishermen by State Fisheries Departments in collaboration with research organizations like Indian National Centre for Ocean Information Services (INCOIS), CMFRI and CIFT. Fish Aggregating Devices

(FAD) which have shown the potential for saving fuel and scouting time, in purse seining, hand lining, pole and line and gillnetting in different parts of the world are also becoming increasingly popular among artisanal fishermen as a way of getting better catches and saving fishing time in the face of increased competition from mechanized craft which are operating in the same fishing ground in inshore waters.

#### **1.4.2. Developments in fish processing technologies and seafood exports**

The seafood export in 1961-62 which was a meager 15,732 metric tons (MT) valued at 3.92 crore Rupees has increased progressively over the decades to reach 612,641 MT in 2006-07 valued over 8000 crore Rupees (Table 1.1). In the last decade, the seafood export doubled, both in value and quantity, and India's share today in the global seafood market is 2.45%. The shrimps and prawns lead with an export earning of 63% of the total trade, while finfish is the second largest commodity with 11% of the total earnings and the rest is from more than 50 minor commodities.

Table 1.1. Growth of seafood exports of India

Year	Quantity (MT)	Value (Rs.Crore)	Decadal Growth rate %	
			Quantity	Value
1961-62	15732	3.92		
1971-72	35883	35	13.3	30.4
1981-82	75591	235	7.2	19.7
1990-91	139419	893.4	10.3	17.2
2000-01	440473	6443.89	8.38	14.6
2006-07	612641	8363.5		

Regarding the quality and safety of seafood which is crucial to fisheries development, the Government of India enacted the Export (Quality Control and Inspection) Act, 1963 for sound development of export trade through quality control and pre-shipment inspection. Under section 3 of the Act, Export Inspection Councils (EIC) was set up to advise the Central Government regarding measures for the enforcement of quality control and inspection in relation to commodities intended for export. Today EIC is the sole government approved certifying authority for exports of fish and fishery products from India and plays a key role in ensuring safety and quality. With globalization, standards for seafood exports require traceability at all stages of production, processing, and distribution so that targeted and accurate withdrawal of the product can be done in the event of any food safety problems. Recently, CIFT has been recognized as the



National Referral Laboratory for quality control for seafood and conducts tests for residues of antibiotics, pesticides and heavy metals in seafood. A large number of seafood-processing factories have already implemented Hazard Analysis and Critical Control Point (HACCP) in their process-line according to the standards of European Union and USA. Consequently the European Union (EU) has emerged as the top market for Indian seafoods followed by USA, Japan and China. In addition, a variety of value added and diversified fish products both for export and internal markets viz., shrimp, lobster, tunas, squids, cuttle fish, bivalves, farmed fish and minced meat from low priced fish have been developed by CIFT.

#### ***1.4.3. Role of Research and Development and financial agencies in fisheries development***

Several international organizations including World Bank, United Nations Development Programme (UNDP), Danish International Development Agency (DANIDA), and Norwegian Agency for Development and Co-operation (NORAD), Overseas Development Agency (ODA, UK and Japan) provide aid to India for development of fisheries sector. Research and Development activities for the fisheries sector is critical for fisheries development and the Food and Agriculture Organization (FAO) has played a key role especially with regard to programs in fisheries resource assessments, reduction of post-harvest losses and developing quality controls in seafood processing sector of India.

In the credit and financial sector, support to fisheries development has largely come from Microfinance initiatives of National Bank for Agriculture and Rural Development (NABARD) through their support of Self-Help groups which have proved effective in combating poverty and empowering the coastal poor both economically and socially. Activities usually undertaken by SHGs in the marine fisheries sector of India are dry fish trade, fish marketing, mussel/oyster/fish farming, crab fattening, ornamental fish breeding and marketing and preparation of fish pickles.

#### ***1.4.4. Fisheries Development under different Plan Periods***

Fisheries development was realized through programmes for the development of marine fisheries under the different Five Year Plans (Table 1.2) such as

- (1) Intensive fisheries resource surveys in the Indian EEZ and resource assessment
- 2) Optimum exploitation of marine resources using a judicious mix of traditional country boats, mechanized boats and deep sea fishing vessels
- 3) Adequate landing /berthing facilities by construction of major and minor fishing harbours

- 4) Intensifying development in processing, storage and transportation sectors
- 5) Improving marketing of fish/fishery products through co-operative sector
- 6) Tapping the vast potential for export of marine products.

Table 1.2. Development thrusts in the marine fisheries sector by GOI through the Plan periods

<b>Plan period</b>	<b>Duration</b>	<b>Major developments</b>	<b>Average annual catch (t)</b>
I Five Year Plan	1951 to 1955	1. Mechanization of indigenous artisanal fishing craft 2. Introduction of mechanized fishing vessels 3. Introduction of modern gear materials 4. Infrastructure for preservation, processing, storage and transportation	565412
II Five Year Plan	1956 to 1960		730699
III Five Year Plan	1961 to 1965	1. Substantial increase in the use of synthetic gear materials 2. Export trade development	730061
Three annual plans	1966 to 1968		904355
IV Five Year Plan	1969 to 1973	1. Imports of trawlers for deep-sea fishing 2. Indigenous construction of deep-sea trawlers 3. Fishing harbours at major & minor ports 4. Intensification of exploratory fishery surveys 5. Expansion of export trade	1070264
V Five Year Plan	1974 to 1978	1. Diversification of fishing, introduction of Purse seining 2. Declaration of EEZ in 1976	1326408
One Annual Plan	1979	1. Diversification of fishery products 2. Motorization of artisanal craft	1365739
VI Five Year Plan	1980 to 1984	1. Exploratory surveys in offshore grounds 2. MZI Act 1981 for regulation of foreign fishing vessels 3. Deep sea fishing through licensing, chartering and joint venture vessels	1434914
VII Five Year Plan	1985 to 1989	1. New chartering policy of 1989 2. Developing of deep-sea fishing	1769040
Two Annual Plans	1990 to 1991	3. Substantial growth in motorized artisanal fleet of ringseiners on west coast 4. Introduction of Beach landing crafts on east coast 5. Coastal shrimp aquaculture	2182412
VIII Five Year Plan	1992 to 1996	1. Deep-sea fishing by joint venture 2. Development of coastal aquaculture 3. Substantial growth in motorized artisanal fleet of ringseiners 4. Export trade changes from a resource-based to food engineering-based industry	2295889
IX Five Year	1997-	1. Stay-over fishing	2532436

Plan	2002	2. Growth of motorized sector 3. Resource specific fishing by trawlers and drift gill nets 4. Popularization of bivalve farming 5. Export of fin-fishes including oceanic tunas 6. Installation of Artificial Reefs/FADs	
X Five Year Plan	2002-2007	1. Development of domestic fish marketing network 2. Development of oceanic fisheries and deep-sea resources like shrimps and lobsters 3. Conversion of idling shrimp trawling fleet to tuna long lining 4. Promotion of mariculture and cage culture 5. Sea ranching	2603795
XI Five Year Plan (thrust areas identified)	2007-2012	1. Sustaining the fisheries resources through Management Plans 2. Development of domestic fish marketing network 3. Development of oceanic fisheries (tunas, cephalopods) and exploitation of deep-sea resources (mesopelagics) 4. Promoting mariculture and cage culture 5. Sea ranching 6. Applied Biotechnology (selective breeding, disease control) 7. Bioprospecting of marine organisms	

## 1.5 Status of Marine Fisheries of India

Marine fisheries play a significant role in the socio-economic development of India, contributing to food/nutritional security and employment opportunities besides being a source of livelihood to many marginalized poor coastal folk. Prior to and immediately after independence, the marine fishing activity was mainly close to the shore and at subsistence levels only with indigenous crafts employing traditional gears such as cast nets, small seines and traps. During 2003-04, the number of people whose major occupation in marine fishing was 1.22 million, in fishery related activities 1.5 million and in the tertiary sector (marketing) about 0.1 million. Today, India is one among the top ten fish producing countries in the world and in 2005-06 contributing over 4% (6.57 million t) of the total world fish production (142 million t). The fisheries sector in India contributes 1.4% of the total national gross domestic product (GDP) and 4.5% of agricultural GDP besides providing employment and income to over 5 million fishers and fish farmers. The marine fisheries sector in the country contributes about 50% of the total fish production. The share of Indian sea foods in the world market has shown an increasing trend over the years since its inception in 1950s with a 21% increase during the 2000-2005 Seafood exports during 2006 -07 were 612,641 metric t worth Rupees 8363.5 crore.

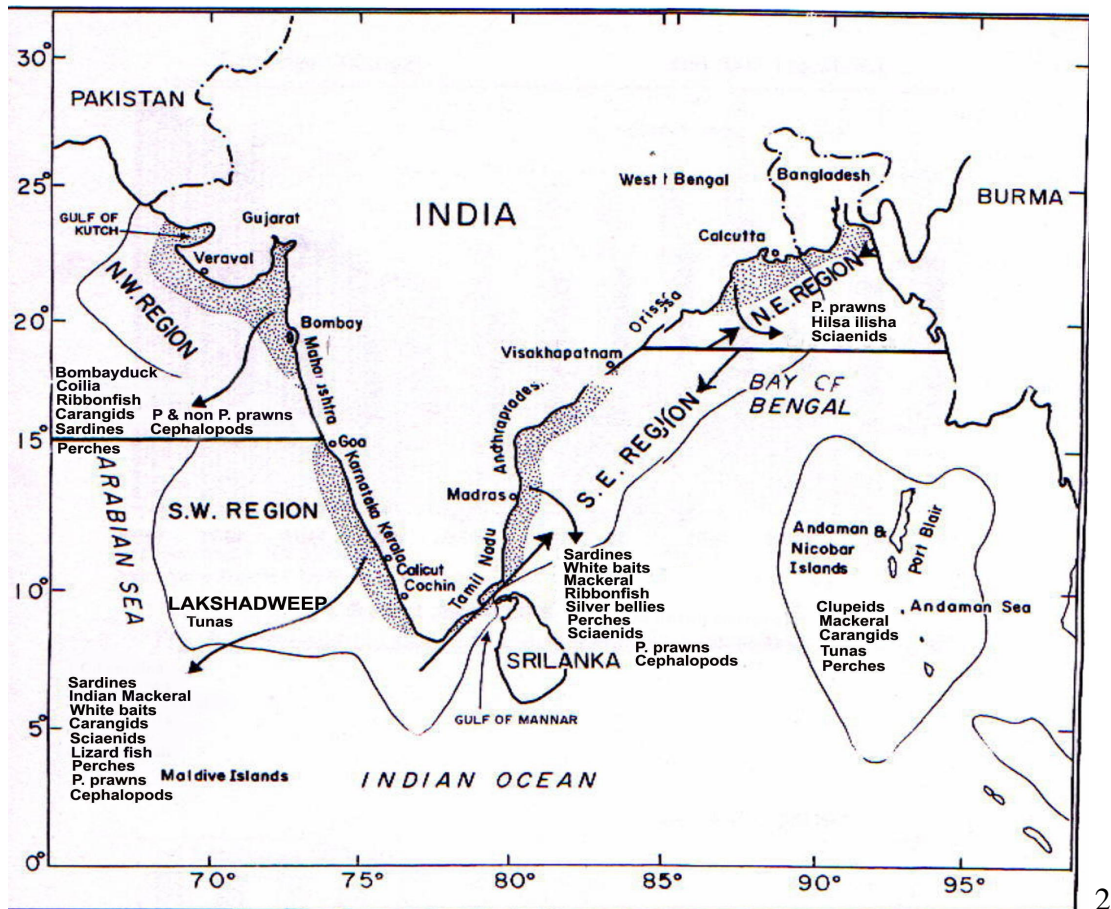
### 1.5.1. Resources

The Indian EEZ (declared in 1976) with a 200 nautical mile boundary has a total area of 2.02 million square km. The availability and distribution pattern of marine fishery resources in the Indian EEZ are typical of tropical waters with a large variety of species (nearly 1570 species of Fin fishes and about 1000 species of shell fishes) coexisting in the same ground (Fig.1.1). Of this, over 200 are commercially important and include the pelagic groups such as sardines, anchovies, mackerel, carangids, Bombay duck, ribbon fishes, seer fishes, tunas; demersal finfish groups like the sharks, rays, croakers (sciaenids), perches, silverbellies, lizardfishes, catfish; crustaceans including the penaeid and non-penaeid shrimps, crabs and lobsters; and cephalopods consisting of squids and cuttlefishes.

