Marine Fisheries Along the Southwest Coast of India

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Abstract

Marine fisheries production in India has increased from 0.5 million t in 1950 to 2.47 million t in 1997. The gross value of fisheries landings in India was US$2.37 billion in 1997. The contribution of fisheries to the Gross Domestic Product (GDP) has risen from 0.7% in 1980 - 81 to 1.2% in 1994 - 95. The contribution to agricultural GDP has risen from 1.9% to 4%. Fisheries production also plays a critical role in food security and livelihood in rural areas.

The southwest (SW) coast, while only 16% of the Indian coastline, is an important area for marine fisheries production, contributing 31.7% (0.74 million t) in 1993 - 98. This production is dominated by pelagic (59% of landings) and demersal species (23%). However, the open access system has resulted in rapid increases in fishing effort, particularly in the coastal areas. The density of fishers inshore has increased from 3.6 to 8.5 fishers per km^2 in the past four decades. This excess effort has resulted in overfishing of the stocks and lower economic rent from the fishery.

The overall objective of coastal fisheries management along the southwest coast of India is sustainable coastal fisheries development. This requires key ecological, social, economic and administrative issues to be addressed. Ecological sustainability requires the reduction of the excess effort through limited entry and effort reduction schemes, appropriate exploitation patterns through improved gear selectivity and restoration of the degraded coastal environment through integrated coastal zone management initiatives. Key social interventions include: creation of alternative employment to reduce fisher numbers, prevention/management of increasing intra- and inter-sectoral conflicts and empowerment of artisanal fishers through co-management schemes, social legislation and improved support/welfare schemes. The key economic issues include declining earnings, particularly of artisanal fishers, which requires; optimizing fleet composition for economic returns, improvement of the marketing system and cold storage chains, improvement of post-harvest processes to increase product value. The key administrative needs are a strong fisheries policy that balances welfare concerns with sustainability, effective implementation of regulations, and increased government resources for fisheries management. Project briefs covering the key interventions are provided, however these require further review and improvement in collaboration with concerned stakeholders.

Introduction

Indian marine fisheries production was only 0.5 million t in 1950, and rose to a peak of 2.7 million t in 1998. In 1998, production from inshore waters (< 50 m depth) reached the estimated potential yield (2.2 million t), and scope for further increase is limited (Anon 1991). Monitoring in fish landing centers shows that catch rates are declining. Fishers and the number and efficiency of fishing vessels has substantially increased, leading to depletion of fish stocks and conflict among different stakeholders. Improvements in craft and gear technology to increase fish production are becoming counter-productive.

The major problem in Indian marine fisheries is inadequate fisheries management. Considering the country's diverse and vast coastline, efforts must be specific to the fisheries' situation in each coastal zone. With this in mind, this paper reviews the fisheries situation along the southwest (SW) coast of India. The paper focuses on identifying key issues and appropriate management directions for fisheries in the area.

Coastal Environment

The southwest coast region of India extends from about 8° N to 15° 30' N (Fig.1) with a coastline length of 994 km, adjoining three maritime states, Kerala, Karnataka and Goa. The continental shelf area off the southwest coast is 75 400 km^2 (Table 1) and 31% of the area is less than 50 m depth.

Wind patterns and water circulation in the Arabian Sea differ drastically from patterns in similar latitudes (Wyrtki 1973). There is a seasonal change in the winds north of the equator. Winds blow over the equatorial ocean between November and March causing the northeast monsoon. From May to September, the system reverses and the southeast trade winds extend across the equator and blow across the northern Indian Ocean as the southwest monsoon (Tomczak and Godfrey 1994). During the northeast monsoon, there is a north equatorial current, while during the southwest monsoon the circulation in the northern Indian Ocean largely reverses and the westward north equatorial current is replaced by an eastward southwest monsoon current, flowing with the equatorial countercurrent.

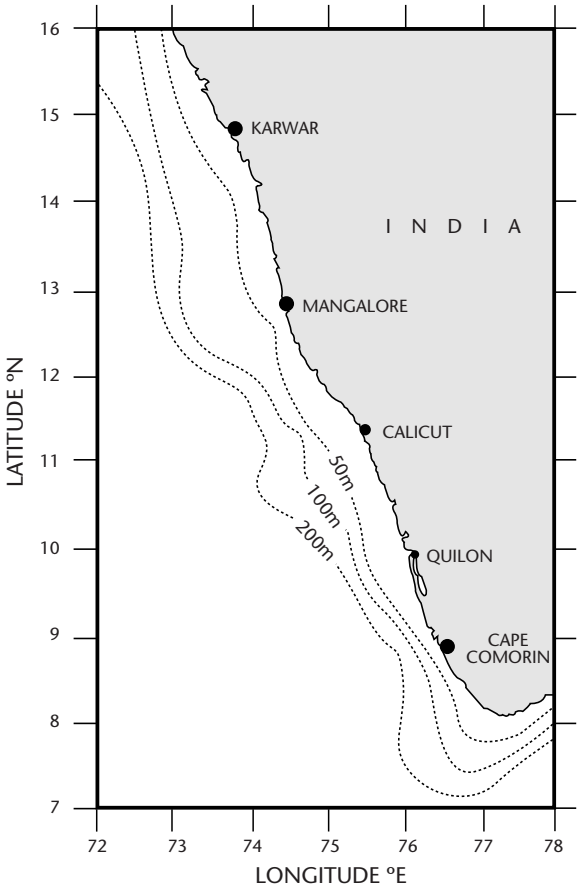

Fig. 1. Study area: the southwest coast of India.

Table 1. Coastline length and shelf area off the southwest coast of India.

State	Location	Length of coast (km)	Area (x10^3 km^2)	
			< 50 m depth	< 200 m depth
Kerala	8° N to 12° N	590	12.6	39.9
Karnataka	12° N to 15° N	300	7.9	25.5
Goa	15° N to 15° 30′ N	104	2.9	10.0
TOTAL	8° N to 15° 30′ N	994	23.4	75.4

Seasonal changes in winds and currents induce an annual cycle of hydrographic events along the southwest coast (Table 2). During the monsoon, the southerly current spreads over the entire continental shelf. Isolines of water temperature, salinity, dissolved oxygen (DO) and density lift to the surface (upwelling) and occupy the area between the southerly current and the coast. Consequently, dense and cool water with low DO occupies the surface near the coast. During the post-monsoon period (October - January), there is a strong current with northerly flow. On the seaward side of the flow, there exists a southerly flow only in the southern region of the southwest coast. During this period, low saline equatorial waters are advected northwards causing sinking of high saline Arabian Sea water between 10º N and 12º N (Devaraj et al. 1997). During the pre-monsoon period (February - May), the northerly current disappears and the southerly flow constricts to a narrow belt.

The southwest coast, particularly the southern part from 9º N to 13º N, is characterized by mudbanks. The mudbanks are 1 to 3 m thick in calm, turbid waters with a high load of suspended sediment. They appear close to shore in a stretch of 2 to 5 km parallel to the coast, and with a width of 1.5 to 4 km. The mudbanks appear with the onset of the southwest monsoon (May/June) and disappear with its withdrawal (September/October). The mudbanks are formed due to periodic stress from the waves over a muddy bottom, resulting in bed erosion, generation of fluid mud and wave attenuation (Anon. 1984). The combined action of waves and currents transport the fluid mud nearshore. After about 2 months, the fluid mud exhibits downslide movement, dissipating the mudbank. The mudbanks usually form in the same place every year. Year to year shifting of the mudbanks, if any, is due to variations in bathymetric conditions, which determine the magnitude of energy convergence.

The mudbank sediment consists of highly cohesive and flocculated clay. The most dominant texture is silt or clay with sand. Mud density ranges from 1 080 to 1 300 $kg \cdot m^{-3}$ and dispersed particle size ranges between 0.5 and 3 µm (Devaraj et al. 1999). The mudbank area is rich in phytoplankton (70 to

Table 2. Hydrographic conditions during pre-monsoon, monsoon and post-monsoon seasons along the southwest coast of India.

Parameter	Pre-monsoon	Monsoon	Post-monsoon
Current	Northerly current disappears; southerly flow restricted to a narrow belt	Southerly current spreads in the entire shelf. Isolines of water temperature, salinity, DO & density lift to the surface (upwelling) and occupy the area between the southerly current and the coast	Strong northerly flow; on the seaward side of flow, southerly flow only in the southern region; Low saline equatorial waters advected northwards, causing sinking of high saline Arabian Sea water below the high saline equatorial waters between 10º N and 12º N
Temperature	Mean Sea Surface Temperature (SST): 30º C	Mean SST: 24º C; Thermocline on the surface	Mean SST: 23ºC; Thermocline moves from surface (Oct - Nov) and reaches deep water (Dec - Feb)
Salinity	Mean Sea Surface Salinity (SSS): 36 ppt	Mean SSS: 32.5 ppt; Maximum salinity at 30 to 50 m depth	SSS (33 ppt) off Cape Comorin, increases towards north and 35 ppt off Karwar; SSS maximum at 100 - 150 m depth
Dissolved Oxygen (DO)	Shelf waters well-aerated (mean DO: 5 $ml \cdot l^{-1}$)	Oxygen deficient waters start penetrating the shelf by May; completely cover the bottom of the shelf by June - July; by August, oxycline becomes shallow and reaches the surface; remains till Sep - Oct; oxycline remains for 6 months in northern sector and only for 2 months in southern sector. However, DO is higher in the north as the intensity of upwelling is low.	Shelf waters well-aerated (mean DO: 4.5 $ml \cdot l^{-1}$)

130 ml•l^{-1}) and chlorophyll a (11 to 33 mg•m^{-3}). Blooms of phytoplankton (> 10 000 cells•ml^{-1}), mainly *Noctiluca* spp., *Skeletonema* spp. and *Fragilaria* spp. occur in the mudbanks, which are inhabited by 58 species of planktonic algae (Anon. 1984). Zooplankton biomass is high (up to 4.1 ml/per 10 minute haul) in the mudbanks compared to that (1 ml/per 10 minute haul) of pre- or post-mudbank seasons. There are 19 groups of zooplankton dominated by copepods (80%).

The sediments of mudbanks carry rich loads of organic matter (5%). About 90 to 95% of benthic fauna in the mudbank consist of polychaetes and molluscs. The calm sea together with high productivity favors fish and shellfish migration to the mudbanks and yields high catches. Fish production in mudbank areas was estimated to be 56% higher than in non-mudbank areas during 1966 - 75 (Anon. 1984). Furthermore, waves as high as 2 to 3 m outside the mudbank get reduced to 0.5 m on the mudbank. This wave dampening facilitates safe anchorage and smooth fishing for traditional fishers during the monsoon season, which is generally unsafe outside the mudbank area.

The monthly mean seawater temperature varies in space and time along the southwest coast. Off Quilon (9º N, 76º 30' E), for instance, the sea surface temperature (SST) is low (27º C) during January - February and June - August, and high (29 to 31ºC) during May (Devaraj et al. 1997). High values are associated with the summer season, prior to onset of the southwest monsoon. Mean water temperature is higher in the northern part of the coast compared to the southern part. For instance, water temperature is 25º C and 17 to 21º C during January - February and June - August, respectively, at 100 m depth off Quilon, while during the same periods it is 29º C and 30º C off Karwar (15º N, 74º E) (Devaraj et al. 1997). The lower temperature is recorded in areas where the intensity of upwelling is comparatively higher. Mean depth of the top of the thermocline also varies from season to season. The top of the thermocline is deepest during the winter months of December to February off Quilon (120 m) and during January - February off Karwar (70 to 80 m). The thermocline reaches near the surface in April and October, i.e. prior to and after the southwest monsoon.

Mean sea surface salinity has two peaks, one during May - June prior to onset of the southwest monsoon and another during September - October immediately after the southwest monsoon. Monthly mean surface salinity varies between 32.5 and 36.1 ppt. The maxima occur comparatively late in the southern areas and are associated with advection of highly saline Arabian Sea water and the presence of highly saline bottom water brought upward to surface levels in areas of upwelling. The minima are associated with monsoon rains and river runoff, and also the incursion of low salinity equatorial surface waters. The minima occur first in the southern region and progressively move northward following the trend in monsoon rainfall (Devaraj et al. 1997). The salinity maximum occurs at depths of 100 to 150 m during the northeast monsoon and between 30 and 50 m during the southwest monsoon. The salinity maximum associated with the main thermocline probably represents an intrusion of high saline waters below the less saline surface layers (Pillai 1983).

In general, the shelf waters are well-aerated during most of the year except during the southwest monsoon and the associated upwelling season. A good correlation between the depth of the top of the thermocline and oxycline has been observed. By May, oxygen deficient waters start penetrating the shelf. By June/July the oxygen deficient waters penetrate below the thermocline and cover the entire bottom of the shelf. In August, the oxycline becomes very shallow and in the areas of upwelling, the low oxygen intermediate water reaches near the surface. Oxygen deficient water remains on the shelf until October, especially in areas where upwelling is intense. By December, the shelf waters are well-aerated again. Mean monthly sea surface DO values range between 5.35 ml•l^{-1} O_2•l^{-1} and 1.10 ml•l^{-1} O_2•l^{-1}. Oxygen deficient waters remain in the continental shelf of the northern region (off Karwar: 6 months) for a longer duration than in the southern region (off Quilon: 2 months) (Pillai 1983).

From the coastal fisheries point of view, upwelling in the southwest monsoon gyre along the southern part of the southwest coast assumes great importance. Upwelling starts by August, intensifies by September and ends by mid-October (Ramamirtham and Jayaraman 1960). However, depending on the intensity of various factors that promote upwelling, the onset, intensity, duration and area of upwelling vary every year (Pillai 1983). During upwelling, coastal waters exhibit a fall in temperature and DO and an increase in nutrient contents resulting in higher productivity (Table 3). The 23º C isotherm and the 1 ml•l^{-1} DO isoline rise to a

Table 3. Comparison of hydrographic, nutrient and productivity values during upwelling (July to September) and non-upwelling (October to June) season along the southwest coast of India.

Parameter	July-Sep	Oct-June	Source
Sea Surface Temperature (°C)	27	27 - 31	Devaraj et al. (1997)
Dissolved Oxygen, DO ($ml \cdot l^{-1}$)	1.1 to 2.5	2.0 - 5.4	Devaraj et al. (1997)
Nitrate (µM)	3 to 4	< 1	de Sousa et al. (1996)
Chlorophyll a ($mg \cdot m^{-3}$)	1.34	0.03 - 0.05	Bhattathiri et al. (1996)
Phytoplankton production ($mg\ C \cdot m^{-2} \cdot day^{-1}$)	49.9	1.1 - 3.3	Devaraj et al. (1997)
Zooplankton production ($mg\ C \cdot m^{-2} \cdot day^{-1}$)	27.5	6.4	Goswami et al. (1992)

depth of 10 to 20 m during August - September every year. The nitrate content in the surface waters is high (3 to 4µM) compared to < 1µM during the other months, which results in higher productivity (de Sousa et al. 1996). The density of chlorophyll a is substantially higher (1.34 $mg \cdot m^{-3}$) during July - August than that during February - May (0.03 to 0.05 $mg \cdot m^{-3}$), resulting in very high primary production of 49.9 mg $C \cdot m^{-2} \cdot day^{-1}$ compared to 1.1 to 3.3 mg $C \cdot m^{-2} \cdot day^{-1}$ (Bhattathiri et al. 1996). In general, the southwest coast is richer in phytoplankton and zoo-plankton biomass than other coastal areas of India. Secondary production along the southwest coast ranges from 6 to 57 mg $C \cdot m^{-2} \cdot day^{-1}$ depending upon the season (Mathew et al. 1990). During upwelling, minimum zooplankton biomass is over 1 $ml \cdot m^{-3}$ and at times attains up to 12 $ml \cdot m^{-3}$ (Madhupratap et al. 1994).

Coral patches abound off the southern part of the southwest coast of India. These coral reefs exhibit rich biodiversity and provide nursery grounds for commercially important fishes. Mangroves, either discontinuous or patchy, abound in the lower reaches of the estuaries in Cochin (9° 50' N, 76° 15' E), Calicut (11° 20' N, 75° 50' E) and Cannanore (12° 00' N, 75° 10' E). Mangroves serve as nursery for many species of finfish and shrimp.

Numerous estuaries dot the southwest coast. In Kerala State alone, 30 estuaries or backwaters with a total area of 500 km^2 forms about 20% of the total backwater area in India. Reclamation for various purposes has substantially reduced the area (Devaraj et al. 1999). Fishing activities in the backwaters support about 0.2 million fishers. The estuaries maintain high levels of biological productivity and play important roles in: (i) nutrient and organic material transport through tidal circulation, (ii) nursery grounds for many species of shrimp and fish, and (iii) breeding grounds for caridian prawns.

The total length of rivers and canals in the maritime states of Kerala (3 092 km), Karnataka (9 000 km) and Goa (250 km) is 12 342 km. There are 4 672 small (< 1 km^2) reservoirs in these 3 states (Sugunan, 1997). The surface area of all these reservoirs is 236 km^2. There are also 24 medium (1 to 5 km^2) and 13 large (> 5 km^2) reservoirs with total surface areas of 44.6 km^2 and 185.7 km^2, respectively. In addition to the reservoirs, tanks and ponds cover 447 km^2.

Fishery Resources and Potentials

Due to high productivity, the southwest coast is one of the most important areas in terms of marine fish production in India. While the length of the southwest coast is only about 16% of the Indian coastline, it contributed 31.7% (0.74 million t) annually to national marine fish production during 1993 - 98. Landings are higher around the southwest monsoon (July to September: 28.6%) and post-monsoon (October to December: 34.6%) seasons (Table 4). Using stratified multistage random sampling, the Central Marine Fisheries Research Institute (CMFRI) has collected data on marine fish landings along the southwest coast. Information on the fishery resources provided here is based on statistical and periodic publications of CMFRI.

Table 4. Distribution of marine fish landings (%) along the southwest coast of India during 1993 - 98.

State	Jan. - Mar.	Apr. - June.	July - Sept.	Oct. - Dec.
Kerala	18.6	18.1	33.7	29.6
Karnataka	26.9	11.9	19.2	42.0
Goa	23.6	9.5	18.7	48.2
SW coast	21.1	15.7	28.6	34.6

Table 5. Mean annual landings (t) and potential yield (t) of demersal fishes in 0 - 50 m depth zone along the southwest coast of India 1970 - 98.

Taxa	1970 - 74	1975 - 79	1980 - 84	1985 - 89	1990- 94	1995 - 98	1970- 98	Potential yield
Rays (Dasyatidae)	3 781	3 855	3 904	2 100	2 493	2 339	3 079	3 800
Catfish (Ariidae)	22 158	20 896	20 429	13 899	2 951	1 219	14 476	18 900
Lizardfishes (Synodontidae)	3 292	5 945	7 123	10 228	14 163	13 329	8 705	16 800
Threadfin breams (Nemipteridae)	N/A	N/A	5 922	35 177	46 924	44 482	31 865	N/A
Other perch	9 478	16 410	11 823	8 643	16 349	20 164	13 357	N/A
Goatfishes (Mullidae)	24 910	689	127	3 740	9 073	133	6 896	N/A
Threadfins (Polynemidae)	337	87	171	166	204	9	173	N/A
Croakers (Sciaenidae)	10 078	15 827	10 529	15 328	17 637	17 293	14 246	20 800
Ribbonfishes (Trichiuridae)	20 911	17 163	9 740	20 326	11 316	21 049	16 444	27 600
Silverbellies (Gerridae)	14 613	7 739	12 152	10 801	8 094	6 444	10 226	14 700
Whitefish (*Lactarius lactarius*)	5 236	1 428	3 040	4 012	2 448	2 658	3 171	N/A
Pomfrets (Barmidae)	2 693	2 631	3 868	4 672	5 093	5 109	3 933	5 800
Mullet (Sillaginidae)	442	81	196	425	137	428	275	N/A
Flatfishes (Platycephalidae)	10 519	6 906	19 181	19 085	29 445	24 446	17 822	25 900
TOTAL	128 448	99 657	108 205	148 602	166 327	159 102	144 668	

Note: N/A = not available

The demersal fishes are exploited primarily by mechanized trawlers (overall length of 12 to 16 m), bottom-set gillnets, seine-netters (using boats) and mini-trawls. In addition, the demersals are landed by stake nets and shore seines. The average annual demersal fish landings along the southwest coast increased from 128 448 t during 1970 - 74 to 159 102 t during 1995 - 98 (Table 5). Average annual landings of demersals during 1970 - 98 (144 668 t) contributed 23.1% to total landings on the southwest coast. The dominant groups (and species) in demersal landings are threadfin breams *(Nemipterus japonicus, N. mesoprion)*, flatfishes *(Cynoglossus macrostomus)*, ribbonfishes *(Trichiurus lepturus, Lepturacanthus savala)*, catfishes *(Tachysurus thalassinus, T. tenuispinis)*, croakers *(Johnieops sina)*, major perches *(Epinephelus* spp., *Lethrinus* spp. *and Lutjanus* spp*)*, lizardfishes *(Saurida tumbil)* and rays *(Himantura bleekeri, Dasyatis* spp.*)*.

During the 1970 - 98 period, the landings of lizardfishes, threadfin breams, other perches, flatfishes and pomfrets increased. The landings of ribbonfishes, croakers and mullets were almost unchanged during the period. The annual landings of catfishes drastically decreased from 22 158 t (1970 - 74) to a mere 1 219 t (1995 - 98) and those of goatfishes from 24 910 t to 133 t. Landings of rays, threadfins, silverbellies and whitefish also consistently decreased during the period.

Utilizing data on primary and secondary production, exploratory surveys and fish landings, the Ministry of Agriculture, Government of India provided estimates of potential yield of fishery in resources India (Anon. 1991). The estimated potential yield of demersal finfishes for the 0 - 50 m depth zone is provided in Table 5. For most of the groups, landings have come close to or have exceeded the estimated potential at some time during 1970 - 98.

The pelagic resources are exploited by purse seines operated from mechanized craft (11 to 14 m length), drift gillnets, ring-seines, and hooks and lines. The mean annual pelagic fish landings increased from

317 667 t during 1970 - 74 to 425 438 t during 1995 - 98 (Table 6). During 1970 - 98, the average annual landings of pelagics (369 453 t) contributed 59.0% to the total landings on the southwest coast. The dominant groups (and species) in the pelagic landings are oil sardine *(Sardinella longiceps)*, Indian mackerel *(Rastrelliger kanagurta)*, carangids *(Caranx* spp. and *Decapterus russelli)*, whitebaits *(Stolephorus* spp.*)*, lesser sardines *(Sardinella* spp*)*, seerfishes *(Scomberomorus commerson* and *S. guttatus)* sharks *(Scoliodon laticaudus* and *Carcharhinus* spp.*)*, barracudas *(Sphyraena* spp.*)* and tunas *(Euthynnus affinis* and *Auxis thazard)*.

During 1970 - 98, landings of white-baits, *Thryssa* spp., carangids, Indian mackerel, seerfishes, tunas and barracudas increased. Landings of sharks and oil sardine decreased over this period. The catches of pelagic fishes have either been very close to or have exceeded the potential yield at some time during 1970 - 98.

Shrimps are the major target group of bottom trawlers that also take demersal fish resources. Average annual shrimp landings during 1970 - 98 was 54 893 t (Table 7), contributing 8.8% to the mean annual total landings in the southwest coast. Annual shrimp landings decreased from 62 056 t during 1970 - 74 to 37 081 t during 1980 - 84 but subsequently increased to 59 278 t during 1995 - 98. Shrimp landings are dominated by *Penaeus indicus, Parapenaeopsis stylifera* and *Metapenaeus dobsoni*. An important feature of the shrimp fishery is fishing peak for a single species (*P. stylifera*) during the southwest monsoon off Quilon. About 75% of the shrimp landings during the monsoon is contributed by *P. stylifera* along the southern part of the southwest coast (George 1988). The catches of shrimps are below the estimated potential yield (80 300 t) (Table 7).

The non-penaeid prawns *(Acetes* spp.*)*, spiny lobsters *(Panulirus homarus, P. polyphagus)*, crabs *(Charybdis* spp.*)* and stomatopods *(Squilla* spp.*)* are the other crustacean resources along the southwest coast. Cephalopod landings substantially increased from 856 t during 1970 - 74 to 48 586 t during 1995 - 98. The contribution of cephalopods, which was only 0.2% of the annual total landings during 1970 - 74, increased to 7.8% during 1995 - 98. However, catches during 1990 - 94 and 1995 - 98 have exceeded the estimated potential (22 300 t)

Table 6. Mean annual average landings (t) and potential yield (t) of pelagic fishes in 0 - 50 m depth zone along the southwest coast of India 1970 - 98.

Group	1970 - 74	1975 - 79	1980 - 84	1985 - 89	1990- 94	1995 - 98	1970 - 98	Potential yield
Sharks	702	716	725	581	349	335	568	700
Oil sardine (Sardinella longiceps)	1 498	15 890	18 176	12 800	12 114	5 792	13 828	17 400
Lesser sardine (Clupeidae)	3 002	3 039	1 431	1 695	3 263	3 258	2 569	2 300
Hilsa spp.	368	135	203	573	599	91	345	N/A
White baits (Galaxiidae)	1 268	1 235	3 389	4 529	5 124	3 797	3 183	3 340
Thryssa spp.	238	321	289	875	1 165	1 672	695	5 850[1]
Carangids (Carangidae)	1 150	1 204	1 638	6 835	11 302	9 529	4 972	9 280
Mackerel (Scombridae)	9 301	6 350	2 713	9 272	11 772	15 037	8 648	12 580
Seerfishes (Scombridae)	479	653	985	1 222	1 039	917	880	1 490
Tunas (Scombridae)	414	1 046	891	1 857	2 315	1 662	1 343	2 520
Barracudas (Sphyrnaenidae)	193	156	961	178	418	537	225	N/A
Total	31 767	30 521	30 353	399 006	48 919	42 544	369 45	

Note: N/A = not available

[1] includes all clupeids except oil sardine, lesser sardines and whitebaits.

Table 7. Mean annual landings (t) and potential yield (t) of crustaceans and cephalopods in 0 - 50 m depth zone along the southwest coast of India 1970 - 98.

Group	1970 - 74	1975 - 79	1980 - 84	1985 - 89	1990 - 94	1995 - 98	1970 - 98	Potential yield
Penaeid prawns	62 056	51 910	37 081	59 191	61 595	59 278	54 893	80 300
Non-penaeid prawns	1 061	306	450	282	212	390	454	383
Lobster	NA[1]	61	100	128	149	174	118	N/A
Crabs	2 564	5 537	2 220	4 826	6 774	7 205	4 686	N/A
Stomatopods	N/A	N/A	12 924	45 684	47 312	39 108	35 940	N/A
Cephalopods	856	5 006	4 091	16 436	32 069	48 586	15 645	22 300
TOTAL	66 537	62 820	56 866	126 547	148 111	154 741	111 736	

Note: N/A = not available

along the southwest coast (Table 7). The cephalopods consist of squids *(Loligo duvaucelli)*, cuttlefishes *(Sepia pharaonis, Sepiella inermis)* and octopi.

The potential yield of fish stocks along the southwest coast has been investigated by different studies (Table 8). The most recent study (Anon. 1991) gives a total potential yield estimate (0 - 500 m depth zone) of 1.31 million t. The mean total annual catch was 0.74 million t during 1995 - 98. While fishing pressure is already heavy in shallow, coastal waters (0 - 50 m depth), there appears scope for expansion of clupeid and tuna catches in deeper areas. The commercial fisheries at present are restricted to the 0 - 70 m depth zone and there is virtually no deep-sea fishing. Viable policies have to be formulated to encourage fishing further offshore.

Table 8. Estimates of potential yield of fish resources along the southwest coast of India.

Depth zone	Potential yield (x10^3 t)	Source
0 - 200 m (oceanic)	1 422	George et al. (1977)
0 to 200 m (only demersals)	438	Joseph (1980)
0 to 500 m (oceanic)	853	Joseph et al. (1976)
0 to 200 m	900	Alagaraja (1989)
0 to 200 m (only demersals)	332	Sudarsan et al. (1989)
0 to 50 m (only demersals)	361	Anon. (1991)
0 to 50 m (only pelagics)	589	Anon. (1991)
51 to 100 m	63	Anon. (1991)
101 to 200 m	29	Anon. (1991)
201 to 500 m (only oceanic tunas)	265	Anon. (1991)
0 to 500 m	1 307	Anon. (1991)

Socioeconomic Background

The total marine, freshwater and land area of India is 5.30 million km^2. The marine jurisdictional area (EEZ) is extensive, spanning 2.02 million km^2, which is 38% of the total area of the country. The gross value of marine fish production at landing center prices was about US$2.37 billion in 1997 (Table 9), and the value at consumers level was about US$4.73 billion of which US$1.1 billion is realized from export.