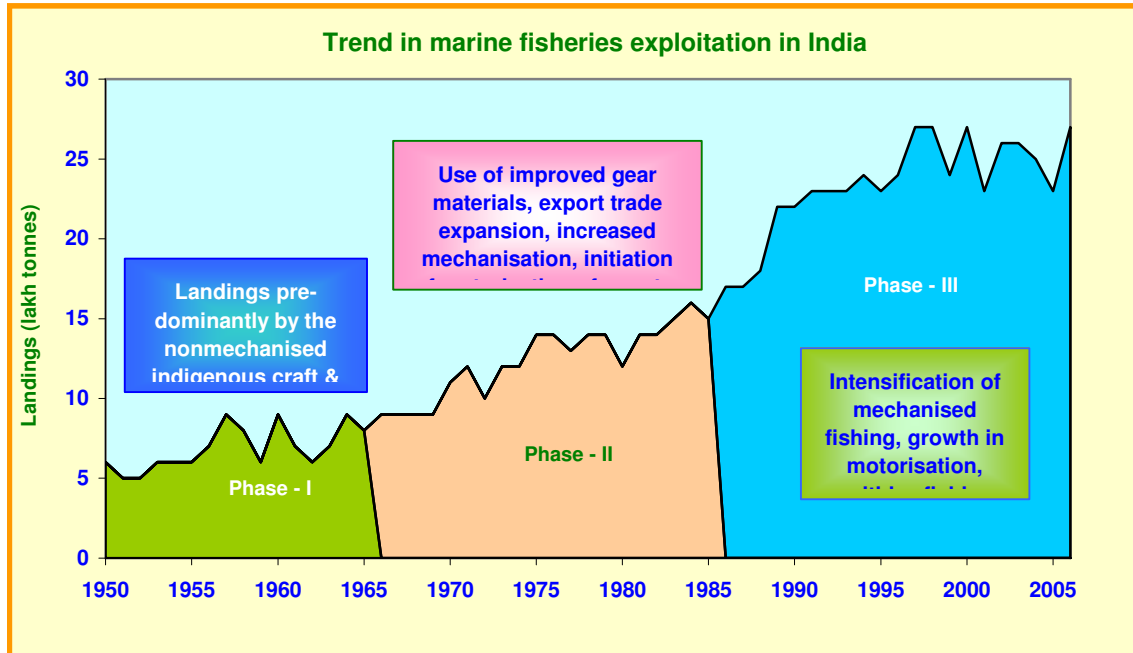
Fig.1.1. Indian EEZ showing distribution of marine fishery resources ???

### 1.5.2. Trend of marine fish production

The marine fish production in the country progressively increased from 0.58 million tons (mt) in 1950 to 2.73 mt in 1997 showing an average annual growth rate of 6.4% over a period of 4 decades (Fig.1.2). The annual marine fish production of India in 2007 was a record 2.88 million t. The intra-annual fluctuations in the marine fish production of the country by and large depend on the success or failure of oil sardine, mackerel, Bombay duck and shrimp fisheries. The



annual catchable potential yield in the Indian EEZ has been estimated to be 3.93 million tones (mt) primarily consisting of demersal (2.02 mt), pelagic (1.67 mt) and oceanic (0.24 mt) resources. The present annual average production of about 2.55 mt forms 64.8% of this revalidated fishery potential.



**Fig.1.2. Trend of marine fish landings in India**



Fig.1.3. Harvesting implications in the Indian marine fisheries sector (No citation in the text)

**1.5.3. Means of exploitation**

Among the different gears, drift and set gillnets and bag nets of varied mesh sizes are widely used along both the coasts while ring-seines, purse-seines and mechanized gillnets are confined to the southwest coast. Trawlers upto 11 m OAL are operated along the entire coast, while the second-generation large trawlers (13-17m) are operated from selected harbours along both the east and west coasts. Pole and line fishing is carried out exclusively in the Lakshadweep seas. There are many fishing craft and gear combinations under each category (mechanized, motorized, artisanal) of fishery (Table 1.3). These multi-gear, multi-species types of interactive and competitive fisheries is one of the main causes for the considerable disparity in income distribution among fishermen communities leading to inter sectoral and intra sectoral conflicts and management problems.

Table 1.3. Specifications of various fishing crafts in India

Craft	Length (m)	Engine power (hp)
<b>Mechanised</b>		
Trawlers	9-20	85-150
Gillnetters	7-14	80-100
Purseseiners	11-15	100-120
Dolnetters	10-15	80-100
Ringseiners	10-20	85-120
Pole & liners	10-12	100
<b>Motorised (with &gt; one outboard motors)</b>		
Plank-built canoes	8-22	35-120
Plywood boats	10-17	40-65
<b>Motorised (with one outboard motor)</b>		
Catamaran	5-7	2-5
Dugout canoes	5-7	2-10
Plank-built canoes	5-12	2-25
Plank-built boats	7-9	8-15
Plank transom canoes	7-9	8-15
Plywood boats	9-12	8-15
<b>Non-motorised</b>		
Catamaran	5-7	-
Dugout canoes	5-7	-
Plank-bulit canoes	5-12	-

#### 1.5.4 Sector wise production

The mechanized sector accounts for 69% (including deep sea sector), motorized sector 26% and artisanal sector 5% of the total production. In the mechanized sector landings increased from about 1.8 lakh tons in 1969 to 17.9 lakh tons in the year 2000 with its contribution to the total landings increasing from 20% (1969) to 67% (2000). The amount of time expended for actual fishing by this sector has almost doubled during the last 15 years rising from about 17.4 million hours during 1986 to 33.5 million hours during the year 2000 mainly due to the introduction and increase in voyage fishing activity in all the maritime states of India. The landings by the motorized sector have increased from about 1.8 lakh tons in 1986 to 6.6 lakh tons in the year 2000. In this sector there has been an increase in the unit operations and also in the fishing hours from about 3.3 million hours in 1986 to about 23 million hours during the year 2000. Consequent on the growth in these sectors, the purely artisanal sector has gradually been marginalized over the years. The average annual growth of the different sectors during the five-year periods from 1986 is summarized below (Tables 1.4,1.5 and 1.6. ).

**Table 1.4.** Average annual landings (lakh tons) and growth rate (%) during the five year periods

YEAR	Mechanized	Motorized	Artisanal	TOTAL
1986-90	12.84	2.76	3.34	18.93
1991-95	16.05	3.70	2.84	22.59
Growth (%)	6.2	8.6	-3.7	4.8
1996-00	18.04	5.30	2.20	25.54
Growth (%)	3.1	10.8	-5.6	3.3

**Table 1.5.** Average annual unit operations (millions) and growth rate (%) during the five year periods

YEAR	Mechanized	Motorized	Artisanal	TOTAL
1986-90	3.018	1.785	8.764	13.567
1991-95	2.926	2.601	6.451	11.978
Growth (%)	-0.8	11.4	-6.6	-2.9
1996-00	3.201	4.622	4.367	12.190
Growth (%)	2.3	19.4	-8.1	0.4

**Table 1.6.** Average annual fishing hours (millions) and growth rate (%) during the five-year periods

YEAR	Mechanised	Motorised	Artisanal	TOTAL
1986-90	20.803	6.639	31.204	58.646
1991-95	27.373	12.330	23.595	63.298
Growth (%)	7.9	21.4	-6.1	2.0
1996-00	35.039	18.774	14.731	68.544
Growth (%)	7.0	13.1	-9.4	2.1

## **1.6 Major Issues in the Marine Fisheries Sector**

Social and economic problems in the fisheries of developing countries like India are caused by overcapitalization and over-supply of labour, encouraged by open access to fisheries. In India, there is a significant workforce of traditional fishermen who are engaged in traditional fishing using bag nets, beach seine, stake nets, push nets etc. many of which are destructive fishing practices because they destroy juvenile fish mostly found in coastal waters. Intensive fishing with bottom trawl nets in coastal waters has led to over fishing of larger and more valuable fin-fish species leaving smaller and short lived species to proliferate and replace the former, a phenomenon called as "fishing down the food web". Coastal mangrove habitat which provide critical spawning and nursery habitats for a wide range of species have been cleared extensively for aquaculture, agriculture, land based development activities and timber. By thus interrupting critical phases of the life cycles of various marine fish/shrimps, many species of fish and shrimps are showing decline. Marine habitats are also susceptible to habitat loss by the widespread use of highly destructive dynamite fishing especially in sensitive coral reef ecosystems. Such large-scale habitat degradation, especially if combined with other human pressures such as over fishing, could trigger extinctions. Rapid development of shrimp culture in certain pockets of the coast has led not only to environmental degradation but also to significant direct and indirect impacts on the natural populations of various species of shrimps and finfish. Due to large scale collection of natural seed of commercial varieties of shrimps their recruitment to the fishery is adversely affected causing resentment among fishermen as well as loss of large numbers of juvenile fishes accidentally caught with these seeds which are simply discarded as they are not candidate species for culture. All these issues require adequate attention of resource managers as well as the stakeholders and extension agencies to prevent such undesirable fishing practices.

Environment plays a critical role in marine fish production by its influence on the spawning success, larval survival and recruitment processes of fish stocks. In recent years, changes in the distribution and abundance pattern of certain marine fish (notably small pelagics such as oil sardine and mackerel) which form important fisheries are being noticed which is attributed to climate change. These changes will have considerable impact on the marine fisheries of the region (Table 1.7.).



**Table 1.7.** Climate change and its impact on marine fisheries and aquaculture

<b>Cause</b>	<b>Effect</b>	<b>Result</b>
Increase in sea surface temperature	changes in growth, survival, reproduction and feeding conditions for fish; coral bleaching; increase in algal blooms, eutrophication and fish kills	Changes in distribution and species composition of landings, changes in recruitment patterns; and increase in infestation of diseases
Sea level rise	Loss of coastal land, mangrove ecosystem, salt water intrusion	Loss of fresh water / brackish water species
Increase in frequency of storms	Sea conditions	Loss of fishing days, damage to crafts and nets, loss of income to fishermen
<i>El Nino</i> Southern Oscillation (ENSO)	Location and timing of ocean current patterns change	Changes in fish catches and species availability
Drought	Salinity changes	Loss of fish stocks, fisher folk migration

Development of multi-day fishing, expansion of fishing grounds and the growing interest in offshore resources such as tunas which are highly migratory/straddling stocks are likely to give rise to conflicts with neighbouring countries fishing on the same stock. This brings into focus the importance of Regional Fisheries Bodies like IOTC (Indian Ocean Tuna Commission) for fisheries management and development in future.

## **1.7 Sustainable Development of Indian Marine Fisheries**

Sustainable development is the globally accepted goal for natural resource management, identified at United Nations Conference on Environment and Development (UNCED) in 1992. The basic principle that governs sustainable development of fisheries is that, it must be conducted in a manner that does not lead to over-fishing, or for those stocks that are over-fished the fishery must be conducted such that there is a high degree of probability the stock(s) will recover and also fishing operations should be managed to minimize their impact on the structure, productivity, function, and biological diversity of the ecosystem. The marine fish production has reached a plateau since 1989, which is because the fishing effort (mainly trawl based) has increased considerably and is concentrated in the 0-100 m depth zone leading to excess pressure in the coastal waters.

Indian fisheries have recently been facing the serious crisis of unsustainable development. As in many developing countries there are problems of over fishing, inter/intra sectoral conflict, low incomes and high degrees of poverty which creates difficulties in shifting to a limited access system from the existing open access system. Sustainability concerns of Indian fisheries can be listed as follows,

- Multi-gear, multi-species, Open Access Fisheries
- Excess fishing effort /Over capitalization especially in the coastal areas upto about 50 m depth zone
- Decrease in area available in the sea per active fisherman and boat for conducting fishing operations
- Conflicts among different categories of fishermen particularly between the artisanal and mechanized groups of fishermen
- Limited scope for increase in fish production from the inshore fisheries as most have reached MSY levels
- Declining trend in catch and catch rates of commercially exploited stocks
- Discards/Indiscriminate exploitation of juveniles of many commercially important species due to use of small mesh nets
- Damage to the benthos and benthic ecosystem by continuous sweeping of the same ground by shrimp trawlers
- Ecosystem degradation (pollution, increased bottom trawling effort in coastal areas, mangrove destruction) affecting the productivity and the carrying capacity
- Conflicts between those engaged in coastal artisanal fishing and coastal aquaculture
- Absence of an informed management regime and a Limited Fishery Management system (Participatory Fisheries Management) due to resistance to imposition of fishery regulations and lack of political will
- Inefficient internal marketing system
- Impacts of climate change on fishery resources already under high fishing pressure

## **1.8 Future Strategies for Indian Marine Fisheries Development**

Prospects for further development and expansion of fisheries include the unexploited component of exploited stocks (eg. offshore tuna fishing), unutilized resources which have not much market value at present but can be utilized after suitable conversion into value added products (eg. certain deep sea resources such as Black ruff *Centrolophus* spp., Bull's eye *Priacanthus* spp., Drift fish *Ariomma* spp., Green eye *Chlorophthalmus* spp.) and mariculture (mussels, oysters, fin-fish, seaweed). Along with this, development and/or improvements in the infrastructure facilities, operational efficiency and quality control at all stages (harvesting/mariculture, processing and marketing), reduction of wastage and value addition of fishery products are vital when planning the development of fisheries.

Presently, Indian seafood exports trade is mainly in the commodity (bulk) packing aimed at processors of the importing countries who reprocess it and sell it under their label. Today the demand is for hygienic, nutritious and attractively packed ready-to-eat or ready-to-cook convenience products. Hence there is tremendous scope for increasing export earnings through value addition to these bulk processed items as many other developing countries are doing. Some of these products include battered and breaded products, fish fingers, Individual Quick Frozen (IQF) products, *Sushi* (shrimp based) and *Sashimi* (tuna) products. For this serious thought to developing adequate technologies for value addition and marketing strategies (for new products, new markets) is required. There is also a good market for ornamental fish and live fish for which good harvesting practices and development of mariculture technologies are required. Proper quality assurance, suitable target markets for high end products and live sea food trade require focused attention which can contribute significantly to fisheries development.

The World Trade Organization (WTO) regime was supposed to facilitate a level playing field for increasing trade of both developing and developed countries. However it has often been observed that tariffs in advanced countries on imports from the developing countries are much higher than those from other advanced countries. The major trade barriers faced by the Indian seafood trade industry in the recent past are given below.