The total population in India is about 1 billion. In the 3 651 fishing villages situated along the 8 129 km coastline, about 1 million are employed full-time in marine capture fisheries (Table 9). Marine fisheries provide employment in the production and post-harvest sectors. Manpower employed in active fishing in the mechanized (large scale) sector is estimated at 0.2 million, of which 0.15 million fishers are engaged in trawl fisheries and the remaining in gillnetters, dolnetters (a specialized type of fixed bag net which targets bombay duck *(Har-*

podon nehereus) and grenadier *(Coilia dussu mieri))*, purse seiners, and sona boats. The motorized (small scale) sector employs 0.17 million in active fishing, 66% of which are engaged in the operation of ring-seines, mini-trawls and gillnets. Motorized dugout canoes, catamarans and plywood boats provide employment to 58 000 persons. The non-mechanised (small scale) sector provides employment to 0.65 million, of which 0.27 million are engaged in catamarans, 0.2 million in plank-built boats and the rest in dugout canoes and masula boats. On average, every 5 kg of marine fish produced provides employment to 2 people, one in the harvesting and the other in the post-harvest sector. While total marine fish landings have significantly increased, catch rate and production per fisher has steadily declined over the years. Operations continue, however, due to appreciation in prices of all varieties of marine fish.

Subsidiary activities provide employment to about 1.2 million people in India. Activities such as boat building and repair, net mending, repair of engines, and sale of diesel, kerosene and other essential items at landing centers provide active employment for 0.1 million. About 25% of those employed in post-harvest operations are women, mostly engaged in marketing. Marketing including transportation, processing, packing and selling provide employment for 1.1 million, 0.2 million in export marketing and 0.9 million in domestic marketing.

The country has 2 271 marine fish landing centers in addition to major and minor fishing harbors (Table 9). There are 47 000 mechanized vessels, 36 500 motorized vessels and 50 000 artisanal craft. There are 372 freezing plants with a freezing capacity of 6 600 $t \cdot day^{-1}$. There are also 450 cold storage plants with a capacity of 80 000 $t \cdot day^{-1}$, 15 fish meal plants with a capacity of 330 $t \cdot day^{-1}$ and 900 peeling sheds with a capacity of 2 700 $t \cdot day^{-1}$. Capacity utilization of processing plants is hardly 25% mainly due to shortage of raw materials. Idle capacity in the processing plants leads to underemployment of about 0.2 million people.

For India, the largest fish production comes from coastal capture fisheries (on average about 62% of total fish production). Gross investment in the marine fishing sector is estimated as US$1 billion in 1996 (Table 9). Of the marine products export of 385 818 t valued at US$1.1 billion during 1997 - 98 (Tharakan 1998), about 310 000 t (80%) was from capture fisheries. This represents only 11.5%

Table 9. Profile of Indian marine fisheries (modified from Devaraj and Vivekanandan 1999).

Characteristic		Estimated Value
Physical		
Length of coastline		8 129 km
Exclusive economic zone		2.02×10^6 km^2
Continental shelf		0.50×10^6 km^2
Inshore area (< 50 m depth)		0.18×10^6 km^2
Biological		
Potential yield in EEZ		3.9×10^6 t
Potential yield in inshore area		2.2×10^6 t
Marine fish production (1997)		2.7×10^6 t
Production from inshore area		2.2×10^6 t
Production from coastal aquaculture (1996)		70 400 t
Human resource		
Fishing villages		3 651
Marine fisher population		5×10^6
Active fisher population		1×10^6
Infrastructure		
Landing centres		2 271
Major fishing harbours		6
Minor fishing harbours		27
Mechanized vessels		47 000
Motorized vessels		36 500
Artisanal vessels		50 000
Processing/Support Facilities	**No.**	**Capacity ($t \cdot day^{-1}$)**
Freezing plants	372	6 600
Canning plants	14	52
Ice plants	148	1 800
Fishmeal plants	15	330
Cold storages	450	80 000
Peeling sheds	900	2 700
Economic		
Gross investment on fishing (1996)		US$1.0 billion
Value of annual production (1997)		US$2.37 billion
Marine products export (1997 - 98)		385 818 t
Value of export		US$1.1 billion

of marine capture fisheries production. Thus, capture fisheries contribute primarily to domestic consumption needs (Devaraj and Vivekanandan 1999).

The increase in marine fish production during the past 5 decades was largely due to efforts of the Government of India and the maritime state governments through successive development plans (Table 10). The major causes for significant increases in marine fish production are:

- Introduction of mechanized fishing vessels and

Table 10. Development thrusts in Indian marine fisheries during various plan periods from 1951 to 1996 (modified from Devaraj et al. 1997).

Plan period	Duration	Major developments	Average annual catch (t)
I	1951 - 55	1. Mechanization of indigenous artisanal fishing craft	565 412
II	1956 - 60	1. Introduction of mechanized fishing vessels	
		2. Introduction of modern gear materials	730 699
		3. Infrastructure for preservation, processing, storage and transportation	
III	1961 - 65	1. Substantial increase in use of synthetic gear materials	730 061
Annual plans	1966 - 68	2. Export trade	904 355
IV	1969 - 73	1. Import of trawlers for deep sea fishing	1 070 264
		2. Indigenous construction of deep sea trawlers	
		3. Fishing harbours construction	
		4. Intensification of exploratory fishery surveys	
		5. Expansion of export trade	
V	1974 - 78	1. Diversification of fishing, introduction of purse seining	1 326 408
Annual plan	1979	1. Diversification of products	1 365 739
		2. Motorization of artisanal craft	
VI	1980 - 84	1. Exploratory surveys in offshore grounds	1 434 914
		2. Declaration of EEZ in 1977	
		3. 1981 Act for regulation of foreign fishing vessels	
		4. Deep sea fishing through licensing, chartering and joint venture vessels	
VII	1985 - 89	1. New chartering policy of 1989	1 724 757
Annual plans	1990	2. Development of deep sea fishing	
	1991	3. Substantial growth in motorized artisanal fleet of ring-seiners	2 182 412
VIII	1992 - 96	1. Deep sea fishing by joint venture	2 295 889
		2. Development of coastal aquaculture	
		3. Substantial growth in motorized artisanal fleet of ring-seiners	
		4. Export trade changes from a resource-based to food engineering-based industry	

modern gear materials during the 1951 - 55 and 1956 - 60 plans.
- Increased use of synthetic gear materials during the 1961 - 65 plan.
- Construction of fisheries harbours during the 1969 - 73 plan.
- Introduction of purse seining during the 1974 - 78 plan.
- Motorization of artisanal craft in 1979.
- Substantial growth in the motorized artisanal fleet operating ring-seines during the 1985 - 96 plans.

The contribution of fisheries (including the marine and inland sub-sectors) to India's Gross Domestic Product (GDP) gradually increased from 0.7% (1980 - 81) to 1.2% (1994 - 95) (Table 11). The share of fisheries in agriculture GDP has increased more conspicuously, from 1.9% to 4.0%. At current prices, the fisheries GDP has increased from US$0.2 billion (1980 - 81) to US$2.5 billion (1994 - 95). Contribution to GDP may not be a true reflection of the actual importance and role of the sector. GDP measures only the value of the produce and employment/services generated by the sector. In the case of fisheries, its significance to food security and livelihood in rural areas of India cannot be over-emphasized.

The total fisher population in India was about 5.4 million in 1980 and 5.8 million in 1990. Of this, the marine fisher population was 2.14 million in 1980 and 3.76 million in 1990. The average size of a marine fisher family varied from 4.7 to 8.6 in the different states during 1980. The active fisher folk population increased from 234 478 in 1961 - 62 to 650 887 in 1990, and at this rate of increase it is estimated that the number of active fishers would have been 1 million in 1998.

While the total and active marine fisher population has increased over the years, the proportion of active fishers to total marine fisher population declined from 23.9% in 1961 to 22.5% during 1973 - 77, and to 19.3% in 1980. At the average rate of decrease of 0.23% per year from 1960 to 1980, the percentage of active fishers to total fisher population in 1998 has been estimated to be only 16.5%. The low percentage of active fishers is due to the following:

i. Fishing is not regarded as a profession of high status in the society.
ii. Most fishers are still illiterate, but literate ones prefer employment in government and private agencies.
iii. Industrialization in coastal areas has lured fishers to land-based industries.
iv. Per capita income from fishing is diminishing and unattractive.

The nutritional contribution of fish can be maximized by increasing its availability to low-income groups and improved marketing and distribution.

Table 11. Contribution of the fisheries sector to GDP of India (Anon. 1996).

Year	Fisheries GDP (US$ x10^9)	Agriculture GDP (US$ x10^9)	National GDP (US$ x10^9)	Contribution of Fisheries to Agriculture GDP (%)	Contribution of Fisheries to National GDP (%)
1980 - 81	0.2	10.8	28.5	1.9	0.7
1986 - 87	0.5	19.2	60.5	2.6	0.8
1987 - 88	0.6	21.5	68.8	2.8	0.9
1988 - 89	0.7	26.5	82.0	2.6	0.8
1989 - 90	0.9	29.5	95.0	3.1	0.9
1990 - 91	1.1	34.4	111.1	3.2	1.0
1991 - 92	1.2	40.2	128.6	3.0	0.9
1992 - 93	1.5	44.9	146.6	3.3	1.0
1993 - 94	1.8	51.6	168.2	3.5	1.1
1994 - 95	2.5	61.8	198.6	4.0	1.2

Very meager information is available on the health and nutritional status of fisher folk involved in small-scale fisheries. A few micro level studies are available from the east coast of India and fishers in the maritime states of Tamil Nadu, Andhra Pradesh, Orissa and West Bengal. These studies indicate:

- High levels of malnutrition among children of fishers, increasing their susceptibility to major diseases;
- High levels of child mortality in fishers' families compared to non-fisher families;
- Fish is the major source of protein for fisher families, with meat and milk consumed only occasionally;
- Substantial numbers of fisher families go without meat on some days due to poor or no catch, especially during the peak of the monsoons.

These conditions are also likely to pertain to families of small scale fishers on the southwest coast.

Capture Fisheries in Focus

This section gives an overview of the capture fisheries sector in India, with relevant institutional and legal aspects given in Annex 1.

Fisheries Sub-sectors

Artisanal

The artisanal sub-sector employs 3 major types of wooden craft-dugout canoes, catamarans and plank-built (with or without outrigger) boats. In 1998, the total number of artisanal crafts was estimated at 127 518 (Table 12). About 46% of the crafts are catamarans. The catamaran, designed to efficiently withstand rough sea conditions, is prevalent along the southeast coast, where wave action is normally high. It is estimated that 54% and 27% of the artisanal crafts are along the southeast and southwest coasts, respectively.

Table 12. Number of artisanal fishing crafts along the Indian coast 1998.

Fishing craft	NW	SW	SE	NE	Total
Motorized	5 096	17 702	23 972	4 152	50 922
Dugout canoes	1 000	5 258	297	0	6 555
Catamarans	0	34	15 822	1 328	17 184
Plank-built	3 894	5 697	5 003	2 509	17 103
Others	202	6 713	2 850	315	10 080
Non-motorized	7 558	17 098	44 382	7 558	76 596
Dugout canoes	2 218	8 414	110	0	10 742
Catamarans	0	6 638	31 650	3 449	41 737
Plank-built					
- with outrigger	3 737	1 209	3 030	3 698	11 674
- without outrigger	775	581	9 440	378	11 174
Others	828	256	152	33	1 269
TOTAL	12 654	34 800	68 354	11 710	127 518

Note: NW - Northwest; SW - Southwest; SE - Southeast; NE -Northeast.

After introduction of motorization in the mid-1980s, the number of artisanal crafts fitted with outboard motors increased. In 1998, about 40% of artisanal crafts were fitted with 7 to 9 HP engines. Motorization was rapid especially along the south-west coast where the number of motorized crafts in 1998 (17 702) exceeded the non-motorized crafts (17 098). With increasing popularity of out-board motors, it is expected that the number of motorized crafts would further increase in the coming years, gradually replacing the non-motorized crafts.

Industrial

Mechanization of fishing crafts commenced in the late 1950s and has accelerated since the mid-1960s. It is estimated that the industrial fishing fleet numbered 49 070 in 1998 (Table 13). Nearly 50% of the mechanized vessels operate along the northwest coast. The fleet consists of 5 major types of craft - trawler, gillnetter, dolnetter, liner and purse seiner. Trawlers, which operate bottom trawls, are the most common; 63.1% of the number of mechanized craft, 42% of which are based on the northwest coast. Small trawlers (LOA < 9 m), which were common in the 1960s and 1970s, are being replaced by larger trawlers. In 1998, about 97% of the trawlers were of 9 to 18 m LOA.

Table 13. Number of mechanized (industrial) fishing crafts along the Indian coast 1998.

Fishing craft	NW	SW	SE	NE	Total
Trawler	13 055	7 342	8 789	1 793	30 979
< 9 m	0	444	506	0	950
9 - 12 m	4 531	4 924	6 077	1 382	16 914
13 - 18 m	8 524	1 974	2 206	411	13 115
Gillnetter	3 981	1 132	867	3 988	9 968
< 9 m	2 266	835	542	965	4 608
9 - 12 m	1 715	297	325	3 023	5 360
Dolnetter	5 423	0	109	6	5 538
< 9 m	3 322	0	5	6	3 333
9 - 12 m	2 101	0	104	0	2 205
Liner	59	32	189	123	403
< 9 m	0	8	111	16	135
9 - 12 m	59	24	78	107	268
Purse seiner	207	799	0	0	
Others	893	3	1	279	1 176
TOTAL	23 618	9 308	9 955	6 189	49 070

Note: NW - Northwest; SW - Southwest; SE - Southeast; NE -Northeast.

Mechanized gillnetters (7 to 12 m LOA) constituted 20.3% of mechanized craft and were common along the northwest and northeast coasts. The length of gillnets used is around 500 m and the nets are operated manually. Dolnetters (7 to 12 m LOA) are operated almost exclusively along the northwest coast. This is a specialized type of fixed bag-net that targets bombay duck *(Harpodon nehereus)* and grenadier *(Coilia dussumieri)*. These two fishes occur almost exclusively along the northwest coast.