**Table1.3.** Non-tariff barriers faced by seafood industry

<b>Country/ Market</b>	<b>Nature of the barrier</b>
USA	<ol style="list-style-type: none"> <li>1. Introduction of Turtle Excluder Device (TED) for trawls</li> <li>2. HACCP regulations</li> <li>3. Imposition of Anti-dumping duties on Indian shrimp</li> <li>4. Bio-terrorism Act</li> </ol>
Europe	<ol style="list-style-type: none"> <li>1. Introduction of EU standards and making EU approvals for processing plants mandatory</li> <li>2. Introducing testing of antibiotics and other chemical residues</li> </ol>
Japan	Complaints of muddy/ mouldy smell in Indian tiger shrimp

In the light of such experience, we should focus on diversification of mariculture from shrimp to other exportable items of fin-fish and shell-fish. In addition, introduction of a regulated oceanic tuna fishing fleet with focus on the high end products like *sashimi* tuna and tuna loins, quality assurance at landing, transporting and processing points through voluntary adoption of appropriate international standards by the industry, promotion of eco-labelling, organic farming and promoting a common trade brand for Indian seafood products through a logo will also go a long way in promoting marine fisheries development in India.

Although the Indian fish processing trade is mostly export oriented, prospects for domestic fish market is bright as recent economic growth of the country is reflecting in larger disposable incomes and purchasing capacity of the people for items such as high quality fresh/processed marine fish. A major concern is that appropriate quality standards for the fish and fishery products sold in the domestic market are generally lacking and there is an urgent need to set up standards for same.

## **1.9 Let us Sum Up**

From very humble beginnings, the Indian marine fisheries sector has rapidly developed to become a major contributor in global fish production and trade. The fisheries development has been facilitated by the thrust given for various fishery development programmes under the various 5 year/annual Plans. In recent years, there has been a tremendous increase in fishing effort in term of fishing operations (units, hours of operation etc) and stagnation in marine landings resulting in decline in catch per unit effort, especially from the inshore waters. This has given rise to awareness about the need for responsible fishing practices. Impacts of climate change are also visible in the marine fisheries sector and possible problems have to be foreseen and appropriate action should be taken. In the light of the importance of the fisheries sector to the economy of the country, fisheries development should be planned on a sustainable basis. For this sustainable fishing practices with recommended mesh sizes, avoiding of over fishing, development of offshore fishing and excellent harvest/post-harvest practices to minimize wastage and discards, appropriate quality controls on fishery products, development of value added products and diversified mariculture activities are suggested.

### **1.10 Key Words**

***Catch per Unit Effort (CPUE):*** The quantity of fish caught (in number or in weight) with one standard unit of fishing effort; e.g. number of fish taken per 1000 hooks per day or weight of fish, in tons, taken per hour of trawling. CPUE is often considered as an index of fish biomass (or abundance) and sometimes referred to as catch rate. CPUE may be used as a measure of economic efficiency of fishing as well as an index of fish abundance.

***Climate:*** It is the long term average pattern of weather which is the fluctuating state of atmosphere around us characterized by temperature, rains, wind, clouds etc.

**Climate change:** Change in climate of the earth as a result of human behaviour (mainly emission of “greenhouse gases” like carbon dioxide and methane) rather than due to natural changes in the atmosphere.

**Fisheries development:** It concerns the processes leading to the progress in harvesting, processing, marketing and utilizing the yields from the natural resources of aquatic animals and plants for the benefit of the people and the country.

**Fish Aggregating Devices (FADs):** Artificial or natural floating objects placed on the ocean surface, often anchored to the bottom, to attract several schooling fish species underneath, thus increasing their catchability.

**Fishing down the food web:** Presently considered as a global phenomenon. It is caused by the removal of top predatory fishes (such as sharks) through fishing which favors proliferation of fish species lower in the food chain (plankton feeders like sardines). The ecosystem implications of removing top predators is unpredictable and there are suggestions that it could lead to ecosystems dominated by microbial loops and also result in pathogen outbreaks in sensitive ecosystems such as sea grass beds and coral reefs. It can also lead to economic hardships to the fishing community as the fishes like sharks, tunas and billfishes higher in the food chain command higher unit value compared to the herbivorous fishes with which it is replaced.

**Potential Fishing Zones (PFZ):** A short term fishery forecast based on parameters such as sea surface temperature and phytoplankton pigment induced ocean colour data obtained through satellite.

**Responsible Fisheries:** Encompasses sustainable utilization of fishery resources with due consideration for the environment; the use of capture and aquaculture practices which are not harmful to ecosystems as well as the fish resources and their quality; value addition to such products through processes meeting the required sanitary standards; and, ensuring the fishing/culture practices provide consumers access to good quality products only.

**Sashimi tuna:** Japanese term for sliced tuna served raw as a delicacy.

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

### 1.11 Further Readings

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### 1.12 Check Your Progress- (Questions and Answers/Hints)

#### 1. What is Fisheries Development and what are its objectives?

**Given in section 1.1 and 1.3**

#### 2. Give an overview of the development of marine fisheries India

Right from pre-independence days, development of the fisheries sector was considered important for the country. With Independence and the various 5 year/Annual Plans, the Indian marine fisheries sector has undergone a rapid development. There have been numerous developments in harvesting as well as processing sectors. There have also arisen numerous challenges and opportunities for further development of the sector. **See section 1.4 for details.**

### **3. What is the present status of marine fisheries of India?**

Indian marine fisheries sector has tremendously progressed since Independence from an average annual fish production of about 50,000 t to an estimated 2.6 million tons during the last decade. The resource base, trends of fish landings and the various changes in the mechanized, motorized and artisanal sector are given. In recent years there has been stagnation in marine fish landings and conflicts between different sectors. **See section 1.5 for more details**

### **4. What are the possible impacts of climate change on the marine fisheries sector.**

Changes in the distribution and abundance pattern of many marine fish, damage to coral reef ecosystem and associated fisheries, frequent storms, migration of fish stocks etc. are possible due to climate change. **See section 1.5.6 for more details**

### **5. Define “sustainable development” and the sustainability concerns in the Indian marine fisheries sector.**

In recent years, marine fish catches are stagnating and undesirable tendencies like rapid increase in fishing fleets and fishing power, fishing of juveniles/undersized fish, discards, ecosystem degradation due to increased trawling effort, mangrove destruction and pollution are observed which has raised concerns about the sustainability of the fisheries. **See section 1.7 for more details**

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## Unit 2

# Fish Stock Assessment and Fisheries Management

## Structure

- 2.0 Objectives
- 2.1 Introduction
- 2.2 Data requirements and Methods of fish stock assessment
- 2.3 Models in fish stock assessment
- 2.4 Fisheries management
- 2.5 Issues in Fisheries Management
- 2.6 Biological Reference Points (BRPs) in Fisheries Management
- 2.7 Approaches in fisheries management
- 2.8 Let us sum up
- 2.9 Key words
- 2.10 Further readings
- 2.11 Check your progress (Questions and Answers/Hints)

## 2.0 Objectives

**After reading this unit, you should be in a position to**

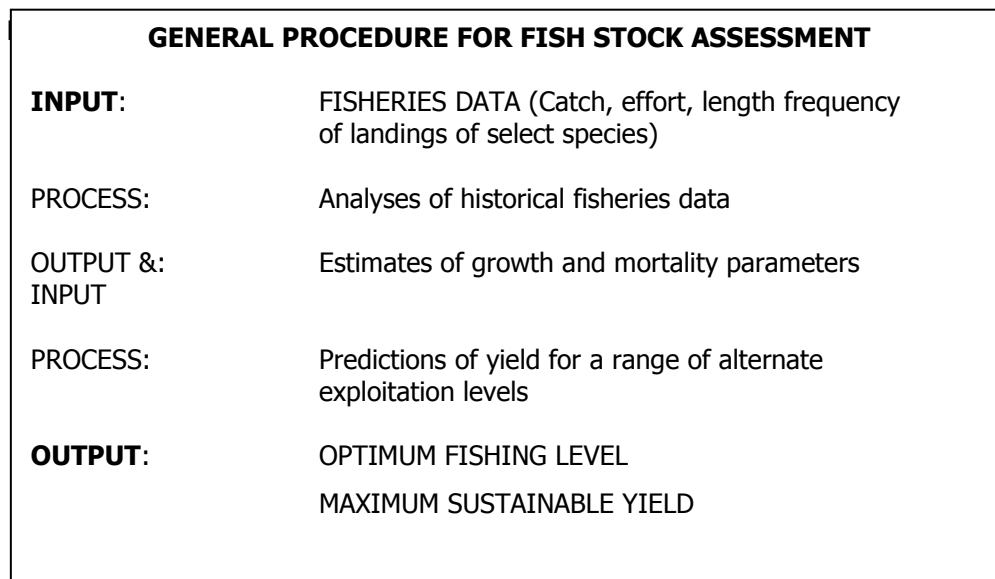
- Define fish stock assessment and fisheries management
- Understand concepts of Fish Stock Assessment, Maximum Sustainable Yield, Maximum Economic Yield, Optimum yield
- Understand concepts of over-fishing
- Understand various approaches to fisheries management

## 2.1 Introduction

There are many definitions for “fish stock” in the literature on fisheries and fish stock assessment. Cushing (1968) defined fish stock as one that has a single spawning ground to which the adults return year after year. Larkin (1972) defined stock as “a population of organisms which, sharing a common gene pool is sufficiently discrete to warrant consideration as a self-perpetuating system which can be managed.” Ricker (1975) defined a fish stock as “the part of a fish population which is under consideration from the point of view of actual or potential



utilization". A group of animals for which geographical limits can be defined may be considered a "stock" in terms of fish stock assessment. Fish stocks are very variable, that is they fluctuate in abundance and structure from year to year due to natural changes as well as due to human interactions. The basic purpose of fish stock assessment is to provide advice on the optimum exploitation of aquatic living resources such as fish and shrimp. There are many forms of stock assessment, some simpler, some more complex, but they all require some level of information or data obtained from monitoring the resource (Fig.2.1). Data are collected by scientists on dedicated research cruises and fishing trips, by inspectors and data collectors through the collection of logbook and landings information by at-sea observers and landings monitored through the biological sampling of catches from commercial fishing vessels and information on fishing activities and by administration personnel through the collection of license and vessel information.



## 2.2 Data Requirements and Methods of Fish Stock Assessment

The basic data required for stock assessment are

- Total catch
- Fishing effort
- Area and type of fishing (gear characteristics, time of fishing)
- Biological characteristics of the catch (length groups/ age groups, reproductive and feeding biology)

The level of precision of fish stock assessment increase with the availability of data and is usually positively correlated to the development of the fishery. In case of unexploited stocks,

assessments are based on surveys with fisheries research vessels as well as general ecological principles. As soon as exploitation starts, the fishery itself provides the database for application of more sophisticated methods. In a very highly developed fishery a large portion of the stocks is landed and therefore accessible to sampling. Hence fish stock assessment is a highly sophisticated scientific exercise requiring different skills as well as a sound knowledge of the biology of the system as well as a good understanding of the fishery and rapport with the fishermen and fishing industry.

## 2.3 Models in Fish Stock Assessment

**2.3.1. Holistic models:** Applied in data limited situations these include the following,

**a) Swept Area method:** Based on Exploratory trawl survey data of catch per unit of area swept by the trawl, an estimate of the biomass in the sea and MSY is made.

**b) Surplus production method:** Based on Catch per unit Effort (CPUE) data obtained from sampling the commercial fisheries over a time series of years an estimate of the biomass in the sea and MSY is made.

**2.3.2. Analytical models:** These are based on a more detailed description of the stock (length/age groups contributing to the fishery, growth and mortality parameter estimates etc.) and are demanding in terms of quantity and quality of input data. Analytical models can be categorized into two. The first category is concerned with the past fisheries data and analyses the effect that a fishery had on different year classes of the stock. Hence it is also called **Virtual Population Analysis** (VPA) or **Cohort Analysis**. VPA is used to determine the optimum fishing strategy which in the long term will give the highest yield from the fishery. The second category is based on the findings of the first category and predicts the effect of different levels of fishing effort on the fish stocks in the future and hence is called the predictive models. This includes the **Thompson and Bell method** and **Beverton and Holt Yield per Recruit method**.

## 2.4 Fisheries Management

Fisheries management can be described as the rational exploitation of fisheries resources based on notions of sustainability, efficiency and equity. According to FAO (1997) its definition is as follows- "The integrated process of information gathering, analysis, planning, consultation, decision-making, allocation of resources and formulation and implementation, with enforcement as necessary, of regulations or rules which govern fisheries activities in order to ensure the continued productivity of the resources and accomplishment of other fisheries objectives". Fisheries management entails a complex and wide-embracing set of tasks. It is a continuous and

interactive process, where, economic, social and ecological costs and benefits are to be understood and interventions designed to sustain and develop fisheries.

## **2.5 Issues in Fisheries Management**

### **2.5.1. Overfishing**

This is the single process that contributes significantly to the problems of fisheries management because it results in damage to stocks which may be sometimes irreparable. If overfishing occurs management action will require restrictions/reduction of the existing fleets causing considerable dislocation of workforce and livelihood securities of poor fishermen forcing them to search for alternate source of income.

**2.5.1.1. Growth overfishing:** This is caused by catching young fish before they have time to grow and remedies are management through mesh size regulations for fishing gear that will allow fish to grow to sufficiently large size before they are caught

**2.5.1.2. Recruitment overfishing** occurs when the development of a fishery causes reduction in the number of young fish entering the fishing ground through the depletion of the spawning stock or as a result of the degradation of the coastal environment which may damage the spawning/nursery areas. This requires regulations which will restrict/prevent fishing in the spawning seasons, spawning areas as well as nursery areas. A combination of these two types of fishing is called **biological overfishing**.

**2.5.1.3. Cacometric overfishing** occurs when stocks are under excessive fishing effort and size at first capture ( $L_c$ ) is very small.

**2.5.1.4. Economic overfishing** occurs when the fishing effort level exceeds the level at which economic rent is maximized or the Maximum Economic Yield (MEY) level is realized.

## **2.6 Biological Reference Points (Brps) In Fisheries Management**

These are stock-specific bench marks that are essential for application of a precautionary approach to fishery management. BRPs are of two types, namely a) Target Reference Points (TRP) – which indicate the desirable status of the fishery and b) Limit Reference Points (LRP) – Points which if crossed will cause collapse of the fishery.

### 2.6.1 Maximum Sustainable Yield

One very basic concept in fisheries management and one of the simplest stock assessment tools is that of Maximum Sustainable Yield (MSY). It is defined as "the maximum catch that can be removed over an indefinite period without causing the stock to be depleted, assuming that removals and natural mortality are balanced by stable recruitment and growth". In simple words it is the largest catch that can be taken from a given fish stock, over the long-term without causing the population to collapse. The concept of MSY is used when optimum fish production (catch) is an objective and it is based on the theory that annual catch from a fishery should not exceed the annual production of that fishery. The aim is to avoid over fishing of the stock but at the same time to allow the maximum catch to be removed. In Fig.2.2 MSY is at the point where the graph starts to flatten out, where an increase in effort no longer results in an increase of the catch and if fishing effort continues to increase then the catch will actually decrease. This is because the fish stock has passed its MSY and growth over fishing is occurring. This means that the resource does no longer reach its maximum possible biomass, fish remain smaller on average and more effort is spent on catching less fish. One of the important limitations with the MSY approach is that it is not effective when you have multi-species fisheries, as fishing of one species will affect the other and the total MSY for a multi-species assemblage will be less than the sum of all the separate MSYs.

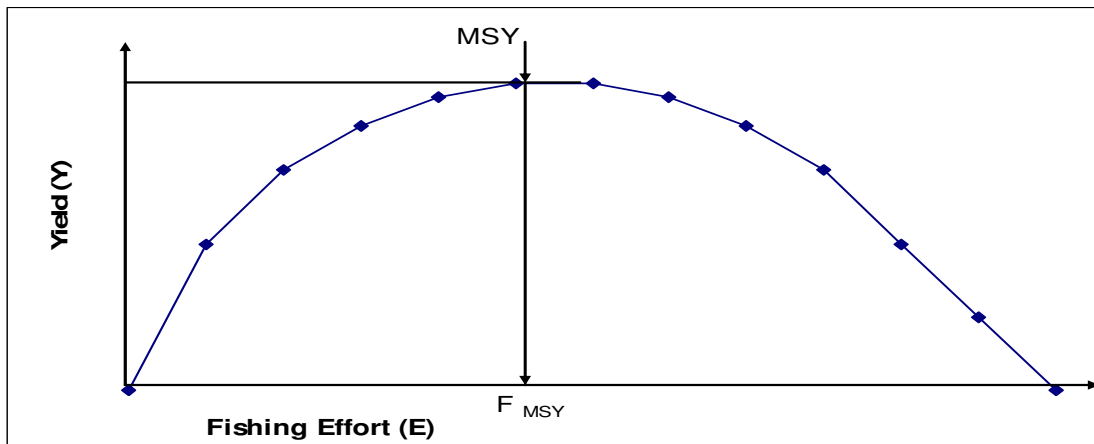


Fig.2.2. The sustainable yield - effort curve showing MSY

### 2.6.2. Maximum Economic Yield

While the MSY is the biological measure of optimal production the economic potential of the fishery is known as the Maximum Economic Yield (MEY) and given in Figure 2.3. The yield curve is replaced by a revenue curve on the assumption that yield is proportional to revenue and the cost of fishing is proportional to fishing effort. The optimum level for economic exploitation (MEY) is at the point when the difference between the costs and the revenue is the greatest. As

can be seen in Figure 2.3 this is to the left of the peak of the curve and therefore at a lower level of fishing effort than the MSY. MEY is again a very simple model and in reality many limitations occur but it is a useful tool to gain a basic understanding of the different elements that need to be considered when making management plans.

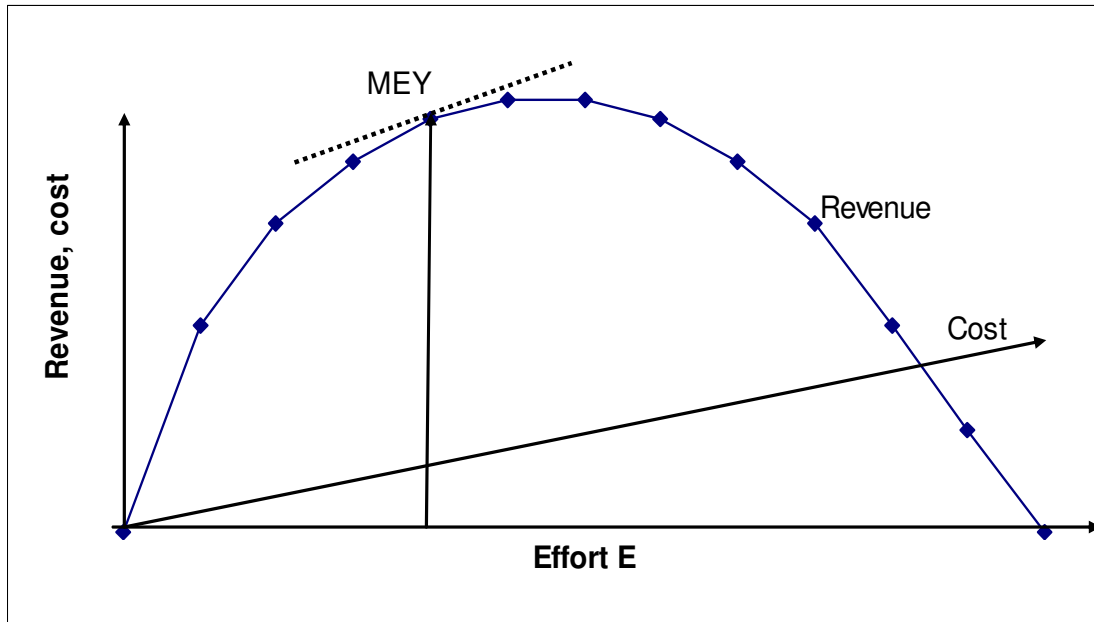


Fig.2.3. Effort Level for Maximum Economic Yield (MEY)

When  $p$  = the price of the fish,  $c$  = the opportunity cost for a unit of effort, the revenue curve is  $R = pY$  and the cost line  $C = cE$  where  $Y$  is Yield and  $E$  is unit effort. Costs is directly proportional to the effort and therefore Fig.2.3(a) shows the cost line when costs are high (e.g. deep-sea fishing) and Fig.2.3(b) shows the cost line when costs are low (e.g. low technology inshore fishing). The open access equilibrium is the point in a fishery when costs are equal to revenue and the point when fishers will start to leave the fishery. Figure 2.3 indicates this is sooner if the costs are high (a) than if the costs are low (b). It can also be seen how the second situation (b) would encourage more entries into the fishery and therefore encourage a higher risk of stock collapse and higher expenses in terms of effort.

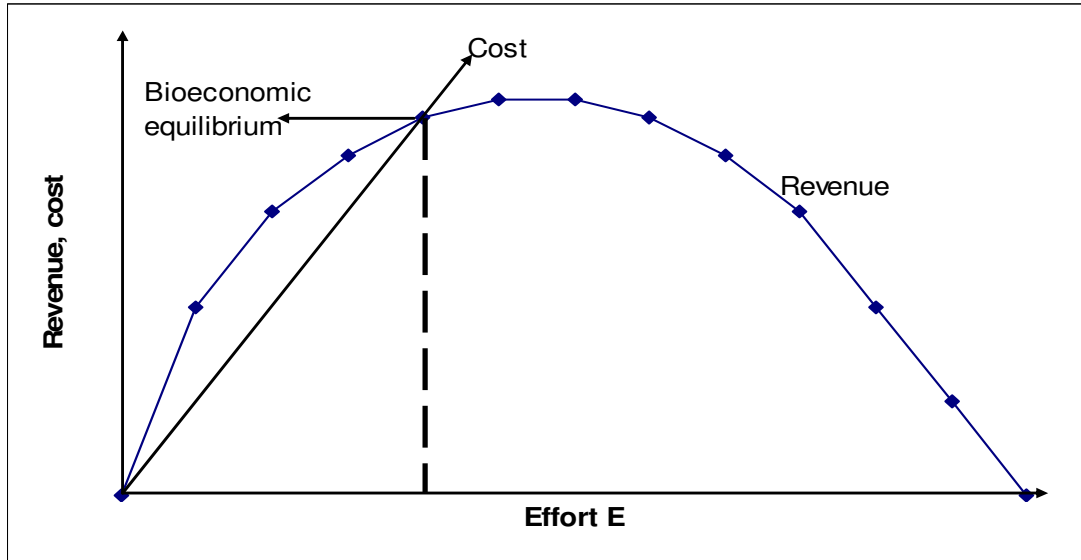


Fig. 2.3a. Economic Equilibrium in a high cost fishery

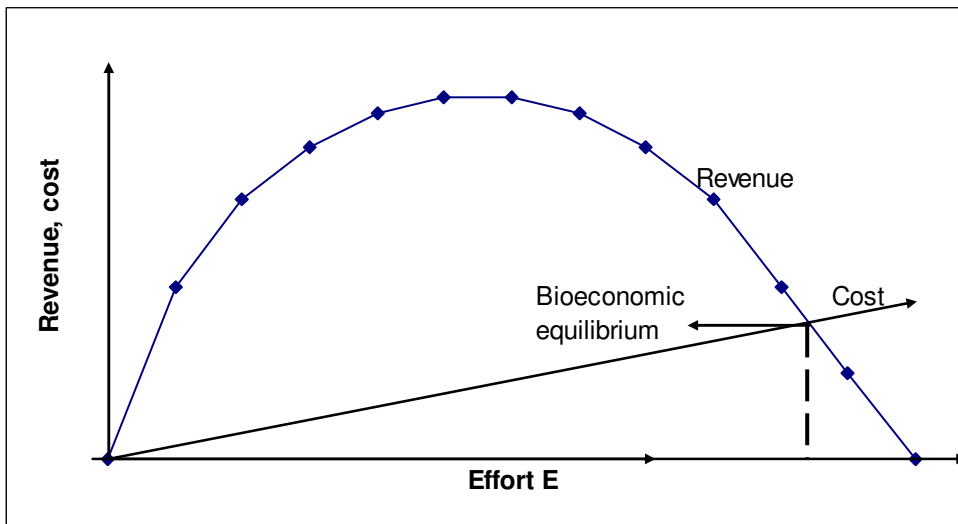


Fig. 2.3b. Economic Equilibrium in a low cost fishery

### **2.6.3. Optimum Yield or Maximum Social Yield**

Often the economic objective of MEY or the biological objective of MSY is seen to be too narrow. The social effects of fisheries management are also considered as important elements of fisheries planning. Therefore the concept of Optimum yield or Maximum Social Yield (MscY) has also been introduced. In this case in a scenario such as 'no alternative employment' to the users of the resource a permissible increase in the level of fishing above that allocated when a purely economic viewpoint is considered is justified.

Although the concept of MSY is based on many unrealistic assumptions such as a steady-state of catch-effort, stability of ecosystem etc. and has been criticized by many fisheries scientists, it still remains the best starting point to understand the dynamics of the fisheries as well as formulate reference points for fisheries management.

## **2.7 Approaches in Fisheries Management**

### **2.7.1 *Participatory fisheries management***

Participatory fisheries management is an innovative approach to decentralize management authority and make fishermen as resource managers. Here, management of fisheries is made more effective by the active involvement of all principal stakeholders in the decision-making and implementation of resource management programmes.

### **2.7.2 *Ecosystem based Fisheries Management (EBFM)***

Traditionally fish population dynamics have been studied as a single species, for example as mackerel, shrimp or sardine and almost always in isolation from the system in which they exist. However, there is growing awareness that these kinds of assessments and management interventions based on these will be unrealistic which gave rise to the concept of EBFM. Fishing activities may have positive or negative effects on other components of the ecosystem through the food chain effect, by-catch or physical damage. It is therefore important to strive for the sustainable use of the entire ecosystem not just the species being targeted in any one management plan. With an ecosystem approach to fisheries management, EBFM is a geographically specified fisheries management that takes account of knowledge and uncertainties about, and among, biotic, abiotic and human components of ecosystems, and strives to balance diverse societal objectives. It takes into consideration trophic (predator-prey) interaction between various fish species in the fishing grounds as well as the environmental variability that affects the productivity of fisheries resources. In India EBFM is being attempted by CMFRI by developing models for the Karnataka coast of south west India, Gulf of Mannar and Northwest coast of India.

### **2.7.3 *Code of Conduct for Responsible Fisheries (CCRF)***

The CCRF was evolved by FAO aimed at long-term sustainable measures for optimal exploitation of fishery resources. It is voluntary in nature and defines the general principle that "The right to fish carries with it the obligation to do so in a responsible manner". The code calls for effective legal and administrative framework for the refusal, withdrawal or suspension of

authorization to fish in the event of non-compliance with conservation and management measures. Also the member countries are required to implement effective fisheries Monitoring, Control and Surveillance (MCS) and law enforcement measures wherever appropriate. The CCRF has been endorsed by India also. There are 12 Articles under the CCRF dealing with aspects such as.