Purse seiners were introduced in the 1970s but are not as popular as trawlers. In 1998, there were 1 006 purse seiners (9 to 13 m LOA). Purse seiners are restricted to the west coast, particularly the middle part, which is characterized by the abundance of small pelagics such as sardines, whitebaits and Indian mackerel.

Catch and Fishing Effort

Marine fisheries in India are characterized by a large variety of gear. The variety of active gear can be classified as (i) encircling, (ii) drifting, (iii) dragging, (iv) seining, and (v) lining types. The stationary gear can be classified as (i) set nets and (ii) fixed nets. The number of fishing gear along the Indian coast is given in Table 14. Of all the types of gear, gillnets are the most numerous. It is estimated that about 75% of the total number of types of gear are gillnets (drift and bottom-set). The most common craft gear combinations are given in Table 15.

The average annual marine fish production in India increased from 1.17 million t during 1970 - 74 to 2.47 million t during 1995 - 98 (Table 16). The west coast consistently contributed 70% of landings during the period. Catches along the northwest, southwest, southeast and northeast coasts increased by 3.0, 1.5, 2.2 and 2.6 times respectively, between 1970 - 74 and 1995 - 98. The increase was highest along the northwest coast, where the average annual landings increased from 318 060 t (1970 - 74) to 948 650 t (1995 - 98). Consequently, the contribution of the northwest

coast to marine fish production increased from 27.2% (1970 - 74) to 38.3% (1995 - 98) (Table 17). On the other hand, the contribution of the southwest coast decreased from 44.4% to 31.2%.

The fishing effort deployed by artisanal, motorized and mechanized craft from 1985 to 1996 is given in Table 18. Owing to motorization of artisanal craft during the period, fishing effort of artisanal crafts declined from 10.2 million boat-days (bd) in 1985 to 4.7 million bd in 1996, while effort of motorized crafts increased more than 5 times, from 0.7 million bd to 3.7 million bd. Effort of mechanized crafts fluctuated between 2.9 and 3.5 million bd. However, due to introduction of larger mechanized vessels in 1990, efficiency rather than the number of boat-days increased during 1985 - 96.

Table 14. Number and type of fishing gear along the Indian coast 1998.

Fishing Gear	NW	SW	SE	NE	Total
Trawlnet	82 461	35 809	29 093	4 103	151 466
Gillnet	1 172 734	56 307	216 656	28 049	1 473 746
Driftnet	10 998	4 760	42 383	2 668	60 809
Dolnet	48 296	0	0	1 390	49 686
Fixed bag-net	13 438	2 733	2 402	9 323	27 896
Purse seine	284	901	0	31	1 216
Rampanitals	92	165	0	0	257
Ring seine	0	2 613	241	23	2 877
Boat seine	0	2 736	4 605	825	8 166
Shore seine	375	1 784	1 818	504	4 481
Hooks and lines	19 907	8 906	58 581	1 867	89 261
Scoop-net	540	0	2 731	448	3 719
Trap	20	35	3 824	189	4 068
Others	40 017	6 909	25 229	11 495	83 650
TOTAL	1 389 162	123 658	387 563	60 915	1 961 298

Note: NW - Northwest; SW - Southwest; SE - Southeast; NE -Northeast.

Table 15. Common fishing craft and gear combinations in India.

Fishing Craft	Construction	Propulsion	Engine power (HP)	No. of crew	Major gear	Area of operation
Catamaran	5 wooden logs tied as raft	Manual/outboard engines	6 to 10	2 to 4	Driftnet, gillnet, boat-seine, lines	Inshore; east coast
Dugout canoe	Hollow single wooden log	Manual/outboard engines	6 to 10	2 to 8	Castnet, boat-seine	Inshore; west coast
Plank-built craft	Wooden planks nailed as a frame	Manual / mechanized	15 to 30	7 to 12	Gillnet, boat-seine, dragnet	Inshore; southwest coast
"Pablo" boat	Wood	Mechanized	10 to 20	3 to 4	Gillnet, Driftnet, Longline	Inshore; all coasts
Purse seiner	Wood	Mechanized	100 to 120	18 to 22	Purse seine	Inshore; southwest coast

Table 15. Common fishing craft and gear combinations in India. (continued)

Fishing Craft	Construction	Propulsion	Engine power (HP)	No. of crew	Major gear	Area of operation
Shrimp trawler	Wood	Mechanized	65 to 120	4 to 6	Trawl net	Inshore; all coasts
Steel trawler	Steel	Mechanized	100 to 400	6 to 16	Trawl net	Offshore; middle southeast coast

Table 16. Mean annual landings (t) along the Indian coast.

Period	NW	SW	SE	NE	Total
1970 - 74	318 060	519 750	284 143	47 993	1 169 946
1975 - 79	468 038	500 263	340 826	47 993	1 357 120
1980 - 84	488 970	498 068	383 199	63 508	1 433 745
1985 - 89	585 866	699 958	409 858	73 357	1 769 039
1990 - 94	758 667	842 290	494 031	126 752	2 221 740
1995 - 98	948 650	772 656	629 027	124 301	2 474 634

Note: NW - Northwest; SW - Southwest; SE - Southeast; NE -Northeast.

Table 17. Contribution (%) of each coastal area to the marine fish production in India 1970 - 98.

Year	NW	SW	SE	NE
1970 - 74	27.2	44.4	24.3	4.1
1975 - 79	34.5	36.9	25.1	3.5
1980 - 84	34.2	34.7	26.7	4.4
1985 - 89	33.1	39.6	23.2	4.1
1992 - 94	34.1	37.9	22.2	5.7
1995 - 98	38.3	31.2	25.5	5.0

Note: NW - Northwest coast; SW - Southwest coast; SE - Southeast coast; NE - Northeast coast.

Table 18. Fishing effort (in boat days) along the Indian coast.

Fishing craft	1985	1986 - 90	1991 - 95	1996
Artisanal	10 216 950	8 905 205	6 425 388	4 678 579
Motorized	708 165	1 208 091	2 348 112	3 715 571
Mechanized	2 890 935	3 475 191	3 384 564	3 339 426
Purse seiner	56 121	85 336	85 765	100 655
Ring-seiner	0	167 564	251 973	240 277
Gillnetter	774 835	1 044 456	910 058	946 643
Trawler	1 444 604	1 818 617	1 980 276	1 853 567

Landings in India consisted of small pelagics (39.2%), large pelagics (10.1%), demersal finfishes (26.9%) and demersal invertebrates (18.8%) during 1970 - 98 (Table 19). The oil sardine, *Sardinella longiceps* is the single largest fishery, contri-buting 9.2% to total landings, followed by penaeid prawns (8.0%), Indian mackerel (6.8%), croakers (6.4%) and bombay duck (5.8%). The following are evident from Table 19:

- Most of the southwest coast landings are small pelagics, (54.0%), dominated by oil sardine, Indian mackerel, carangids and whitebaits.
- The Northwest coast landings are dominated by Bombay duck (16.2%), non-penaeid prawns (12.0%), croakers (10.7%) and penaeid prawns (9.3%). Small pelagics, demersal finfishes and demersal invertebrates contribute almost equally to northwest coast landings (27.0 - 27.9%). However, the demersal invertebrates contribution was significantly higher along the northwest coast than along the other coasts.
- The southeast and northeast coasts are characterized by high contributions of small pelagics and demersal finfishes. Lesser sardines and silverbellies dominated the southeast coast landings while croakers and *Hilsa* spp. dominated the northeast coast.
- Landings along the Lakshadweep Islands are dominated by large pelagics, especially tunas (69.9%).
- Landings along the Andaman and Nicobar Islands are dominated by lesser sardines and perches.

Table 19. Contribution (%) by resource group to mean annual marine landings in India during the period 1970 - 98.

Group	NW	SW	SE	NE	LAK	A&N	INDIA
Small Pelagics							
Oil sardine *(Sardinella longiceps)*	0.3	22	4.1	0.07	0	0	9.2
Lesser sardines (Clupeidae)	0.4	4.1	11.3	3.7	0	12.5	4.6
Hilsa spp.	1.1	0.05	1.3	13.8	0	0.2	1.4
Whitebaits (Galaxiidae)	0.2	5.1	4.8	0.9	0	5.5	3.2
Thryssa spp.	0.9	1.1	2.4	0.8	0	4.5	1.4
Coilia spp.	4.4	0.01	0.4	3.2	0	0	1.7
Setipinna spp.	0	0	0.1	2.2	0	0	0.1
Bombay duck *(Harpadon nehereus)*	16.2	0	0.2	7.2	0	0	5.8
Flying fishes (Exocoetidae)	0	0.01	0.7	0	0.6	0	0.2
Carangids (Carangidae)	1.9	7.9	4.8	1.7	1.4	6.0	4.8
Indian mackerel *(Rastrelliger kanagurta)*	1.6	13.7	4.7	0.8	0	3.0	6.8
Sub total	27.0	54.0	34.8	34.4	2.0	31.7	39.2
Large Pelagics							
Sharks	2.9	0.9	2.5	2.8	4.5	2.6	2.1
Ribbonfishes (Trichiuridae)	6.3	2.6	4.3	4.1	0	1.6	4.3
Seerfishes (Scombridae)	1.8	1.4	2.4	2.8	1.4	3.0	1.8
Tunas (Scombridae)	0.8	2.1	1.0	0.2	69.9	3.2	1.5
Barracudas (Sphyraenidae)	0.1	0.4	0.8	0.05	0.3	3.5	0.4
Sub total	11.9	7.4	11.0	9.9	76.1	13.9	10.1

Table 19. Contribution (%) by resource group to mean annual marine landings in India during the period 1970 - 98. (continued)

Group	NW	SW	SE	NE	LAK	A&N	INDIA
Demersal Fish							
Rays (Dasyatidae)	0.9	0.5	3	1.4	0.6	0.6	1.3
Eels	1.0	0.01	0.2	0.5	0	0	0.4
Catfishes (Ariidae)	3.4	2.3	2.3	8.1	0	2.1	3.0
Lizardfishes (Synodontidae)	0.6	1.4	1.0	0.2	0	0	1.0
Threadfin breams (Nemipteridae)	2.1	5.1	2.4	0.3	0	0	3.2
Other perches	1.1	2.1	4.2	1.1	3.8	8.6	2.3
Goat fishes (Mullidae)	0.3	1.1	1.3	0.3	0.9	0	0.8
Threadfins (Polynemidae)	0.9	0.03	0.6	0.8	0	0.8	0.5
Croakers (Sciaenidae)	10.7	2.3	5.1	15.5	0	1.1	6.4
Silverbellies (Gerridae)	0.2	1.6	10.4	1.0	0.4	6.2	3.2
Whitefish (*Lactarius lactarius)*	1.0	0.5	0.4	0.08	0	0	0.6
Pomfrets (Barmidae)	3.9	0.6	1.3	8.1	0	1.3	2.3
Mullets (Silliganidae)	0.4	0.04	0.3	0.08	0	4.4	0.2
Unicorn cod (*Bregmaceros mcclellandii*)	0.2	0	0	0	0	0	0.1
Flatfishes (Platycephalidae)	1.2	2.8	0.7	0.4	0	0	1.6
Sub total	27.9	20.4	33.2	37.9	5.7	25.1	26.9
Demersal Invertebrates							
Penaeid prawns	9.3	8.7	5.9	4.5	0	1.1	8.0
Non-penaeid prawns	12.0	0.07	0.7	2.6	0	0	4.3
Lobsters	0.2	0.02	0.1	0	0	0.02	0.1
Crabs	0.7	0.7	2.8	0.5	0	0.5	1.2
Stomatopods	2.4	5.7	0.4	0.6	0	0	3.0
Cephalopods	3.0	2.5	1.4	0.2	0.4	0.3	2.2
Sub total	27.6	17.7	11.3	8.4	0.4	1.9	18.8
Others	5.6	0.5	8.7	8.4	15.8	27.4	5.0

Note: NW - Northwest; SW - Southwest; SE - Southeast; NE - Northeast; LAK - Lakshadweep; A&N - Andaman and Nicobar.

Economics and Marketing

Most of the annual marine landings of 2.7 million t (1998) is used in fresh or iced condition for domestic consumption (44%), with only about 15% exported, 3% for curing and drying and 15% for reduction to fish meal and for canning and freezing (Sathiadhas et al. 1995). Fishes like bombay duck, whitebaits, and ribbonfishes are cured (25 - 30% of landings are processed). This results in low availability of fresh fish in demand centers and poor returns to the producer.

Analysis of economic performance (costs and return) of different fishing units operating in Indian marine waters is given in Pillai et al. (this vol.) Performance of various non-motorized and moto-rized artisanal fishing units, as well as mechanized units operating nearshore and offshore, based on 1993 - 94 data given by (Sathiadhas et al. 1995) were analyzed. These data indicate high rates of return for the various fishing units (24% to 46%).

Owners of fishing craft and the laborers share the net earnings from fishing operations after deducting fuel and other operational expenses. Nearly 70% of gross earnings of mechanized vessels and 50% of earnings of motorized units go to operating expenses, whereas non-mechanized units have egligible operating expenses. About 30% of net earnings in mechanized and motorized units and 65% of gross earnings in non-mechanized units are paid to fishing laborers as wages. The per capita earnings of a fishing laborer per trip is about US$4 for mechanized craft, $1.7 for a motorized unit and $1.0 for artisanal craft. Annual wages of a fishing labourer depend on the actual number of fishing trips. Considering 200 fishing days/year, the annual income of a labourer working in mechanized, motorized and artisanal craft would be $795, $350 and $200, respectively.

The fisher's share in consumer's price provides an index of the efficiency of the fish marketing system. Marketing studies indicate that fisher's share in consumer's price ranges from 30 to 68%. Wholesalers receive 5 to 32% and retailers 14 to 47% for different groups of marine fishes. Fishers in Gujarat receive 37% (catfishes) to 83% (ribbonfishes) of consumer's price while in Maharashtra it ranged from 36% (barracudas and sharks) to 81% (seerfishes) (Table 20). Fishers realize the highest share for cephalopods (71%) in Karnataka and Kerala, for whitefish (67%) in Tamil Nadu and for sardines (58%) in Andhra Pradesh.