Article 1: Nature and scope of the Code

Article 2: Objectives of the Code

Article 3: Relationships with other international instruments such as UNCLOS (United Nations Conference on Laws of the Sea) and UNCED (UN Conference on Environment and Development) Declarations

Article 4: Implementation, Monitoring and Updating

Article 5: Special requirements of developing countries

Article 6: General principles concerning environment, harvesting, handling, processing, conservation

Article 7: Fisheries Management

Article 8: Fishing Operations

Article 9: Aquaculture development

Article 10: Integration of fisheries into coastal management

Article 11: Post-harvest practices and trade

Article 12: Fisheries Research

Adherence to the CCRF helps in sustainable fisheries development as it ensures that

- a) excess fishing capacity is avoided and exploitation of the stocks remains economically viable
- b) the economic conditions under which fishing industries operate promote responsible fisheries
- c) the interests of fishers, including those engaged in subsistence, small-scale and artisanal fisheries, are taken into account
- d) biodiversity of aquatic habitats and ecosystems is conserved and endangered species are protected
- e) depleted stocks are allowed to recover or, where appropriate, are actively restored



- f) adverse environmental impacts on the resources from human activities are assessed and where appropriate, corrected and
- g) pollution, waste, discards, catch by lost or abandoned gear, catch of non-target species, both fish and non-fish species, and impacts on associated or dependence species are minimized through measures including, to the extent practicable, the development and use of selective, environmentally safe and cost-effective fishing gear and techniques.

#### **2.7.4 National Resource Accounts- Valuation of fishery resources**

Globally many fisheries have been overexploited and in conjunction with natural impacts like climate change and environment/habitat degradation due to coastal development and associated pollution, their capacity to recover and cope with the environmental changes taking place have been adversely affected leading to poor economic performance. The GNP/GDP estimates centers around the quantity of market activity without considering the social and ecological costs involved and has been found to be an inadequate measure of true prosperity. New indicators of progress which will include the presently unpriced value of natural and social capital in addition to the value of conventionally measured economic production are needed. To address these gaps, FAO and UN developed the System of Environment and Economic Accounts (SEEA) for fisheries (FAO, 2004) similar to the System of Natural Account (SNA) for environmental goods and services. Fisheries Sector Accounts provide information that can be used by both fisheries managers and non-fisheries policy makers by including components on fisheries statistics, fisheries resource economics and fisheries policy. Following the SEEA (2003), the four categories of accounts are given below

1. Asset accounts: These record stocks of natural resources (fish) and their changes if any in addition to other resources which may be related to fish health such as land use, forestry etc.
2. Flow accounts for pollution, energy and material: These provide information at the industry level about use of energy and materials as inputs to production and final demand and the generation of pollutants and solid waste. This information is used to construct input-output tables
3. Environmental Protection and Resource Management Expenditure Accounts: This identifies expenditures incurred by the industry, government and households to protect the environment or manage the resource. It also includes income through taxes and sale of fishing licenses.

4. Environmentally-adjusted macroeconomic aggregates: These consider how economic aggregates can be adjusted for the impact of the economy on the environment. Basically two sorts of adjustments are considered: those related to depletion (of fish resources) and those related to degradation (of fish habitat).

In this system, however, there is still disagreement over concepts of sustainability and reliability of economic valuation of certain environmental benefits, especially non-market ones such as ecosystem services and biodiversity conservation. But still the system has been adopted by many developing countries to efficiently manage their resources, e.g., in Namibia, soon after a peak performance of the fisheries during the 1960s and 1970s, there was a collapse. In 1990, after its independence the country established control and introduced a fisheries policy to manage its resource. It began its National Resource Accounting (NRA) Programme in 1995 for fisheries besides others such as water, land, minerals, wildlife, energy etc. To ensure sustainability of their fisheries, annual TACs were set for all major commercial species (Hake *Merluccius* spp., Horse mackerel *Trachurus capensis* and pilchard *Sardinops ocellatus*). Resource rent policies with suitable subsidies for Namibians and criteria for allocation of rights of exploitation favorable for Namibian ownership were put in place and together this achieved a remarkable transformation of the Namibian fishing industry by the end of 1998.

#### **2.7.5 Eco-labeling**

This is a process that works towards sustainability by providing recognition for the products that are produced in a manner that does not impact the environment in an unacceptable manner. Eco-labeling programmes fall into 3 categories as given below,

- 1<sup>st</sup> party labeling – involves self-declaration from the industry
- 2<sup>nd</sup> party labeling – involves industry endorsement
- 3<sup>rd</sup> party labeling - entails assessment by a third party, independent certifier.

Only the last approach has been endorsed by the FAO International Guidelines for the Eco-labeling of Fish and Fishery Products of Marine Capture Fisheries. The Marine Stewardship Council (MSC) based in UK is the organization concerned with eco-labeling of marine fisheries and has evolved an MSC Standard called the ***Principles and Criteria of Sustainable Fishing***. This consists of 3 principles as follows

**Principle 1.** A fishery must be conducted in a manner that does not lead to over-fishing or depletion of the exploited populations and for those populations that are depleted the fishery must be conducted in a manner that demonstrably leads to their recovery

**Principle 2.** Fishing operations should allow for the maintenance of the structure, productivity, function and diversity of the ecosystem (including habitat and associated dependant and ecologically related species)

**Principle 3.** The fishery is subject to an effective management system that respects local, national and international laws and standards and incorporates institutional and operational frameworks that require the use of the resource to be responsible and sustainable.

On a voluntary basis fisheries can opt to be assessed against the MSC standard. The process involves an initial evaluation (pre-assessment) against the MSC standard by an independent certification body accredited to MSC followed by a full evaluation by a team with combined expertise in fish stock assessment, ecosystem impact, fisheries management and local fisheries knowledge. For a fishery to be certified to the MSC standard the fishery must obtain a score of 80 or more for each of the 3 principles. After a fishery is certified, a Chain of Custody Certification is carried out by an independent certification body which considers all parts of the supply chain from point of landing to final point of purchase by consumers, paying particular attention to any steps in the supply chain where MSC-certified products could be mixed with products from non-certified fisheries. Finally an MSC logo is granted to the certified fishery which indicates to the customer it comes from a well managed fishery. Surveillance audits carried out on fisheries already certified to the MSC Standard reveal that eco-labeling has had the effect of improving fisheries, in terms of encouraging responsible fishing. It has also been employed as a tool for accessing new markets where customers are willing to pay a premium for certified products. Some of the famous fisheries certified by MSC are the Western Australian Rock lobster fishery; Alaska salmon, New Zealand Hoki fishery etc.

## **2.8 Let us Sum Up**

Fish stock assessment is a very vital process for fisheries management and requires extensive knowledge of the fishery, the biological aspects of the resource and the effect of environment and social factors operating on the functioning of the fishery. Depending on the availability of data various stock assessment models are employed. It is the duty of the scientists to make reliable stock assessment to enable the policy maker to make appropriate decisions for the sustainable development of fisheries. Availability of data on the fishery either from exploratory surveys or commercial landings is an important factor in stock assessment. The fishermen also have a critical role to play in providing data to scientists to make realistic assessments. Fisheries management advisories are based on stock assessment studies.

## 2.9 Key Words

**CPUE:** Catch per Unit Effort

**Biological Overfishing :** Occurs when too many small fish are being harvested through excessive fishing effort and poor selectivity (e.g. too small mesh sizes of fishing nets) and the fish are not given enough time to grow to the size at which the maximum yield-per-recruit from the stock would be obtained. In such cases, a reduction of fishing mortality on juveniles, or their outright protection, would lead to an increase in yield from the fishery.

**Biological Reference Point:** A biological benchmark against which the abundance of the stock (biomass) or the fishing mortality rate ( $F$ ) which is indicative of the fishing effort can be measured in order to determine stock status. These reference points can be used as targets (representing desirable outcomes) or limits (to ensure stocks remain within safe biological limits and fisheries do not collapse). Some target reference points are  $MSY, F_{MSY}, B_{MSY}$

**Chain of Custody:** The set of measures which is designed to guarantee that the product put on the market and bearing the eco-label logo is really a product coming from the certified fishery concerned.

**Eco-labeling:** In fisheries, eco-labeling schemes entitle a fishery product to bear a distinctive logo or statement which certifies that the fish has been harvested in compliance with conservation and sustainability standards. The logo or statement is intended to make provision for informed decisions by purchasers which will promote and stimulate the sustainable use of fishery resources.

**Ecosystem based fisheries Management.** An approach that takes major ecosystem components and services both structural and functional into account in managing fisheries. It values habitat, embraces a multispecies perspective, and is committed to understanding ecosystem processes. Its goal is to rebuild and sustain populations, species, biological communities and marine ecosystems at high levels of productivity and biological diversity so as not to jeopardize a wide range of goods and services from marine ecosystems while providing food, revenues and recreation for humans.

**Fish stock:** A distinct genetic population defined by movement pattern, part of a fish population potentially harvestable, or a quantity of fish from a given area; usually isolated from other stocks of the same species and so self sustaining.

**Fishing mortality ( $F$ ):** Deaths of fish from fishing and is an indicative of the fishing effort on the stock.

**Length at first maturity ( $L_m$ ):** Defined by: (1) the minimal size at which maturity is reached for concerned fish species; (2) the size at which 50% of the fish in the stock are mature.

**Management Reference Points:** Conventional (agreed values) indicators of the desirable (Target reference point, TRP) or undesirable state (Limit reference point) of a fishery resource. Reference points could be biological (e.g. expressed in spawning biomass or fishing mortality levels), technical (fishing effort or capacity levels) or economic (employment or revenues levels).

**Maximum Sustainable Yield (MSY):** It is the largest catch that can be taken from a given fish stock, over the long-term without causing the population to collapse.

**Natural mortality ( $M$ ):** Deaths of fish from all causes except fishing (e.g. Ageing, predation, cannibalism, disease and perhaps increasingly pollution).

**Optimum Yield (OY):** The yield from a fishery which provides the greatest overall benefit to the nation and is based on MSY as modified by economic, social or ecological factors.

**Recruitment :** The number of fish added to the exploitable stock, in the fishing area, each year, through a process of growth (i.e. the fish grows to a size where it becomes catchable) or migration (i.e. the fish moves into the fishing area).

**Recruitment overfishing :** The rate of fishing above which the recruitment to the exploitable stock becomes significantly reduced. This is characterized by a greatly reduced spawning stock due to a decreasing proportion of older fish in the catch resulting in very low recruitment (production of young ones) year after year.

**Spawning Stock Biomass (SSB):** The total weight of the fish in a stock that are old enough to spawn; the biomass of all fish beyond the age or size class in which 50% of the individuals are mature. This may be used instead of measuring egg production.

**Status of exploitation :** An appraisal of exploitation is given for each stock using the terms unknown, protected, not exploited, underexploited, moderately exploited, fully exploited, and over-exploited. These terms describe the effect of current fishing effort on each stock, and are based on current data and the knowledge of the stocks over time.

**Stock assessment:** A report that summarizes biological condition of a fish stock.

**Surplus Production model:** Mathematical representation of the way a stock of fish responds to the removal of its individuals (by fishing) represented by a relationship between yield or CPUE, and fishing effort or mortality.

**Survival Rate :** Number of fish alive after a specified time interval (usually on a yearly basis), divided by the initial number.

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

**Sustainable yield:** The number or weight of fish in a stock that can be taken by fishing without compromising the ability of the population/ecosystem to regenerate itself assuming that environmental conditions remain the same.

**Target Reference Points (TRP):** TRPs indicate to a resource and/or state of a fishing which is considered desirable and at which management, whether during fisheries development or stock rebuilding should aim. The commonly used TRPs are  $MSY$ ,  $F_{MSY}$ ,  $B_{MSY}$  and  $SSB_{MSY}$  which respectively is the Maximum Sustainable Yield and the Fishing Mortality rate, Stock Biomass and Spawning Stock Biomass associated with  $MSY$ .

**Virtual Population Analysis:** A retrospective analysis of the catches obtained from a given year class at each age (or length interval) over its life in the fishery. It allows estimation of fishing mortality and abundance at each age as well as recruitment. Eg., If 10 fish from the 1968 year class were caught each year for 10 successive years from 1970 to 1979 (age 2 to age 11), then 100 fish would have been caught from the 1968 year class during its life in the fishery. Since 10 fish were caught during 1979, then 10 fish must have been alive at the beginning of that year. At the beginning of 1978, there must have been at least 20 fish alive because 10 were caught in 1978 and 10 more were caught in 1979. By working backward year by year, one can be virtually certain that at least 100 fish were alive at the beginning of 1970. A virtual population analysis goes a step further and calculates the number of fish that must have been alive if some fish also died from causes other than fishing.

**Year class (or cohort):** Fish in a stock born in the same year. For example, the 1987 year class of mackerel includes all mackerel born in 1987, which would be age 1 in 1988. Occasionally, a stock produces a very small or very large year class which can be pivotal in determining stock abundance in later years.

**Yield/Recruit (Y/R):** The expected lifetime yield per fish recruited in the stock at a specific age. It depends on the exploitation pattern (fishing mortality at age) or fishing regime (effort, size at first capture) and natural mortality.