The growth of fish production and development of fisheries is enhanced by an efficient marketing system. Post-harvest operations provide more employment than the production sector. Involvement of intermediaries in transporting the fish to the consumer is very high in India. Marine fishes procured from 2 244 landing centers are distributed throughout the country. Monophony characterizes the fish marketing structure in various stages. Five types of marketing channels exist. They are: (i) Producer-retailer-consumer (ii) Producer-whole-saler-retailer-consumer, (iii) Producer-commission agent-wholesaler-retailer-consumer, (iv) Producer-wholesaler-commission agent-retailer-consumer, and (v) Producer-commission agent-wholesaler-commission agent-retailer-consumer.

Table 20. Fisher's share in consumer's price for selected varieties of fish in different marine states 1996 - 97.

	Fisher's Share (%)					
Group	**Gujarat**	**Maharastra**	**Karnataka**	**Kerala**	**Tamil Nadu**	**Andhra Pradesh**
Seerfishes	71	81	40	65	49	49
Pomfrets	64	68	46	43	51	53
Barracudas	0	36	55	53	54	24
Tunas	63	43	0	51	60	36
Sharks	45	36	40	63	60	17
Catfishes	37	76	35	58	63	33
Mackerel	50	50	33	50	55	26
Sardines	60	57	54	43	63	58
Ribbonfishes	83	60	41	37	55	36
Rays	0	0	0	30	57	40

Table 20. Fisher's share in consumer's price for selected varieties of fish in different marine states 1996 - 97.

Group	Fisher's Share (%)					
	Gujarat	Maharastra	Karnataka	Kerala	Tamil Nadu	Andhra Pradesh
Whitebaits	0	0	33	26	48	22
Lizardfishes	44	43	31	30	53	36
Goatfishes	0	0	0	60	60	42
Threadfins	43	0	0	0	53	23
Croakers	56	45	38	31	63	27
Silverbellies	0	0	0	35	32	21
Whitefish	0	0	60	45	67	44
Mullets	0	45	42	56	46	38
Half & full beaks	0	0	0	61	65	0
Cephalopods	63	75	71	71	51	44

Source: Sathiadhas et al. (1995)

Management Issues and Opportunities

Capture fisheries are an example of exploiting renewable but limited natural resources. The resources are common property, with free and open access. Irrespective of the type of fisher, their operation will not be limited until zero profitability thresholds are reached (Anderson 1987). Hence, there is a need for a management system to intervene and regulate activities. The fisheries management system must set up fishing regimes that appropriately match the productive capacity of the resource base (Silvestre and Pauly 1997).

Fisheries management is a dynamic resource allocation process with sustainable production and value to society as the prime objectives. The objectives of coastal fisheries management along the southwest coast of India are given in Fig. 2. With sustainable coastal fisheries development as the overall goal, key third level objectives are given, consistent with the ecological, social, economic and administrative thrusts of fisheries management in the area. These were synthesized from available policy instruments, plans and documents relevant to fisheries in the area.

Fig. 3 gives a summary of the key issues impacting sustainable coastal fisheries development in the southwest coast of India, together with relevant interventions for their resolution or mitigation. The key issues (and interventions) relevant to the ecological objectives are:

- The currently high and increasing fishing intensity off the southwest coast of India (9 308 mechanized and 34 800 traditional fishing crafts in 1998) leading to symptoms of overfishing, particularly in near-shore areas. This requires the introduction of limited entry and effort reduction schemes, together with promotion of fishing in deeper, "far sea" areas.
- Inappropriate patterns of exploitation of available fishery resources via extensive trawling and use of small-meshed nets, as well as the inappropriate temporal and spatial deployment of various types of fishing gear. This requires implementation of relevant provisions of the Code of Conduct for Responsible Fisheries to improve gear selectivity and optimize species and size composition of catches.
- Degradation of the coastal environment from various non-fishing activities. This requires more rigorous implementation of various measures to protect coastal environmental health, including enhancement of the Environmental Impact Assessment systems, coastal zonation schemes and wider implementation of integrated coastal zone management initiatives.

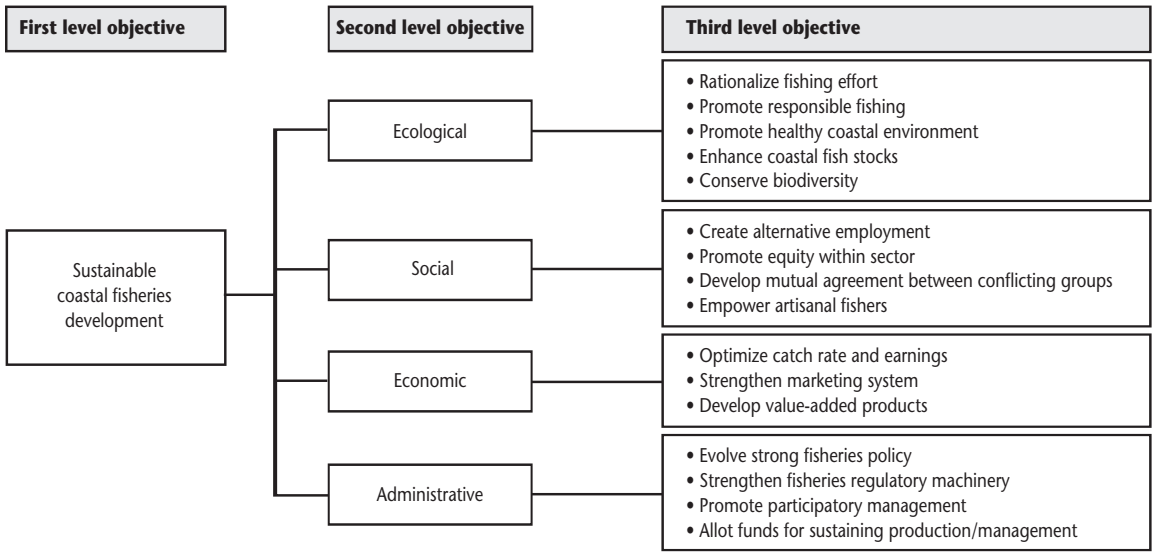

Fig. 2 Goal/objective structure for coastal fisheries management along the southwest coast of India.

- Declines in fish stocks and biodiversity from the combined effects of the above issues. These require the promotion of resource enhancement or restocking, sea farming, and the development of marine parks and sanctuaries. Marine parks have been developed in other Indian coastal areas, but remain to be developed systematically on the southwest coast.

The key issues and relevant interventions related to social objectives for the southwest coast fisheries are:

- High and increasing number of active fishers (from about 85 600 in 1961 to 200 000 in 1998). It is estimated that the density of active fishers in inshore fishing grounds (from the shoreline to 50 m depth) has increased from 3.6 to 8.5 fishers per km^2 in the past four decades. This requires the creation of alternative employment opportunities, given the momentum of increase in the fishers' population and the already high fishing intensity in inshore grounds.
- High and increasing numbers of intra- and inter-sectoral conflicts. Conflicts between and among the artisanal and mechanized fishing sub-sectors for resources and fishing grounds are intensifying, particularly in near shore areas. Conflicts between trawlers and artisanal fishers are of particular concern. Conflicts between fishers and other sectors (e.g. marine transport, mangrove forestry) also require attention. Prevention/management of these conflicts requires mechanisms to promote awareness and equity among various fishers, as well as promote mutually acceptable agreements across sectors. Promotion of spatial zonation schemes in coastal areas and integrated coastal zone management deserves attention. Land-based activities affecting hydrology and the coastal environment should consider their impacts on fisheries.
- High and increasing poverty among artisanal fishers. This requires empowerment of artisanal fishers through co-management schemes, social legislation and improved support/welfare schemes, and assistance in technology upgrading for fishers who remain in fishing.

The key issues and interventions relevant to the economic objectives are:

- Decline in earnings of fishers, particularly those in the artisanal sub-sector. This requires addressing the issue of high fishing intensity in general, and diversifying the fleet composition or configuration to optimize economic returns from fishing. Promotion of gear to utilize underexploited species and resources in deeper areas deserves attention.
- Inefficiencies in the domestic marketing system. The infrastructure for domestic marketing lags behind that available for export of fishery

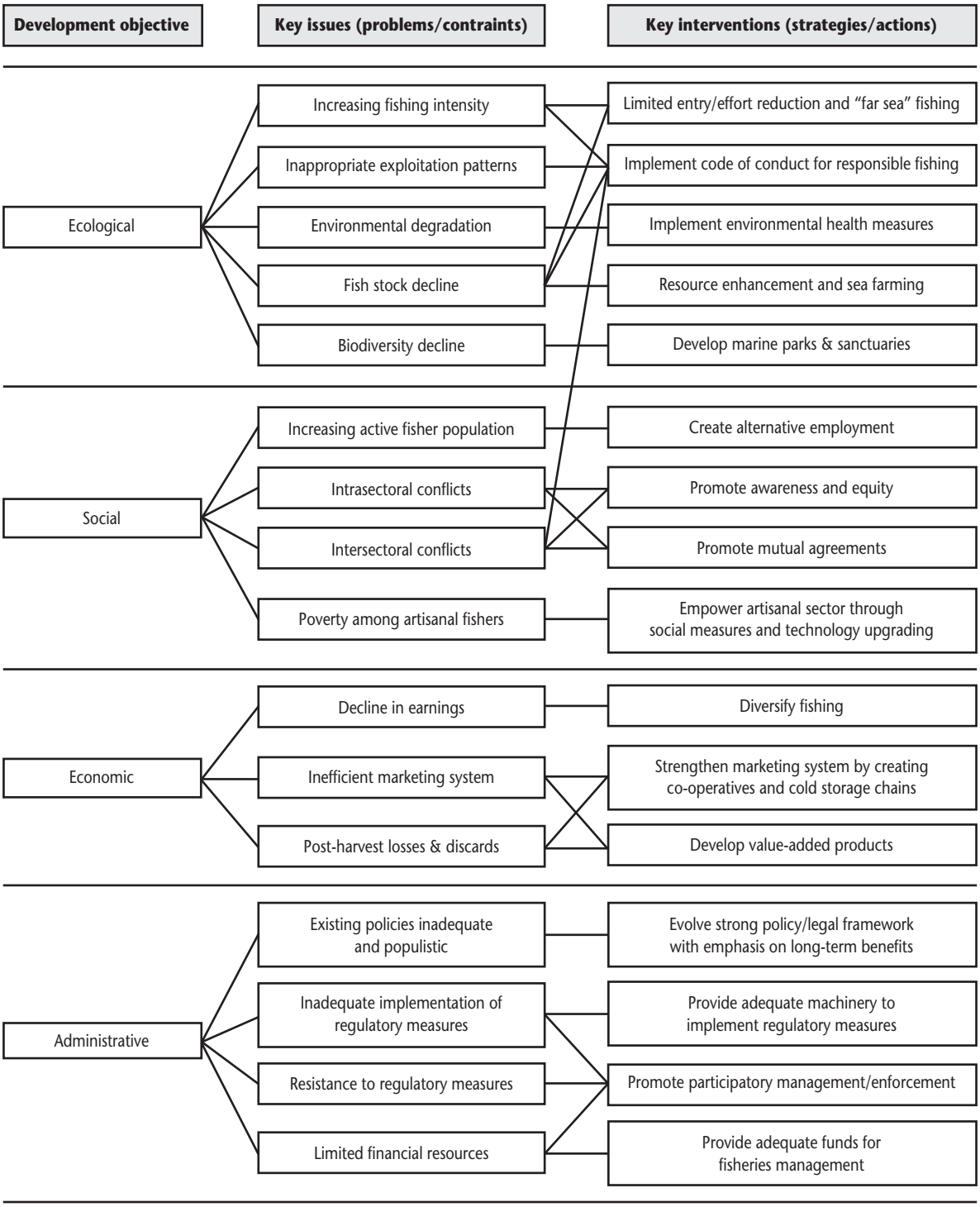

Fig. 3 Problem/opportunity structure for coastal fisheries management along the southwest coast of India.

products. This requires improvement of the marketing system and cold storage chains supporting the 540 landing centers in the southwest coast.

- High post-harvest losses and discards resulting in value losses to fishers. Discarding is particularly a problem for the trawl fisheries principally targeting shrimps. The development of value-added fishery products requires attention, together with improvement of the domestic marketing infrastructure, to be able to reach markets further inland. Large quantities of crabs, stomatopods and non-penaeid shrimps are currently used for reduction to fishmeal, and they alternatively can be used for human consumption.

The key issues and interventions relevant to the administrative objectives are:

- Inadequacy of existing fisheries policies. Existing policies mostly revolve around populist welfare measures. Overall, the country needs a strong fisheries policy that balances welfare concerns with sustainability. For instance, Acts defining fishing zones or areas for artisanal fishers, closed seasons, surveillance and enforcement schemes, and licensing require review and updating, involving various stakeholders.
- Inadequate implementation of, and resistance to, regulations. Many regulations are not adequately implemented due to lack of personnel, limited budgets, poor institutional collaboration, and resistance from fishers. This requires attending to causative factors and appropriate participatory mechanisms or co-management arrangements to allow more effective implementation of regulatory measures.
- Limited financial resources for fisheries management and development. The fisheries sector's contribution to national GDP was about 1.3% in 1995 - 96. The current five-year plan allocates only 0.35% of the plan budget to fisheries. Increasing the government allocation of resources to fisheries requires attention, as well as exploration of cost-sharing schemes for fisheries management with the fishing industry.

The key issues and interventions outlined above need immediate attention by the maritime states in the southwest coast and the Government of India. Table 21 illustrates the key interventions and the most relevant agencies for their implementation, given the existing institutional structure (see Appendix 1). Relevant research support agencies for the interventions are also provided in Fig. 3. Two interventions requiring regional collaboration are included in addition to the ones already discussed above. These pertain to the need for management of straddling stocks and sharing of successful fisheries management policies and practices among developing Asian countries. International agencies with interest in the region should help spur research and collaboration among countries in these areas. Project briefs (covering objectives, scope, implementation arrangements, and indicative costs) for the key interventions given in Fig. 3 and Table 21 for the southwest coast fisheries of India have been prepared by the authors to facilitate their uptake by implementing agencies. These project briefs require further review and improvement in collaboration with concerned stakeholders in the near future and are available upon request from the authors or the TrawlBase project team based at CMFRI.

Table 21. Key interventions and implementing organizations.