## 2.10 Further Readings

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## 2.11 Check Your Progress (Questions and Answers/Hints)

### 1. What is fish stock assessment?

Fisheries resources although renewable are exhaustible. The objective of fish stocks assessment is to predict changes in size of stock and size of yields as functions of both fishery dependant (fishing effort) as well as fishery independent (environment caused) factors, so that optimum levels of effort and yield can be determined. Stock assessment is done after taking into consideration the effect of fishing as well as environment on the stock and based on this policy makers can make various decisions on fisheries management. **See section 2.1 –2.3**

## **2. What is the difference between Holistic and Analytical models of fish stock assessment?**

Stock assessment is done using simple “holistic models” based on mere catch-effort data as well as the more complex “analytical models ” which consider aspects such as growth and mortality parameters of the fishes in the stock. **See section 2.3 for details**

## **3. What is the difference between MSY and MEY?**

MSY is a BRP that is based on the biological characteristics of the stock only like age/length at capture, fishing mortality and resultant yield. It does not take into considerations the economic aspects like cost of fishing and revenue from a fishery. Hence the concept of MEY is used. MEY is always at a lower level of fishing effort than MSY. **See section 2.6 for details**

## **4. What is Fisheries Management?**

Fisheries Management entails management of fish stocks for maximum benefit of all people involved in the sector. It is usually based on stock assessment made by scientists after taking into consideration the effects of fishing, environment, economic and social factors. There are various approaches to fisheries management and when properly enforced shall ensure the sustainability of the resources. **See section 2.4 and 2.5 for details**

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## Unit 3

# Management of Marine Fisheries in India

## Structure

- 3.0 Objectives
- 3.1 Introduction
- 3.2 Fisheries Legislations for Management of Marine Fisheries of India
- 3.3 Fisheries-related policies
- 3.4 Technical Controls in Marine Fisheries Management
- 3.5 Options for sustainable development of marine fisheries of India
- 3.6 Let us sum up
- 3.7 Key words
- 3.8 Further Readings
- 3.9 Check your Progress- (Questions and Answers/Hints)

## 3.0 Objectives

### After reading this unit you should be able to

- Explain fisheries management plans
- Understand various legislations for fisheries management in India
- Know the various options for fisheries management in India

## 3.1 Introduction

Fisheries Management Plans (FMP) is all about determining a detailed plan of what is required to achieve the policy objectives for that fishery resource. It is a task that, although usually performed by the fisheries management authority, is best performed with full participation of all interest groups in particular the fishermen, governments and concerned NGOs in the field. Single species management practices prevalent in temperate waters will not be suitable to multi species-multi gear systems of tropical waters such as in India. In a multi-species system it is impossible to maximize returns from all the constituent stocks. Here the goal of management should be to promote sustainable fishing practices that do not decrease the stock levels, ensure livelihood security, resource sustainability, economic efficiency and ecosystem integrity. Besides, fish stocks live in a highly variable and complex ecosystem, affected by human

intervention as well as the vagaries of nature resulting in environmental variations. Recently many reports of climate change induced variations in fish abundance and distribution patterns have been widely reported in many fisheries of the world including India. Therefore this uncertainty factor also has to be incorporated in the management strategies. Fisheries resources must be managed to harvest stocks at sustainable levels for ensuring livelihood security for the benefit of the present and future generations. Hence management of fisheries is not managing the fish stocks alone but also has to take into account all the stakeholders who are directly or indirectly involved, such as the fisher folk, traders, fish processing sector and consumers. Thus management measures should involve action taken for improvement/addition to infra structure, performance of fishing operations, reduction of wastage (by-catch, discards); improvements in quality/ value of fish caught and income from fisheries; protection of important coastal habitats such as mangroves and estuaries and resource enhancement programmes such as sea ranching, artificial reefs etc and efficient fish storage, distribution and marketing systems to ensure steady prices for the fishes caught and minimize wastage of valuable protein food.

To ensure that the management plan is put into operation and functions efficiently includes responsibilities such as:

- Collecting and analyzing the biological and fishery data necessary for assessment, monitoring, control and surveillance
- Adoption and promotion of appropriate and effective laws and regulations necessary to achieve objectives
- Ensuring that fisheries comply with them to achieve the objectives

### **3.2 Fisheries Legislations for Management of Marine Fisheries of India**

The need for fisheries legislation was emphasized as long back as in 1873 when the attention of the then Government of India was drawn towards widespread slaughter of fish, fry and fingerlings and was convinced of the urgency to adopt legislative measures to conserve the fisheries resources. As a result the Indian Fisheries Act came into being in 1897 with the following highlights,

- Prohibition of destructive methods of fishing such as dynamiting or use of fish poisons in inland and coastal waters (up to 3 nautical miles from the coast)
- Empowerment of Provincial governments to frame rules for protection of fish in selected water bodies, restricting the creation and use of fixed engines (dams, weirs, etc.) for catching fish; to put a limit on mesh size, size of fish and catch, and to ban the fishing in certain seasons and certain sensitive fish habitats such as nursery/spawning grounds

The rapid development of fisheries during the 60s and 70s paved the way for conflicts among the traditional and emerging mechanized sector and this prompted the Central Government to formulate a committee in 1976 to examine the questions of delimiting the areas of fishing of different types of boats. It culminated with the submission of a model Marine Fisheries Regulation Bill by the Committee in 1978, based on which all maritime states and union territories were required to make suitable legislations. Kerala and Goa were the first to enact the Marine Fisheries Act in 1980, followed by Maharashtra (1981), Orissa (1982), Tamilnadu(1983), Karnataka (1986), West Bengal (1993), Andhra Pradesh(1994), Gujarat and Andamans and Nicobar islands (2003) and Lakshadweep (2004). These Acts demarcate fishing zones in territorial waters for fishing by non-mechanized and mechanized fishing vessels which varies from state to state, generally reserves 5-10 km inshore waters only for the traditional sector although they are free to operate anywhere in deeper water also (Table 12.1). Along the west coast there is a seasonal closure of mechanized fishery for a period varying from 45 to 60 days during the south west monsoon period (June –August) and along the east coast for a period of 46 days from 15<sup>th</sup> April to 30<sup>th</sup> May.

Table 3.1. Fishing zone demarcation under MFRA of various states

State	Area demarcated for fishing	
	Artisanal	Mechanised
Maharashtra	10 - 20 m	beyond 20 m
Goa	within 5 km	beyond 5 km
Karnataka	within 6 km	OAL<15m: beyond 6 km OAL>15m: beyond 20 km
Kerala	within 10 km	GRT<25: beyond 10 km GRT>25: beyond 23 km
Tamil Nadu	within 5 km	beyond 5 km
Andhra Pradesh	within 10 km	OAL<20m: beyond 10 km OAL>20m: beyond 23 km
Orissa	within 5 km	OAL<15m: beyond 10 km OAL>15m: beyond 20 km

### 3.3 Fisheries-Related Policies

Recognizing the importance of fisheries in the coastal ecosystems and national economy several regulations and notifications have been promulgated by the central and state governments. The important ones are

- 1) Indian Ports Act (1963)
- 2) Indian Wildlife (Protection) Act (1972)
- 3) Water (Prevention and Control of Pollution ) Act (1974)

- 4) Territorial Waters, Continental Shelf, Exclusive Economic Zone and other Maritime Zones Act (1976)
- 5) The Coast Guard Act (1978)
- 6) The maritime Zones of India (Regulation of Fishing by Foreign Vessels ) Act (1981)
- 7) Environmental (Protection) Act (1986)
- 8) General Standards for Discharge of Wastewaters in Marine Coastal Areas (1993)
- 9) Notifications declaring coastal stretches as Coastal Regulatory Zone (CRZ) and regulating activities in CRZ (1991, 1994,1996)
- 10) Environmental Impact Assessment notification (1994)
- 11) Offshore Areas Mineral (Development and Regulation) Act (2002)
- 12) Marine Fishing Policy (2004)
- 13) Coastal Aquaculture Authority Act (2005)

Protection to coral and coral reefs which are critical fish habitats, forming valuable fisheries and of great livelihood importance are provided under the powers conferred under Section 10(3) of the Mines and Minerals (Regulation and Development) Act 1957. Marine turtles and mammals such as whales and dolphins are placed as endangered species under the Indian Wildlife (Protection) Act (1972) and protected. Turtle excluder devices (TEDs) are required to be fitted to fishing gears to reduce mortality of turtles. Coastal Regulation Zone (CRZ) Act, 1991 was promulgated by the Ministry of Environment and Forests and is concerned with regulating various activities in the coastal belt which is divided into 4 zones. CRZ is defined as the coastal stretches of seas, bays, estuaries, creeks, rivers and backwaters which are influenced by tidal action (in the landward side) upto 500 meters from the High Tide Line (HTL) and the land between the Low Tide Line (LTL) and the HTL. Marine parks have been created in many parts to afford protection to marine flora and fauna eg., Gulf of Mannar, Gulf of Kutch, Wandoor Marine Park, Andamans. India abides by the Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES). In June 1981, India also became a signatory to the Bonn Convention on the Conservation of Migratory species of Wild Animals.

### **3.4 Technical Controls in Marine Fisheries Management**

In order to maintain the fish stocks at a target level, the management used is that of controlling fishing mortality, that is the amount and age of the fish removed and this is achieved through various technical measures such as restrictions or constraints that regulate the efficiency

of fishing (mainly closed seasons, closed areas, gear restrictions such as type of gear, mesh size etc.)

#### **3.4.1. Input controls**

This is control of the effort put into the fishery. Effort can be measured in many ways e.g. number of vessels combined with size, horsepower, number of crew, number of fishing lines or gear; number of fishers combined with the gear they are using; or the number of days fished or other time measure. This includes,

- ❖ Limiting of Access to fisheries (e.g., through licenses)
- ❖ The size and power of boats (craft OAL, engine hp)
- ❖ The amount of time (days/hours) a boat can fish each month
- ❖ Size of the nets used

It is vital that if this type of control is being used that the increase in the technological ability of gears and fishers is taken into account. As this increases so does the effort and efficiency of the fishery.

#### **3.4.2. Output controls**

This is the direct regulation of the catch taken from the fishery, e.g. forms of quota management. This is a more total control of the primary factor 'the catch', but it can be both expensive and complex to enforce. Additional controls on the catch can also be made such as the size of fish or the maturity stage (juvenile/adult/spawner) of the fish.

- ❖ Total Allowable Catch (TAC) for a fishery
- ❖ Size limits ( for capture and marketing)
- ❖ Closed areas for fishing
- ❖ Closed seasons for fishing

##### **3.4.2.1 Total Allowable Catch (TAC) and Individual Transferable Quotas (ITQ)**

Concepts such as Total Allowable Catch (TAC) and Individual Transferable Quotas (ITQ) are followed in some countries to manage fisheries resource as part of output control measures. Under TAC system, a limit is set on the total quantity of fish belonging to a stock that can be taken during one fishing season. When this limit is achieved no more fishing is allowed until next season. This system forces each fisherman to engage in intensive fishing at the start of the fishing season to get the maximum share of the TAC before the total limit is reached. Since all fishermen operate based on this reasoning, there is a high possibility of many undesirable effects

such as glut in fish landings at the beginning of the fishing season itself, causing decline in returns as well as quality (if processing facilities are not equipped to handle the extra production) and wastage of fish. Disruption in the normal rate of fish production due to early closure of fishery can cause loss of employment as well as strain on the facilities and undesirable costs to the processors and traders. TACs are relatively difficult to implement in multi-species, small scale fisheries as in India where forecasting abundance and making proportionate changes in TAC allocations as well as exploiting all species at their optimum level is an up-hill task. In the Individual Transferable Quota (ITQ) mechanism, the sustainable catch giving MEY at a particular effort level or the TAC, is divided among fishermen in such a way that each one gets only a fixed quota. This is usually fixed as a percentage of the TAC, instead of the absolute value of the catch (tons or kilograms) to compensate for the annual variations in TAC due to natural fluctuations in abundance of stock primarily caused by environmental conditions. Being transferable, it is possible for trading of quotas which can be acquired by the fishermen with the lowest cost from the higher-cost fishermen who will be happy to sell their quota if the buyer can offer more value than the earnings they themselves will make by using their quota. ITQ is thus a "rights based" management and have been adopted in many countries including Australia, New Zealand, Canada and Iceland. Fisheries with a limited number and well defined group of participant, with a more or less homogenous fishing fleet are more amenable to management using ITQs. But the Indian marine fisheries sector is very much complex as example, there is one fishing village for every 2 km of coastline with an active fisher population of more than 0.9 million. In comparison the active fisher population at Iceland and New Zealand combined is only 12,000 and these two countries together produce 2.6 million tonnes annually (216 t per fisher) compared to 2.9 t per fisher in India. Hence in the Indian context, output control measures are not practicable as it involves enormous cost of monitoring and accurately quantifying the catches. Input control measures are relatively easier to implement but require an efficient monitoring system.

### **3.5 Options for Sustainable Development of Marine Fisheries of India**

#### **3.5.1 *Shift from Open-access to user rights***

As an input control measure, policy measures that abandons the present "open access" system to resource allocations and establishment of user rights is likely to be most effective for resources management and protection of critical fish habitats in the aquatic environment. If such measures are introduced they will, *inter alia*, provide greater incentives to reduce excess fishing capacity/pressure, which has been one of the major factors responsible for overfishing and unsustainable development. In addition, the establishment of user rights is particularly important in protecting the interest of artisanal fishers from unequal competition with industrial vessels.

The policy should aim to ensure socio-economic security for the artisanal fishermen whose livelihood depends solely on this avocation. Thus, the measures suggested are:

- Mandatory registration and licensing of all motorized and mechanized boats.
- Review of registration and licensing every five years.
- Upward revision of the registration, licensing fees and berthing charges to discourage new entrants.

### **3.5.2 Reduction of fishing effort**

The fishery regulation through effort reduction that is in vogue in different maritime states is chiefly aimed at the trawl fishery. In recent years, there has been significant increase of the motorized sector, especially the ringseine fishery and the mini-trawl fishery. This trend is most evident along the Kerala coast, causing concern for sustenance of some of the exploited stocks. There have been huge increases in the dimensions of gears employed giving it wider coverage of the fishing areas and resulting in higher catchability. Similarly, the increase in the time spent for fishing in the mechanized sector by undertaking multi-day voyage and use of sophisticated electronic devices for fish finding and communications has resulted in increased fishing efficiency. Action points suggested are:

- Fixing and capping the size and power of the boats in each sector by imposing upper limits for the length and horsepower, especially the large ring seiners operating in Kerala.
- Restriction of multi-day fishing by fixing upper limit for absence from the shore in all the states.
- Discourage further entry into the fishery through refusal of licensing to new boats.

### **3.5.3 Closed season/closed area /Marine Protected Areas (MPAs)**

Recognizing the necessity for ensuring sustainable yields from the exploited stocks, certain maritime states have enacted fishery regulation acts enabling effort reduction, rebuilding of the stocks and ecosystem rejuvenation by closure of fishery for a specified period of time. Restriction of the number of days of fishing during monsoon is the most common method followed in India. The objectives being protection of the spawning stocks from capture by mechanized fishing vessels and also allow the natural replenishment of the fish stocks. Presently, there is consensus among the fishermen that the intensive exploitation of the coastal waters does adversely affect the ecosystem resulting in low productivity from different trophic levels. This has led to the acceptance of a uniform ban on mechanized (mainly trawl fishing) crafts during the monsoon months along the entire Indian coast.

Designating areas of fish spawning and feeding as Marine Protected Areas (MPAs) in which fishing is prohibited, allow rapid build-up of fish spawning stock biomass. The idea behind reserves is that if the fish are protected from fishing, they live longer, grow larger and produce an exponentially increasing number of eggs. It is observed that adult fishes tend to remain in the protected areas while their larvae help replenish adjacent fisheries. Marine reserves in the Gulf of Mannar, Gulf of Kutch and Andamans are a right step in this direction.

**The suggested measures are:**

- Mandatory closed fishing season from 15<sup>th</sup> June to 31<sup>st</sup> July for the west coast.
- Mandatory closed fishing season from 15<sup>th</sup> April to 30<sup>th</sup> May for the east coast.
- Only non-motorized and low horse powered motorized (up to 10 HP) OBM/IBM vessels to be allowed to operate during the closed season.
- *DoI* net operations off Maharashtra and Gujarat to be controlled by closure of fishing area in specified fishing zones.

**3.5.4 Mesh-size regulations and curbs on destruction of fish juveniles**

The fine meshes of gears like trawls and bag nets cause large-scale destruction of juveniles of many important commercial fishes. The cod end mesh size (CEMS) of the trawls prevalent in India is uniformly very small (10-15 mm stretched knot to knot) while the recommended minimum stretched mesh size is 35 mm. It may be recommended that a cod end mesh size of 35 mm may be enforced in Indian waters to ensure sustainable exploitation of the fish and shrimp stocks. As regards to lobster resource, Central Marine Fisheries Research Institute (CMFRI) has recommended the Minimum Legal Weight (MLW) for capture of four species of lobsters to ensure sustainable exploitation of the resource. Based on the recommendations of CMFRI, the Ministry of Commerce, Govt. of India has issued orders specifying the Minimum Legal Weight fixed for lobster exports as *Panulirus homarus* – 200 g, *P. polyphagus* – 300 g, *P. ornatus* – 500 g and *Thenus orientalis* – 150 g. Similarly, for silver pomfret (*Pampus argenteus*) the MLW suggested is 300g.

The fishing for shrimp seed along the coastal waters of the east coast is yet another example of the destruction of valuable ichthyo-plankton. For every shrimp seed collected, hundreds of other larvae and juveniles of commercially important species of fin-fishes and shell-fishes are destroyed. The juvenile fishing should be stopped forthwith and interventions required are:

- Complete ban on landing and marketing of juvenile fish.
- Minimum export size of high value resources should be fixed.



- Restrictions on collection of natural shrimp seeds.
- Awareness creation

### ***3.5.5 Diversification of vessels and targeting specific resources***

To ease out fishing pressure in the inshore waters, the existing vessels may be suitably upgraded/modified as multipurpose/combination vessels to harvest the under tapped resources like tunas, bill fishes, pelagic sharks and oceanic squids available in the oceanic and deeper waters. The suggested options are:

- Diversification of fishing to passive fishing by gill nets, squid jigging and hooks & lines
- Promote deep-sea fishing by resource specific craft and gear (long lining) to tap the oceanic/deepwater tuna resources.

### ***3.5.6 Participatory management***

Management of fisheries can be made more effective if the principal stakeholders are involved in the decision-making and its implementation. Fishermen cooperatives can be formed which can be vested with the responsibility of protecting the fisheries resources they harvest. They should be made aware of the biological and environmental basis for sustainability of fish stocks by constant interactions with the scientific community. Such interactions will be mutually beneficial to the fishermen, fishery scientists and the policy makers and make the implementation of the management measures/options smooth and effective.

### ***3.5.7. Strengthening of Management Information System***

The basic requirement for knowledge based fisheries management is availability of reliable and adequate data on the resources and their dynamics including economics of fishing. For this, an effective data acquisition mechanism is needed. The maritime states must develop mechanisms to generate reliable data on marine fish landings and fishing effort, which can be used for understanding dynamics of the fisheries as well as for regulating their exploitation. For this, linked to the schemes for registration of crafts and availing of subsidies etc. by the fishermen, compulsory availability of fishing log books to identified national research institutes such as CMFRI, can be enforced.

### ***3.5.8. Strengthening of Fisheries Extension Programmes:***

Fisheries development is closely related with the improvement in the ability of the fisherman's/fish farmer's understanding and adoption of sustainable fishing practices and innovative mariculture technologies. Extension agencies facilitate transfer of useful and practical

information emerging from research activities and inform the scientific community of the problems of fishermen/farmers for finding suitable solutions. The extension system in Marine Fisheries in India is conspicuous by the absence of its formal institutionalization as in the case of Agriculture sector where the Transfer of Technology (ToT) approach (a three tier system comprising of technology generation, frontline extension and grassroots level extension) is followed. In this approach the technology generation and frontline extension activities come under the mandate of ICAR research institutes as well as State Agricultural Universities while grassroots level extension is carried out by State departments. The Krishi Vigyan Kendras (KVK), Brackishwater Fish-Farmers Development Agencies (BFFDA); the Institute Village Linkage Programme (IVLP) and Agricultural Technological Information Centres (ATIC) of Indian Council of Agricultural Research (ICAR) are playing an important role in extension programmes of the marine fisheries sector. However, the State Fisheries Departments the main agency concerned with extension, are doing little extension work, and are mainly concerned with implementation of regulatory measures and welfare programmes for fishermen. Hence, there is great need to develop a Research-Extension system oriented towards responsible and sustainable fisheries in the country. In marine fisheries sector extension efforts were fruitful in the introduction of mechanized trawler boats under the Indo-Norwegian Project (INP), fiberglass beach landing crafts by the Bay of Bengal Programme (BOBP), improved 45 feet OAL mechanized boats for deep sea trawling under Indo- Danish (DANIDA) Project and improved fish processing by sun drying and salt curing. Further scope for useful extension exists in creating awareness among fishermen of adverse consequences of destruction of fish eggs and juveniles and discarding fish at sea; conservation of endangered species and fragile marine ecosystems, improvement of hygiene and sanitation in landing/processing centres, production of value added products, ornamental fish culture and mariculture activities.

### ***3.5.9 Implementation of appropriate Fishing Policy***

Fisheries policies give broad directions and priorities on how the resources of nation or region are to be utilized. These policies consider the biological characteristics of the stock, the nature of existing or potential fisheries and other activities related to or impacting on the stock. They also consider the potential economic and social contribution of the fishery to national or local needs and goals. Review of fisheries policy is required and will depend on changes in the national or regional scene. A comprehensive national fishing policy namely, *Marine Fishing Policy - 2004* was introduced for the first time recently by the Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture, Govt. of India. The policy objectives are: (1) to augment marine fish production of the country up to the sustainable level in a responsible manner so as to

boost export of sea food from the country and also to increase per capita fish protein intake of the masses, (2) to ensure socio-economic security of the artisanal fishermen whose livelihood solely depends on this vocation, (3) to ensure sustainable development of marine fisheries with due concern for ecological integrity and biodiversity. In the policy, the need for a shift from the open access to the limited entry concept in the territorial waters besides enforcing stringent management measures for sustained production is stressed. It seeks to bring both traditional and coastal fishermen into focus together with stake holders in the deep sea sector so as to achieve development of marine fisheries in the territorial and off shore regions of the Indian EEZ.

Thus, a road map for ensuring sustainability, equitability, ecosystem conservation, eliminating destructive gears, reducing by-catch and discards and juvenile destruction, diversification of fishing into new areas, new resources, ensuring conservation of endangered and threatened species groups, putting into practice the FAO Code of Conduct for Responsible Fisheries and ultimately evolving a working model for an informed participatory management of marine fisheries resources of the country is the need of the hour. This can be achieved only jointly by all the stakeholders including fishers, scientists, policy developers and implementers.

### **3.6 Let us Sum Up**

Fisheries Management Plans are necessary to ensure sustainable development of fisheries sector and are best done with the involvement of scientific community, fishermen and other stakeholders as well as policy makers. Compared to temperate countries, the multi-gear and multi-species fishery common in tropical waters (eg.India) poses lots of challenges in the formulation of management plans. Various fisheries legislations and policies are in place to enforce FMP in Indian waters. However, there are still weak links in the Monitoring, Control and Surveillance (MCS) activities related to fisheries management. Various options for the sustainable development and management of the marine fisheries sector include shifting from an "open access" to a "rights based" fishing system, reduction in fishing effort in coastal waters, sustainable fishing practices aimed at minimizing catches of juveniles and discards, habitat conservation through MPAs, closed seasons and closed areas, protection of mangroves; encouragement to offshore fishing, strengthening of extension services and formulation and implementation of appropriate fishing policies.

### **3.7 Key Words**

***Closed season*** : The banning of fishing activity (in an area or of an entire fishery) for a few weeks or months to protect juveniles or spawners.

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

**Fishery Management Plan (FMP):** A plan to achieve specified management goals for a fishery. It includes data, analyses and management measures for a fishery.

**Fishing power.** The catch which a particular gear or vessel takes from a given density of fish during a certain time interval. Larger vessels have greater ability to catch more fish and hence greater fishing power combined to smaller vessels. Also improvements in craft or gears (fish finders, engine horse power, less visible net material etc.) can increase fishing power.

**Individual Transferable Quotas (ITQ) :** It is a rights based fisheries management measure where the TAC, is divided among fishermen in such a way that each one gets only a fixed quota ( usually fixed as a percentage of the TAC). Being transferable, it is possible for trading of quotas among the fishermen.

**MPA:** Any area of intertidal or subtidal terrain, together with its overlaying waters, and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment. They are a kind of a precautionary approach to fisheries management

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

**Open access :** A condition of a fishery in which anyone who wishes to fish may do so.

**Over-capitalisation:** Where the amount of harvesting capacity in a fishery exceeds the amount needed to harvest the desired amount of fish at least cost

**Total Allowable Catch (TAC):** As a fisheries management measure, a limit is set on the total quantity of fish belonging to a stock that can be taken during one fishing season and is called TAC.

### 3.8 Further Readings

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### 3.9 Check Your Progress- (Questions and Answers/Hints)

#### 1. What is a Fishery Management Plan?

FMP is a detailed plan of what is required to achieve the policy objectives for that fishery resource—conservation, increased exploitation/ restricted exploitation etc. It is a task that has to be performed by the fisheries management authority with full participation of all interest groups in particular the fishermen, governments and concerned NGOs in the field to get best results. An FMP should contain various guidelines and adequately address concerns of livelihood security, resource sustainability, economic efficiency and ecosystem integrity. **See section 3.1 for details**

#### 2. What are various fisheries legislations in India aimed at conserving /protection of fisheries?

Various fisheries legislations in India aimed at conserving /protection of fisheries are in place the earliest being in 1897, the Indian Fisheries Act. Based on this Marine Fishing Regulations have come up in various state. In addition there are various laws and policies to ensure sustainable development of marine fisheries in India. **See section 3.2 and 3.3 for details**

### **3. What are the various options for fisheries management in India?**

The various options for fisheries management in India include a gradual switch over from an open-access fishing system to a rights based/well- regulated fishery, controls on fishing effort, fishing areas, diversify fishing to offshore, adoption of better harvest/post-harvest methods, reduction in destructive fishing (discards, dynamite fishing, juvenile fishing etc.), strengthening of fisheries extension and awareness programmes, participatory management programmes and strengthening of management information system. **See section 3.4 and 3.5 for details**

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## Unit 4

# Mariculture and Fisheries Development

### Structure

- 4.0 Objectives
- 4.1 Introduction
- 4.2 Mariculture technologies
- 4.3 Constraints and interventions required
- 4.4 Let us sum up
- 4.5 Key words
- 4.6 Further readings
- 4.7 Check your progress (Questions and Answers/Hints)

### 4.0 Objectives

**After reading this unit you should be in a position to**

- Understand mariculture
- Know various mariculture technologies in India

### 4.1 Introduction

Given that yields from marine capture fisheries are stagnating the only sector which can augment the yield and income from marine fisheries is mariculture which is the culture of marine organisms in the coastal or open sea environment. India has vast areas of suitable coastal areas, lagoons and bays but the annual mariculture production is only about 80,000 to 100,000 tons only, almost entirely constituted by shrimps such as tiger prawn (*Penaeus monodon*) or Indian white prawn (*Penaeus indicus*). A wide variety of species are used for mariculture globally. In south-east Asian countries, the Asian sea bass, *Lates calcarifer*, grouper *Epinephelus* spp., cobia *Rachycentron canadum* are favored. The sea breams (*Sparus aurata* (gilthead), *Chrysophrys major* (red sea bream) are cultured in Japan and Korea. Yellowtail *Seriola quinqueradiata* is the most important cultured fish in Japan while mullet *Mugil cephalus* is highly priced in the Mediterranean. Japan, Korea, Taiwan, China and Phillipines have highly successful seaweed culture and processing sectors. The seaweeds cultivated include edible species such as *Porphyra* and *Undaria*; agar yielding species like *Gracilaria*, *Laminaria* etc and carrageenan yielding *Kappaphycus* spp. Historically, mariculture in India is synonymous with crustacean culture, mainly shrimps, although Hornell as early as in 1911 suggested that marine finfish culture may be initiated in the coastal saline swamps, estuaries, backwaters and saltpans. Initiatives were also

taken by the Madras Fisheries Department to farm milkfish and mullets in the tide fed marshy swamps of Krusadi islands, Mandapam as early as in 1944. However mariculture has not yet reached its full potential in India although a lot of positive developments have taken place in recent years. The CMFR Institute is the pioneering institute in the country that initiated mariculture research and developed mariculture technologies. Although mariculture of fin-fish and seaweed is yet to attain its full potential, culture technologies developed for crustaceans and mollusks have contributed immensely to the development of the fisheries sector. The total area under shrimp culture during 2002-03 period was 0.152 million ha. Shrimp farming has resulted in substantial increase in shrimp production for exports of the country and also generated employment directly as well as in related industries (hatcheries, aqua-feed manufacturing and marketing, health monitoring etc.). Today, coastal aquaculture has developed into an industry with a total investment of about 2000 crore rupees, bulk of which is from private sector funding. The Coastal Aquaculture Authority Act (2005) was created to give the impetus to develop sustainable aquaculture practices as well as encourage species diversification with regards to candidate species for coastal aquaculture.