Key Interventions	Implementing Organization	Research Support
Limited entry, effort reduction and "far sea" fishing	Ministry of Fisheries (State governments) Ministry of Agriculture (GOI)	CMFRI and FSI
Implement code of conduct for responsible fishing	Ministry of Fisheries (State governments)	CMFRI, CIFT and CIFNET
Implement environmental health measures	Ministry of Fisheries (State governments), NGOs.	DOD, CICEF and Fisheries colleges
Resource enhancement programs	Ministry of Fisheries (State governments), & Ministry of Agriculture (GOI)	CMFRI
Creation of marine sanctuaries	Ministry of Agriculture (GOI), Ministry of Fisheries (State governments), NGOs.	ZSI, CMFRI and NBFGR
Provide alternative employment	Ministry of Fisheries (State governments), NGOs, Financing institutions	CMFRI
Promote awareness	Ministry of Fisheries (State governments), fisher associations, NGOs, Village Panchayats	–
Promote mutual agreements	Ministry of Fisheries (State governments), fisher associations, NGOs, Village Panchayats	–
Empowerment of artisanal fishers through social and technology upgrading	Ministry of Fisheries (State governments), Ministry of HRD, Government of India NGOs, Village Panchayats	–
Diversify fishing	Ministry of Agriculture (GOI), Ministry of Fisheries (State governments)	CIFT, FSI and CIFNET
Strengthen marketing system	Ministry of Fisheries (State governments), Ministry of Agriculture (GOI), Village Panchayat, Fisheries Associations	Fish.co-ops.,CIFT, IFP, Fisheries Colleges
Develop value-added products	Ministry of Fisheries (State governments)	CIFT, IFP, Fisheries Colleges
Evolve strong fisheries policies	Ministry of Agriculture (GOI) & State Governments	CMFRI and IIM
Provide machinery for implementation	Ministry of Fisheries (State governments), fisher associations,NGOs, Village Panchayats	–
Promote participatory management	Ministry of Fisheries (State governments), fisher associations, NGOs, Village Panchayats	–
Provide adequate funds for fisheries management	Ministry of Finance & Ministry of Agriculture Government of India	–
Management of straddling stocks	Regional organizations (Worldfish Center, BOBP, SEAFDEC, APFIC)	CMFRI, FSI and DOD
Experience-sharing with neighbouring countries	Regional organizations (WorldFish Center, BOBP, SEAFDEC, APFIC)	CMFRI and FSI

Note: CMFRI = Central Marine Fisheries Research Institute, FSI = Fisheries Survey India, CIFT = Central Institute of Fisheries Technology , CIFNET = Central Institute of Fisheries, Nautical and Engineering Training, DOD = Department of Ocean Development, CICEF = Central Institute of Coastal Engineering for Fishery, ZSI = Zoological Survey of India, NBFGR = National Bureau of Fish Genetic Resources, IFP = International Fisheries Project, IIM = Indian Institute of Management.

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Appendix 1. Institutional and Legal Background

Fisheries Policies

Fisheries is a state subject under Schedule VII, Article 246 of the Constitution of India. However, fishing and fisheries both in and beyond territorial waters are in the Union List. Hence, matters relating to fisheries, particularly marine fishing within territorial waters are largely within the purview of state governments and fishing beyond territorial waters come directly under the national government. Nevertheless, according to Article 297 of the Constitution, the Government of India exercises a coordinating role in respect of fisheries (both within and outside territorial waters).

Under the enabling provision of the Indian Fisheries Act 1897, various states and union territories of India have introduced fishery regulations. These legislations are enacted to suit local demands and conditions. Under the Maritime Regulation Act, the Government of India has requested maritime states to frame rules for regulation of fishing to protect traditional fishers and the operation of large fishing vessels.

Development plans are carried out through Five Year plans. The Ninth Plan (1997 - 2001) has established targets for selected programs (Annex Table 1). The broad objectives of fisheries development are to: (i) increase fish production and thereby raise nutritional standards of the population, (ii) generate income, employment, and growth and subsidiary industries, (iii) ensure the welfare of

Annex Table 1. Ninth plan targets for the fisheries sector in India, 1997 - 2001.

Particulars	Targets
Fish production (x10^6 t)	
Marine	3.0
Inland	2.5
Total	5.5
No. of mechanized vessels	50 000
No. of deep-sea vessels	350
No. of minor fishing harbours	140
Exports	US$1.5 billion

fisher communities, and (iv) maximize foreign exchange earnings through export of marine products.

Centrally-sponsored schemes currently in operation for development of coastal marine fisheries include the following: (i) financial assistance by way of subsidy to fishers for motorization of traditional craft, (ii) introduction of plywood craft and intermediate craft, (iii) reimbursement of central excise duty on oil used by small mechanized fishing vessels, (iv) assistance to maritime state governments for enforcing marine fishing regulations by way of providing patrol boats and equipment, and (v) resource enhancement through artificial reefs and mariculture.

In addition, the following development directions are in place:

i. The Government of India meets 100% of expenditure in construction of major fisheries harbors, and 50% of expenditure in construction of minor fisheries harbors and fish landing centers. The balance is borne by concerned state governments.
ii Strengthen the infrastructure of state fisheries corporations/federations, and provide assistance for marketing by way of refrigerated vans, cold storage, ice plants, and related equipment.
iii. Under the Fish Farmers' Development Agency, a package of assistance consisting of fish seed/feed, subsidy, training and extension is provided to fish farmers to expand fish culture and to increase productivity of fish farms.
iv. Under the Brackish-water Fish Farmers Development Agency, a package of assistance consisting of brackish-water culturable species (especially penaeid shrimp seed/feed), subsidy training and extension is provided to brackish-water fish/shrimp farmers to expand brackish-water fish/shrimp culture and increase productivity of brackish-water fish/shrimp farms.

Promotion of deep-sea fishing is envisaged through the Deep-sea Fishing Policy, which became fully effective in 1993 - as a number of vessels under joint venture, test fishing and leasing were permitted. However, due to operational, managerial and social problems, there is currently no deep-sea fishing for resources other than shrimps. About 160 deep-sea shrimp trawlers owned by 85 companies are now operating along the central part of the east coast of India. For integrated development of the deep-sea fishing sector, the following schemes are being implemented:

i. Assistance for deep-sea fishing and processing ventures - funds under this scheme are released to the Marine Products Export Development Authority (MPEDA, Ministry of Commerce, Government of India), who in turn participate by way of equity in deep-sea fishing and processing ventures.
ii. Assistance for diversified fishing - funds under this scheme are released to MPEDA, who in turn provide subsidy towards the cost of modification of vessels.
iii. Scheme for providing loans for acquisition of deep-sea fishing vessels - the Shipping Credit and Investment Company of India, Ltd. (SCICI) provides loans to fishing companies for acquisition of fishing vessels.
iv. Communication facilities for coastguard - communication facilities are strengthened by providing funds to set up ship-to-shore radio communication links with fishing vessels.

A major activity is implementation of fishers' welfare schemes. At present, the following welfare schemes are being implemented:

i. Group accident insurance scheme for active fishers - fishers are insured and the premium cost is shared equally by the central and state governments.
ii. Development of model fishing villages - aims at providing civic amenities such as housing, drinking water and community halls in selected fishing villages with the cost shared equally by the central and state governments.
iii. Savings-cum-relief schemes - provides financial assistance to traditional fishers during non-fishing seasons (1/3 of the fund per fisher is provided by the central government, 1/3 by the maritime state governments and 1/3 by the beneficiaries on a monthly installment basis during fishing months with the full amount reimbursed to the beneficiaries during non-fishing months).

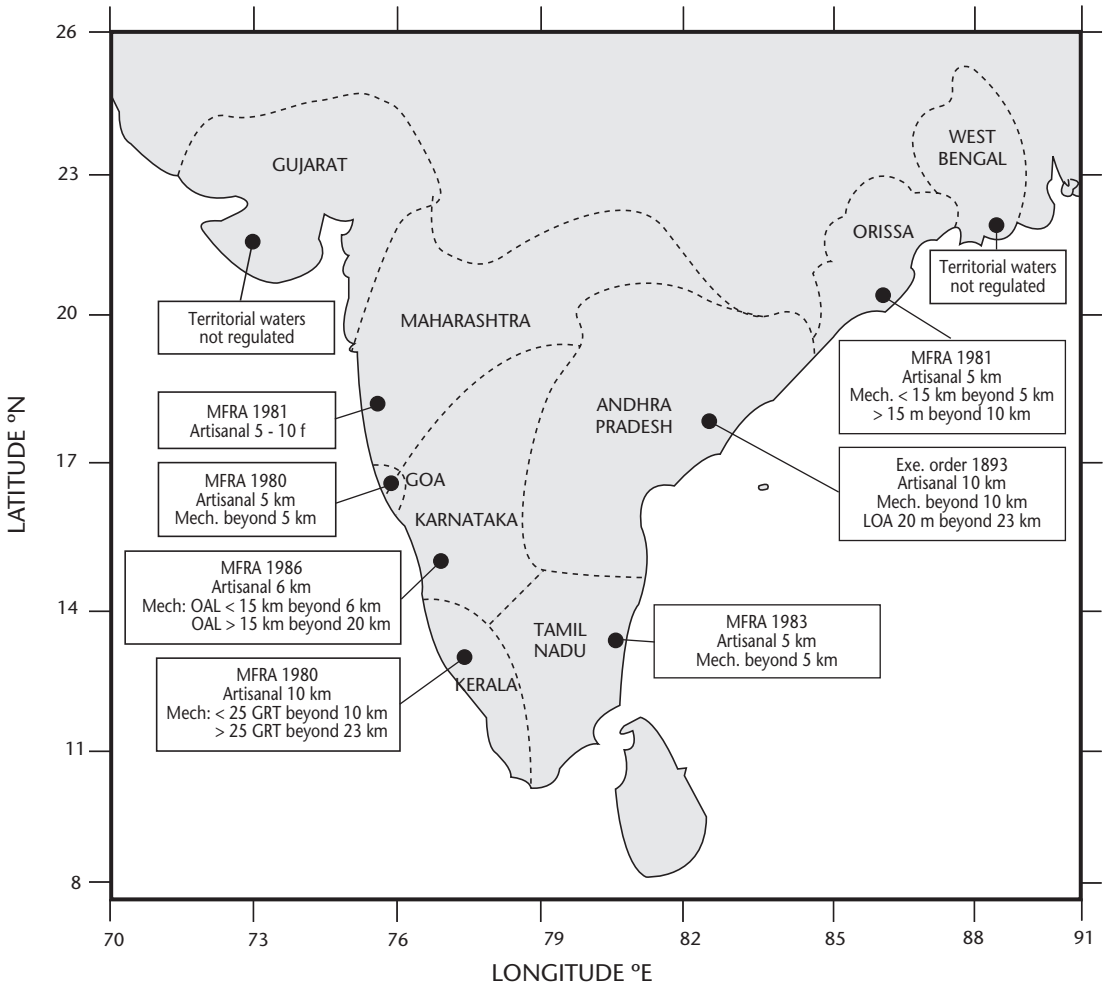
The Indian Fisheries Act 1897 was enacted by the Government of India more than 100 years ago with provisions for the issue of rules by state governments. This Act is still in force and various state governments have issued rules under this Act for regulation and protection of fisheries. Regulations concerning Indian marine fisheries are as follows:

i. Nilgiris Game and Fish Preservation Act 2 of 1879, Government of Madras;
ii. Bengal Private Fisheries Protection Act 2 of 1889, Government of Bengal and Madras amendment Act 1929 (Act 11 of 1929);
iii. The Indian Fisheries Act, No. IV of 1897, Government of India;
iv. The Indian Fisheries Act as adopted and applied by the State of Saurashtra, 1897;
v. The Mysore Game and Fish Preservation Act 2 of 1901, Government of Mysore;
vi. The Game and Fish Protection Regulation Act 12 of 1914, Government of Travancore (1914) (modified 1921);
vii. Cochin Fisheries Act 3 of 1917 (modified 1921), Government of Cochin;
viii. Andaman and Nicobar Islands Fisheries Regulation 1 of 1938;
ix. The United Provinces Fisheries Act 45 of 1948;
x. Government of Travancore-Cochin Fisheries Act 34 of 1950;
xi. The Maharashtra Fisheries Act 1960 (modified 1962), Government of Maharashtra;
xii. The Indian Fisheries (Pondicherry Amendment) Act 18 of 1965;
xiii. The Indian Wildlife Act 1972. 21b-The territorial waters, continental shelf, EEZ and other maritime zones Act 1972;
xiv. The Marine Products Export Development Authority Act 1972;
xv. The Maritime Zones of India (Regulation of fishing by foreign vessels) Act 1981;
xvi. The Kerala Marine Fishing Regulation Act and Rules 1980 (Act 10 of 1981);
xvii. The Goa Marine Fishing Regulation Act, 1980;
xviii. The Maharashtra Marine Fishing Regulation Act 1981, Government of Maharashtra;
xix. The Orissa Marine Fishing Regulation Act 1981 (Orissa Act 10 of 1982) and the Orissa Marine Fishing Regulation Rules 1983;
xx. The Tamil Nadu Marine Fishing Regulation Rules 1983;
xxi. Executive Order 1983 of Government of Andhra Pradesh; and
xxii. The Karnataka Marine Fishing Regulation Act, 1986.

The marine fishing regulation Acts (xvi-xxii above) are being implemented following a "model bill" circulated by the Government of India to all maritime state governments for regulation of exploitation of marine fisheries resources in territorial waters of India. These Acts demarcate fishing zones in ter-ritorial waters for fishing by non-mechanized and mechanized fishing vessels. The distance from the shore earmarked for each category varies according to situations in the state concerned. In general, 5 to 10 km is reserved for operation by non-mechanized vessels (Annex Fig. 1). Mechanized vessels are classified according to size and the area/depth of operation is delineated accordingly. As fish density is generally related to water depth, there were complaints in demarcating the areas of fishing based on distance from the shore. At a distance of 5 km from the shore, the depth may be only 20 m in certain areas like the Gulf of Mannar (SE coast), but 100 m in other areas. In response to complaints, some state governments incorporated the depth factor in their Acts in addition to distance from shore. For instance, the Kerala Marine Fishing Regulation Act 1980 divides the coastline into two sectors, a southern sector of 78 km coastal length and a northern sector of 512 km length. In the southern sector distance from the shore up to 32 m depth, and in the northern sector distance from the shore up to 16 m depth, have been reserved exclusively for artisanal craft. In the 32 to 40 m depth zone in the southern sector and the 16 to 20 m depth zone in the northern sector, only motorized craft are permitted to operate. Small mechanized vessels (< 25 GRT) are allowed to operate between 40 and 70 m depth in the southern sector and between 20 and 40 m depth in the northern sector.