## **4.2 Mariculture Technologies**

### ***4.2.1. Shrimp farming and hatchery technology***

The origin of shrimp mariculture in India can be traced to the “trapping and holding” system for shrimp seed brought in by tides into the low-lying ponds in the vicinity of the Vembanad lake of Kerala and Sunderbans of West Bengal. In course of time this technology was adapted to selectively stock some additional seed of fast growing species (like *Penaeus indicus*, *Penaeus monodon*) besides the species already coming in with the tides and also some additional inputs like feed and water exchange. In course of time the technology and package of practices have evolved to include selective stocking of species according to the productivity of the farm, feeding with formulated feeds and growing to pre-determined duration for maximum yield and profitability. To meet their needs farmers depended on natural seed collection from estuaries and backwaters. As timely availability of shrimp seed of desired quality and in the required quantity is crucial to the success of shrimp farming hatchery production of shrimp seed was emphasized for the development of scientific shrimp farming. The Narakkal Prawn Culture Laboratory (NPCL) of CMFRI with its attached shrimp hatchery was established in 1974 and within a short period was able to breed and rear larvae of many commercially important species of shrimps. Shrimps being a highly valued export commodity, shrimp farming took up on a large scale during the 1990s. The MPEDA also gave much thrust to these programmes through their various subsidies for the farmers. Many new farms and hatcheries sprang up and created new employment opportunities. But the euphoria could not last as the developments were not subject to any regulations nor



guided by any principles of sustainability. Large number of farms practicing intensive shrimp culture along the coastal areas caused conflicts with traditional fishermen whose access to the sea was blocked. Large scale exploitation of shrimp seed from coastal areas to stock some of these farms were perceived as harming the natural recruitment to the fishery adversely affecting their catches and income. Disease outbreaks under the highly intensive stocking of shrimp seed and discharge of waste effluents which were causing pollution in the coastal areas became major issues. Finally the Supreme Court of India had to intervene and many regulations like the CRZ Act, Polluter Pays Principle etc. came into being to regulate shrimp farming in a sustainable manner. The situation improved thereafter and during 2003-04 India produced about 1.12 lakh tons of shrimps by culture from an area of 1.55 lakh ha.

#### **4.2.2 Mussel/oyster farming**

Culture of the filter feeding bivalves which are low in the food chain and hence do not require any supplementary feed is a low energy input activity that can be successfully undertaken by small scale coastal fisher-folk in nearby water bodies. This is already evident in many maritime states of India like Kerala, Karnataka and Goa. Mussel (*Perna viridis*) is cultured by raft method (in bays, inshore waters), rack method (in estuaries and backwaters) and long-line method (in open sea). Mussel seed (15-25 mm size) collected from natural beds are attached to coir/nylon ropes of 1-6 m length and enveloped by a mosquito net. These ropes are hung from rafts, racks or long-lines depending on the technology adopted. After a few days, seeds get attached to the rope while the netting disintegrates. A harvestable size of 70 -80 mm is reached in 5- 7 months and the production per meter of rope is 12-14 kg (shell on). Oyster (*Crassostrea madrasensis*) using rack and ren method is also being taken up by small scale fishermen. In all these technology transfers, various agencies like BFFDA, Department of Women and Children in Rural Areas (DWCRA), Aquaculture Development Agency for Kerala (ADAK) and Training Rural Youth for Self-employment (TRYSEM) have played a key role. NABARD has also accepted these technologies developed by CMFRI for refinance and thanks to these initiatives farmed mussel production along the Kerala coast was around 16000 t in 2007 compared to nil in late 1990s.

#### **4.2.3 Pearl oyster farming and Pearl production**

Success in production of cultured pearls was achieved for the first time in 1973 by CMFRI using the pearl oyster *Pinctada fucata*. Raft culture and rack culture in inshore areas are two methods commonly adopted for rearing pearl oysters and recently on-shore technology has also been developed. Shell bead nucleus (3-8 mm) implantation is done in the gonads of the oyster through surgical incision while graft tissues are prepared from the donor oysters of the same size and age group. Implanted oysters are kept in flow-through systems in the laboratory for 3-4 days

and then shifted to the farm in small cages for rearing for 3-12 months. Periodical cleaning is required during this period and about 25% pearl production has been demonstrated in a series of farm trial along the Indian coast. Pearls are categorized as A, B or C depending on their colour, lustre and shape. Technology for mass production of pearl oyster seed has paved the way for its emergence as a successful coastal aquaculture activity. Pearl oyster farming and pearl production has been successfully carried out with active involvement of coastal fishermen of Vallinokkam Bay as part of the technology transfer programme of CMFRI. Recently, the M.S. Swaminathan Foundation, Chennai has also initiated activities on pearl culture as a community programme in the Gulf of Mannar area using nucleated pearl oysters supplied by CMFRI.

#### **4.2.4 Seaweed farming**

Surveys carried out by Central Salt and Marine Chemicals Research Institute ( CSMCRI) and CMFRI have revealed vast seaweed resources along the west coast of India which have great potential for development of seaweed based industries (for agar, agarose and carrageenan) in India. The leading seaweed mariculture countries are China, Korea, Japan, Phillippines, Chile, Norway, Indonesia and USA followed by India. The seaweed industry in India until recently was mainly a cottage industry based on the natural stock of agar yielding red seaweeds (*Gracilaria edulis*, *Gelidiella acerosa*) and algin yielding brown seaweeds (*Sargassum* spp.). In recent years the farming of the carrageenan yielding *Kappaphycus* spp. has picked up on a large scale along the Tamilnadu coast. Seaweed mariculture is essential for a continuous supply of raw material for the industry with improved yield and quality which can also ease the exploitation pressure on natural beds. Culture methods involve either vegetative propagation using fragments from mother plants or using spores. Fragments of adult/juvenile plants, spores are seeded on to polypropylene ropes of 10 mm diameter and hung from floating rafts at depths upto 3-4m. Considering the immense market for seaweed products, it shall play a key role in development of coastal fishing communities and a valuable foreign exchange earner. There is urgent need to promote and train coastal fisher-folk especially women in taking up seaweed mariculture. Already many state governments and NGOs are taking up this promotion and the newly constituted National Fisheries Development Board (NFDB) is also encouraging training on seaweed farming. Polyculture of seaweeds in association with shrimp/fish also has been demonstrated to have benefits on productivity of the ponds as well as a source of additional income to the farmer and the same needs popularization. The impacts of sea farming on the ecosystem can also be done simultaneously by concerned research organizations to ensure a sustainable type of seaweed mariculture development process.

#### **4.2.5 Marine ornamental fish breeding**

Marine ornamental fish breeding technologies have the scope to reduce the fishing pressure on the various ornamental resources which are mostly found in sensitive ecosystems such as coral reefs and sea grass bed. They are also likely to be more economically feasible than that of marine food fish culture due to high unit price per number of ornamental fish. In addition these can be taken up by coastal fisher-folk, especially women as a means to supplement their income. CMFRI has developed breeding and seed production technologies for marine ornamentals such as clownfishes and damsel fishes (*Amphiprion sebae*, *A.percula*, *A.ocellaris*, *Premnas biaculeatus*, *Pomacentrus pavo*, *P.caeruleus*, *Neopomacentrus filamentosus*, *N.nemurus*, *Dascyllus auranus*, *D.trimaculatus* and *Chromis viridis*).

#### **4.2.6 Lobster fattening**

There is huge demand for lobsters in the international seafood market and the price difference between a small (<100 g) and larger (>100 g) lobster is three fold. At the same time a large number of undersized lobsters are caught and these have been successfully grown to larger sizes in small inter-tidal ponds, feeding them with cheap molluscan meat and trash fish until they reach 125 g weight.

#### **4.2.7 Open Sea Cage Culture / Capture based aquaculture (CBA)**

Open sea cage culture is fast developing as the most efficient and economical way of raising fish. It has several advantages over land based aquaculture systems in that it can achieve optimum carrying capacity as current flow brings in fresh water and removes metabolic wastes and excess feed. Simple cage designs for inshore waters are relatively easy to construct with minimal skilled labour. The ideal locations for cage farming along the Indian coast include the bays in Ratnagiri, Goa, Karwar, Palk Bay, Gulf of Mannar, Lawson's Bay, Lakshadweep islands and Andaman and Nicobar islands. Capture based Aquaculture (CBA) is defined as the practice of collecting "seed" material (from early life stages to adults) from the wild and its subsequent rearing in captivity using aquaculture techniques to a marketable size. It is an intermediate between capture fisheries and true mariculture and can provide alternate livelihood or an additional source of income for local coastal communities. In India since the seed production technologies of many species are either not standardized or commercially viable, CBA can be developed with proper management. Many fin-fish seed of commercially important species are netted along with other fish during operation of shore seines and other artisanal gears by coastal fishermen. These can be used to stock in cages in the nearshore areas to grow them to marketable sizes and thus help the fishermen make an additional income.

#### **4.2.8 Conservation mariculture**

The stocks of many commercially important marine species have shown decline due to unsustainable fishing practices as well as environment and habitat changes. Gastropods such as chanks (*Xancus*), *Trochus*, *Turbo*; sea horse (*Hippocampus* spp.) and sea cucumbers (*Holothuria* spp.) are some of the species amenable for conservation through large scale seed production and sea ranching.

### **4.3 Constraints and Interventions Required**

A major lacuna in the development of mariculture in the country is the ambiguity surrounding use of coastal water bodies which are “common property” and the lack of clear legislations regarding their use for mariculture activities. Leasing policies for open sea mariculture sites and protection from poaching are to be considered on a priority basis. Another major constraint is the lack of availability of seed for commercial level of farming for which a concerted research thrust for development of commercial level seed production technologies of candidate species is required. Guidelines for open sea mariculture on precautionary principles should also be evolved. A focused research and development thrust along with proper legislations and policy formulations in marine farming sector can pave the way for India to emerge as one of the major mariculture production countries of the world in the near future.

### **4.4 Let us Sum Up**

Mariculture is the culture of marine organisms. In spite of its immense potential mariculture has not yet taken off in India although in many other Asian countries such as China, Indonesia and Thailand immense progress has been made with regards to culture of shrimps and finfish. There are various mariculture technologies present in India today which can be adopted successfully to increase marine fish production and also provide additional income to fishermen.

### **4.5 Key Words**

**Mariculture:** Cultivation, management and harvesting of marine organisms in the sea, in specially constructed rearing facilities e.g. cages, pens and long-lines. For the purpose of FAO statistics, mariculture refers to cultivation of the end product in seawater even though earlier stages in the life cycle of the concerned aquatic organisms may be cultured in brackish water or freshwater or captured from the wild.

**Polluter-Pays Principle:** Adopted by OECD in 1972 as a fundamental principle for allocating to polluters the costs of pollution prevention and control measures introduced by public authorities

## 4.6 Further Readings

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## 4.7 Check Your Progress (Questions and Answers/Hints)

### 1. Define mariculture and its role in fisheries development.

Mariculture is the cultivation, management and harvesting of marine organisms in the sea, in specially constructed rearing facilities. There are a variety of candidate species for mariculture, including fin-fish, mollusks, seaweeds and echinoderms. Mariculture activities can be taken up successfully in India given that there is a vast area of open sea as well as sheltered bays and coves, besides estuaries. Mariculture development offers a means of augmenting income of coastal fishermen of India as many low-cost and environment friendly technologies are available eg., Mussel/oyster farming. However, there are also constraints and mariculture has not yet taken off completely and realized its full potential. **See section 4.1 and 4.3 for details.**

### 2. What are the various mariculture technologies available in India?

Mariculture technologies available in India include those developed for shrimps, mussels, oysters, pearl oyster, marine ornamental fish, sea cucumber, lobsters, seaweed and finfish. Many of these technologies are to be further developed to be adopted on a commercial scale. **See section 4.2 for details.**

### 3. What is capture based aquaculture and its scope for fisheries development?

Capture Based Aquaculture (CBA) is intermediate between capture fisheries and true mariculture. It allows the culture of undersized marine organisms of mariculture importance to be grown to marketable sizes in enclosures placed in the sea. CBA allows fishermen to make additional income as well as prevent undesirable loss of valuable fish seed/juveniles that are incidentally caught in near shore fishing operations such as by shore seines. In India CBA has been attempted with lobsters and also certain fin-fishes. **See section 4.2.7 for details.**

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