In addition to regulation of fishing areas, there are regulations for cod-end mesh size of trawl nets. However, in the absence of effective surveillance systems, these regulations can not be implemented strictly. Encroachment by mechanized vessels in areas demarcated for artisanal craft and usage of very small mesh size in the cod-ends (< 10 mm) continue even after promulgation of the Acts.

The maritime state governments along the west coast implement seasonal closure of fishing operations by mechanized vessels. Unlike regulations of fishing areas provided in the Acts, the decision on seasonal closure is taken on a year to year basis normally prior to or during the onset of the south-west monsoon (June to September) (Annex Fig. 2). Gujarat has been observing seasonal closure for the past 2 decades, and Karnataka and Kerala for the past decade. Along the east coast, there is no effective seasonal closure. However, mechanized vessels of Andhra Pradesh observed 40 days closure during April - May 1999. Mechanized vessels in the Gulf of Mannar (southern Tamil Nadu) fish only on 3 days a week and artisanal craft on the remaining 4 days.



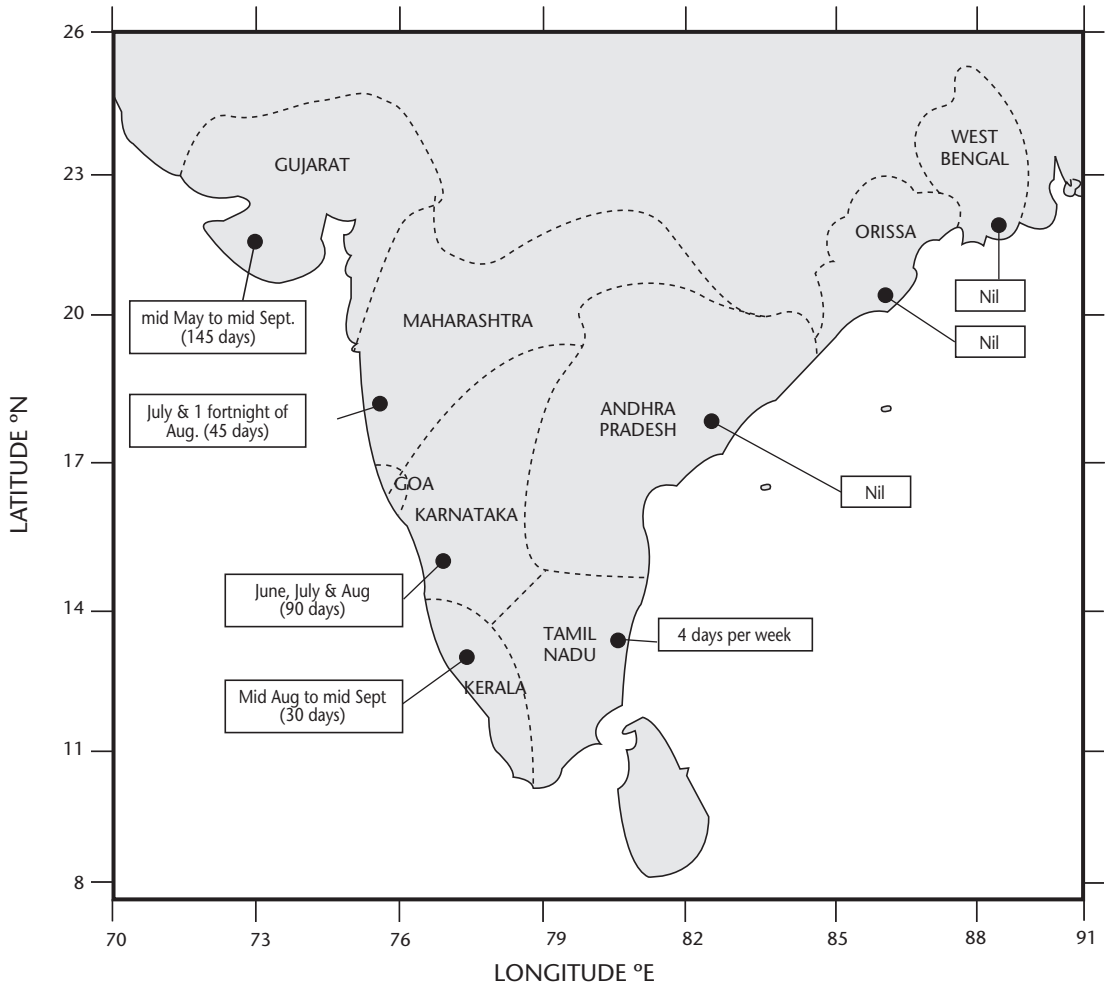
Annex Fig. 1. Regulation of fishing areas in Indian territorial waters.

The state government Acts have a few other restrictions such as a ban on fishing using destructive gears in backwaters, and a ban on fishing by unlicensed vessels. The governments encourage formation of fishermen cooperatives mainly for the purpose of extending welfare measures such as distribution of outboard motors and granting subsidies. However, policies related to restrictive fishing measures are found to be difficult to implement, while the welfare measures are accepted by the fishers.

Fisheries-related Policies

Over the last decade, management of the coastal zone and resources for their sustainable use has become a critically important issue for India. Included among these resources are some of the most extensive mangrove areas and coral reefs and a few endangered and threatened species. Recognizing the importance of coastal ecosystems and the country's reliance upon its endowment of natural resources, several regulations and notifications have been promulgated by the central and state governments. The important ones are:

i. General standards for discharge of wastewaters in marine coastal areas (1993);
ii. Notifications declaring certain coastal areas as a marine sanctuary or marine national park;
iii. Notification declaring coastal stretches as Coastal Regulatory Zone (CRZ) and regulating the activities in the CRZ (1991, 1994, 1996);
iv. Environmental impact assessment notification (1994);



Annex Fig. 2. Seasonal closure in the operation of mechanized vessels during 1997.

v. Indian Ports Act (1963);
vi. Wildlife Act (1972);
vii. Water Act (1974);
viii. Environment Act (1986).

These Acts are primarily concerned with resources and coastal ecology and also in regulating fishing in public and private waters through a system of licensing by government authorities. For conserving the coastal zone specifically, the Ministry of Environment and Forest (MOEF), Government of India, issued the CRZ, under which every maritime state had to prepare a coastal zone management plan. The Government of India identified parameters for development that are permissible in coastal areas up to 500 m from the high tide line (HTL). Coastal areas have been categorized as follows: *CRZ I* - ecologically sensitive areas (such as mangroves, coral reefs) and the area between the low tide line and HTL where no construction shall be permitted within 500 m from the HTL; *CRZ II* - areas already developed up to the shoreline in urban/built-up areas where buildings are permitted only on the landward side of existing roads/ structures; *CRZ III* - relatively undisturbed areas which do not come under CRZ I and II in rural areas under this category, the area up to 200 m from the HTL is a no-development zone and the development of vacant plots between 200 and 500 m is subject to approval by MOEF; *CRZ IV* - Andaman & Nicobar, Lakshadweep and other small islands, where no new construction will be permitted within 200 m from the HTL in the Andaman & Nicobar Islands and permission for

construction in Lakshadweep and other small islands will be decided by MOEF, depending on the size of the island.

Indian coastal areas harbor one of the world's major mangrove systems. It is estimated that mangroves in India cover an area of 0.7 million ha. The Sundarbans in the northern Bay of Bengal makes up the largest contiguous block of mangrove forests in the world, and approximately 40% (about 0.2 million ha) of this area is situated in India. About 12 genera and 45 mangrove and associated species have been recorded in India. Approximately 50% of India's mangrove areas have been destroyed during the last two decades (Brown 1997).

The coastal mainland of India has two widely separated areas of coral reefs. These are the Gulf of Kutch in the northwest and the Gulf of Mannar in the southeast. Other patches of coral growth occur in intertidal zones and up to 50 m depth along the west coast. Extensive reef development can be found in the Andaman & Nicobar and Lakshadweep Islands. A rich biodiversity in stony corals has been recorded along the Indian coast with 9 genera in the Lakshadweep, 21 in the Gulf of Kutch, 32 in the Gulf of Mannar and 39 in the Andaman Islands (Wafar and Whitaker 1992). Some of these sites (e.g. Andaman & Nicobar Islands) have not been intensively studied and it is likely that diversity has been significantly under-estimated (Brown 1997).

Coral reefs are being destroyed to a very large extent. The destruction is due to human exploitation in the Gulf of Kutch and Gulf of Mannar and due to siltation and tourism in the Andaman & Nicobar islands (Mahadevan and Nair 1972). For protection of the corals and coral reefs, there is a provision under the powers conferred under Section 10 (3) of the Mines and Minerals (Regulation and Development) Act 1957. The Government of Tamil Nadu (southeast coast) has issued a mining lease for collection of coral limestone under certain terms and conditions. In order to facilitate periodic growth of corals, the following stringent conditions have been imposed: (i) prohibition of mining in the islands; (ii) restriction of mining to 30 m from the fringe of the island at low tide level and on the seaward side of coral islands; (iii) prohibition of usage of explosives under any circumstance; (iv) reefs not to be mined beyond a depth of 1.5 m from the top of the reef at low tide; and (v) no mining on the live coral fringe. The Act also regulates collection of dead shells.

Marine turtles and mammals such as whales, dolphins and porpoises are the endangered species occurring along the Indian coast. Among the 5 species of marine turtles, the olive ridley *Lepidochelys olivacea* mass nests along Orissa (northeast coast) during December - March every year. It is estimated that, on average, 0.2 million nesting females frequent the Gahirmatha beach of Orissa every year (Rajagopalan et al. 1996). Following large-scale exploitation of nesting turtles and eggs, the Government of India developed conservation and management measures. To protect the turtle population, the Indian Wildlife (Protection) Act (1972) was promulgated wherein all species of sea turtles were placed as endangered species in Schedule I and thereby protected. India is a member of the Convention on International Trade in Endangered Species of Fauna and Flora (CITES), which prohibits trade in turtle products by member countries. In 1981, India became a party to the Bonn Convention on the Conservation of Migratory Species of Wild Animals. To protect sea turtles, about 65 000 ha of intensive nesting beach area in Kanika island and 12 other offshore islands were declared as wildlife sanctuaries in 1975. In addition to this, the coastal mainland has 4 national parks and 17 protected areas. There are 94 sanctuaries in the Andaman & Nicobar Islands. Consequent upon these conservation measures, poaching on nesting females and eggs of turtles has substantially decreased. However, a major threat which persists is incidental catch of turtles in fishing gear such as the trawl and gillnet. It is estimated that about 5 000 turtles are incidentally caught and stranded every year along the Indian coast (Rajagopalan et al. 1996). Efforts are on-going to reduce the mortality by attaching turtle excluder devices to the trawl and by declaring closure of fishing during the mass nesting season.

None of the marine fishes is listed as an endangered species. The whale shark *Rhiniodon typus* is the only species listed as vulnerable. The whale shark is exploited using harpoons off Veraval (northwest coast) when it migrates from oceanic regions of the Indian Ocean to the NW coast of India during February - April to feed on abundant non-penaeid shrimps. It is estimated that about 10 000 sharks (length of 5.6 to 12.0 m) were killed during 1998 for their liver, fins and meat (Vivekanandan and Zala 1994). Proper conservation measures, similar to the programs on marine mammals and turtles need to be taken up for this species. The whitefish *Lactarius*

lactarius and the unicorn cod *Bregmaceros mcclellandi* are treated as indeterminate. According to conservation status classification, indeterminate refers to taxa expected to be endangered or vulnerable. The whitefish occurs along the west coast and the unicorn cod is restricted to the northwest coast. Appropriate strategies have to be devised also to restore the populations of these two species.

Under the Indian Fisheries Act 1897, the sedentary fisheries such as chanks and pearl oysters were declared a monopoly in the Gulf of Mannar and Palk Bay by the erstwhile Madras Presidency (southeast coast) and in the Gulf of Kutch by the then Government of Saurashtra (northwest coast). These sedentary fisheries belonged to the government and are fully protected even now. Seasonal fisheries are conducted by the government departments by issuing licenses.

The coastal zone is extensively used for a large number of activities. These multiple uses are not always compatible, and this results in a wide array of problems for fisheries. The coastal area is in increasingly strong demand for human settlements due to increases in population. (Rajagopalan et al. 1996) listed 16 major causes for degradation of coastal zones/resources in India (Annex Table 2). Of these, population pressure has been identified as the most serious factor, and wastewater disposal, increasing urbanization, solid waste disposal and coastal constructions have been identified as serious factors. For effective management of coastal zones/resources, coastal areas could be set aside for primary uses such as (i) conservation, (ii) fish harvesting, (iii) tourism and recreation, (iv) ports and harbours, (v) industries, (vi) oil exploration and mining, and (vii) ocean dumping (Zingde 1996). For adopting such a classification system, great care is required for formulating and administering legislation.

Agricultural and industrial growth can lead to increased pollutants in coastal areas. Waste waters from industries have potential negative impacts on coastal fisheries. These impacts range from relatively minor disturbances (such as temporary, localized turbidity increase) to major disruptions (e.g. water pollution caused by discharge of toxic chemicals). Aside from outright fish kills, pollution causes pervasive and continuous degradation that is evidenced by gradual disappearance of fish or shellfish or a general decline in natural carrying capacity of the system. The persistence of pesticides and other chemicals in bays and lagoons is of great concern. These can have a direct impact on the suitability of fish for human consumption.

Excess nutrients received by the aquatic environment from land sources often result in negative impacts due to excessive algae and oxygen deficiency. Land-based sources of pollution are believed to be responsible for more than 75% of marine pollution (Clark 1992). The rest comes from shipping, dumping, offshore mining and oil exploration and production.

Annex Table 2. Factors responsible for degradation of coastal zones/ resources in India. 43 - most serious factor; 2.5 to 2.0 - serious factors; 1.5 to 1.0 - least serious factors, modified from Rajagopalan et al. 1996.

Factors	Seriousness index
Population pressure	4.0
Destruction of mangroves	2.5
Waste water disposal	2.5
Increasing urbanization	2.5
Solid waste disposal	2.5
Coastal constructions	2.5
Natural disasters	2.0
Ports	2.0
Coastal erosion	2.0
Atmospheric pollution	1.5
Aquaculture	1.5
Tourism	1.5
Increase of seawater?	1.5
Coastal mining	1.5
Power plants	1.5
Sea level rise	1.0
Coastal highways	1.0

Fisheries Institutions

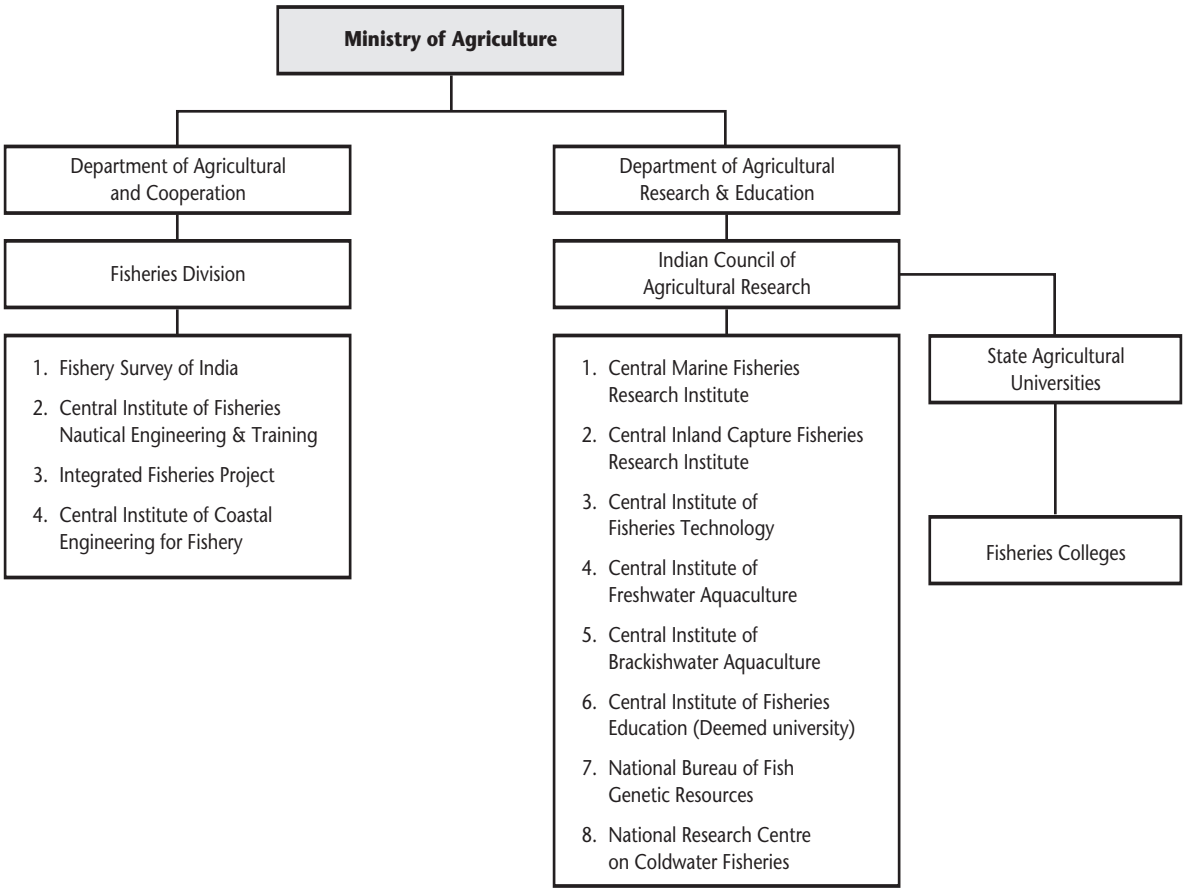
The Government of India firmly believes that the key to increase fish production is through application of science and technology. Consequently, effective research and extension programs, which are critical to the development of fisheries have been given priority. Different ministries, with the Ministry of Agriculture as nodal ministry, are involved in various fisheries activities such as research, management, development and coordination (Annex Fig. 3). The mandate of the institutions under the Ministry of Agriculture are given below:

Department of Agriculture and Cooperation (DAC)

The DAC acts as the nodal agency for development of inland, brackish-water and marine fisheries. It implements various production-oriented, infrastructure development and fishermen welfare programs either directly or through the maritime states/union territories. The department also negotiates with international agencies for obtaining financial technical assistance for specific fisheries projects in state/central sectors.

Fishery Survey of India (FSI)

The activities of FSI are aimed at exploration, development and management of deep-sea fishery resources through survey and biological/technical research, the results of which provide the government with scientific information for formulation of deep-sea fishery policies and development plans. The FSI also provides advice to the fishing industry and to development and financing institutions concerning fishing vessels, fishing gear and fish resources. The FSI has headquarters in Mumbai



Annex Fig. 3. Organization of the Ministry of Agriculture, Government of India.

(Maharashtra) and zonal bases in Porbandar (Gujarat), Mormugoa (Goa), Cochin (Kerala), Chennai (Tamil Nadu), Visakhapatnam (Andhra Pradesh) and Port Blair (Andaman & Nicobar Islands).

Central Institute of Fisheries, Nautical Engineering and Training (CIFNET)

The objectives of the Institute are to: (i) train manpower to man ocean-going fishing vessels, to run infrastructure establishments and to train technical teachers to man fishers' training centers attached to the maritime states and the union territories, (ii) provide a technical consultancy service in marine fisheries with particular reference to technical manpower requirements, (iii) conduct studies on fishing craft, gear and equipment and provide extension training to accelerate advancement in fisheries technology, and (iv) help developing nations in Southeast Asia, Middle East and Africa to train technical manpower for fishing. The CIFNET headquarters is in Cochin (Kerala) and centres are in Chennai (Tamil Nadu) and Visakhapatnam (Andhra Pradesh).

Integrated Fisheries Project (IFP)

The objectives of the project are to: (i) convert low-value fish obtained from the deep-sea into value-added products and study the commercial feasibility of deep-sea fishing, (ii) optimize and popularize the utilization of low-value fishes by converting them into value-added products, (iii) develop suitable animal/poultry feed making use of fish waste offal, and (iv) provide necessary infrastructure and maintenance facilities for fishing vessels belonging to the government and fishing industry. The IFP headquarters is in Cochin (Kerala) and there is a centre in Visakhapatnam (Andhra Pradesh).

Central Institute of Coastal Engineering for Fishery (CICEF)

The objectives of the Institute are to: (i) undertake engineering and economic investigations and the preparation of project feasibility reports for development of fishing harbors, (ii) locate sites suitable for brackish-water farms, develop engineering designs and prepare techno-economic feasiblity reports on the sites, and (iii) establish guidelines for designing coastal farms and train personnel to undertake feasibility studies. The Institute is located in Bangalore (Karnataka).

Department of Agricultural Research and Education (DARE)

DARE is the nodal department for fisheries research and education in the country. Research is carried out through the Indian Council of Agricultural Research (ICAR, which is an autonomous registered society attached to the Ministry of Agriculture) and the state agricultural universities. ICAR sponsors, coordinates and promotes research and education in agriculture, veterinary and fisheries science. The ICAR has 5 central fisheries institutes, one deemed a university, one a national bureau and one a national research center:

Central Marine Fisheries Research Institute (CMFRI)

The mandate of the Institute is to: (i) assess and monitor the status of exploited and unexploited fish stocks in the Indian EEZ in relation to fishery dependent and independent factors, (ii) assess marine capture fisheries potential and production, (iii) evaluate the techno-economics and socio-economics of marine fishing operations, (iv) develop suitable mariculture technologies, test and transfer them to different target groups comprising fishers, farmers and industries, (v) monitor the health of coastal ecosystems in relation to fishing and pollution, (vi) conduct postgraduate teaching at master and doctoral levels in mariculture, and (vii) provide training and consultancy services on various aspects of marine capture fisheries and sea farming. The Institute's headquarters is at Cochin (Kerala) with one regional center, 11 research centers and 29 survey centers.

Central Inland Capture Fisheries Research Institute (CICFRI)

The mandate of the Institute is to: (i) develop systems for monitoring and improving production in natural and man-made inland water resources through stocking, optimum exploitation and conservation, (ii) evolve management systems for optimizing production, and (iii) provide training, extension and consultancy services on various aspects of inland capture fisheries. The Institute's headquarters is at Barrackpore (West Bengal) with 12 research centers and 6 field centers.

Central Institute of Freshwater Aquaculture (CIFA)

The mandate of the Institute is to: (i) develop

intensive and extensive freshwater fish farming systems for commercially important finfishes and shellfishes, (ii) conduct training and extension programs in freshwater aquaculture, and (iii) act as a nodal agency to provide scientific information for freshwater aquaculture development. The Institute's headquarters is at Bhubaneswar (Orissa) with five research centers.

Central Institute of Brackish-water Aquaculture (CIBA)

The mandate of the Institute is to: (i) develop techno-economically viable and sustainable culture systems for brackish-water finfishes and shellfishes, (ii) provide technology support for optimizing brackish-water productivity and production, and (iii) provide training, extension and consultancy services in brackish-water aquaculture. The Institute's headquarters is at Chennai (Tamil Nadu) with three research centers.

Central Institute of Fisheries Technology (CIFT)

Activities revolve around research and extension on fishing craft and gear, fish processing, biochemistry, microbiology, electronics and engineering. The Institute's headquarters is at Cochin (Kerala) with six research centers.

Central Institute of Fisheries Education (CIFE)

CIFE is a deemed University. Its mandate is to: (i) conduct postgraduate diploma and degree courses and doctoral programs, (ii) conduct short- and long-term training courses in different disciplines of fishery science, (iii) conduct research in basic disciplines of fisheries, and (iv) provide consultancy services. The Institute's headquarters is at Mumbai (Maharashtra) with four training centers and three fish farms.

National Bureau of Fish Genetic Resources (NBFGR)

The mandate of NBFGR is to: (i) collect, classify and evaluate information on genetic resources, (ii) catalogue genotypes, (iii) maintain and preserve fish genetic materials especially those of endangered species, and (iv) monitor introduction of exotic fish species in Indian waters. The Bureau is located in Lucknow (Uttar Pradesh).

National Research Center on Coldwater Fisheries (NRCCF)

The Center's mandate is to: (i) conduct research on assessment and management of coldwater fishery resources, (ii) monitor the factors affecting them, and (iii) conduct training and extension programs. The headquarters are at Haldwani (Uttar Pradesh) with two sub-centers.

There are 7 fisheries colleges under the State Agricultural Universities, which are engaged in teaching and research programs.

In addition to the Ministry of Agriculture, the following ministries of the Government of India are involved in the management and development of the marine fisheries sector.

Ministry of Commerce

The Marine Products Export Development Authority (MPEDA), Cochin, under the Ministry of Commerce, Government of India, is the nodal organization for regulation, development and promotion of export of Indian marine products. In addition to promotion of exports, the mandate of the MPEDA includes: (i) developing offshore and deep-sea fishing through promotion of joint ventures, (ii) rendering financial and other assistance and acting as an agency for extension of relief and subsidy, and (iii) helping the fishing industry in processing and exporting value-added seafood.

Ministry of Food Processing Industries

The Ministry has the following two schemes on seafood processing:

i. Scheme for tuna and other fish processing: Under this scheme, it is proposed to assist public sector/joint sector/state level cooperatives by providing grants to the extent of 50% of the capital cost to establish modern fish processing plants for tunas, shrimps, lobsters and trash fishes.
ii. Scheme for setting up of cold chain: This is a scheme for the development of infrastructure facilities such as cold storage, ice plants and insulated vehicles for preservation and supply of fish at major fish producing and marketing centers.

Input for fisheries research and development also comes from the National Institute of Oceanography, NIO (Council of Scientific and Industrial Research), the Department of Ocean Development, DOD, and the National Remote Sensing Agency, NRSA (Department of Space). The NIO conducts research on exploitation of living and non-living ocean resources. The mandate of NIO includes coastal zone management, oceanographic surveys and resources mapping in the EEZ of India. The NRSA is the nodal agency for satellite data acquisition, data processing and dissemination, and various research disciplines including oceanography and forecasting. The NRSA program on marine fisheries has the following two objectives: (i) to provide information on sea surface temperature (SST) and (ii) to utilize the SST information for identifying Potential Fishing Zones (PFZs) and disseminate such information for the benefit of fishers.

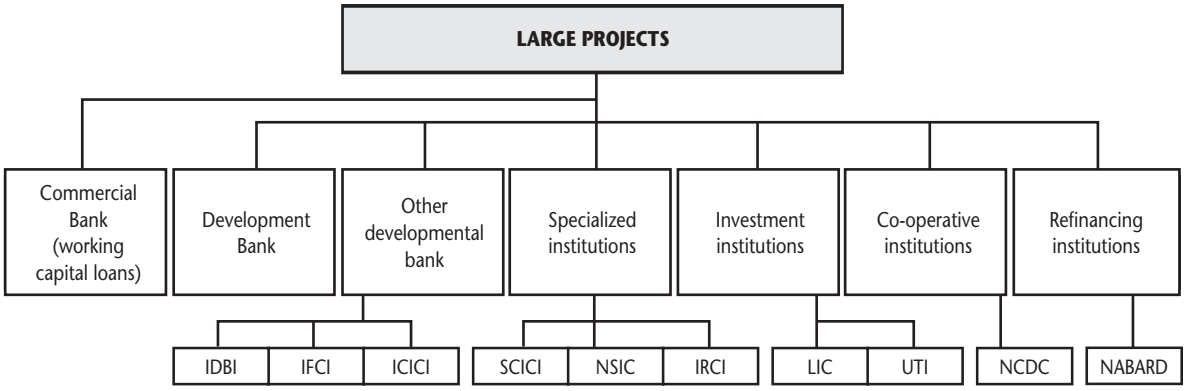
Anna University (Tamil Nadu) and Jadavpur University (West Bengal) are involved in coastal zone management.

In India, the major sources of long-term finance for capital expenditure are various lending institutions such as Industrial Finance Corporation of India (IFCI), Industrial Credit and Investment Corporation of India (ICICI) and Industrial Development Bank of India (IDBI). These apex lending institutions provide financial support either directly through their specialized subsidiaries to deal with specific sectors such as Shipping Credit and Investment Corporation of India (SCICI) or through the State Finance Corporations (SFC). The National Cooperative Development Corporation (NCDC) provides financial support to help cooperative institutions. The National Bank for Agriculture and Rural Development (NABARD) operates as a separate financial agency to provide refinancing facilities for primary lending to agricultural and agro-industrial projects made by the commercial banks. Thus, there exists an elaborate structure of institutional finance which caters to large (Annex Fig. 4) and medium and small projects (Annex Fig. 5) of the fisheries sector.

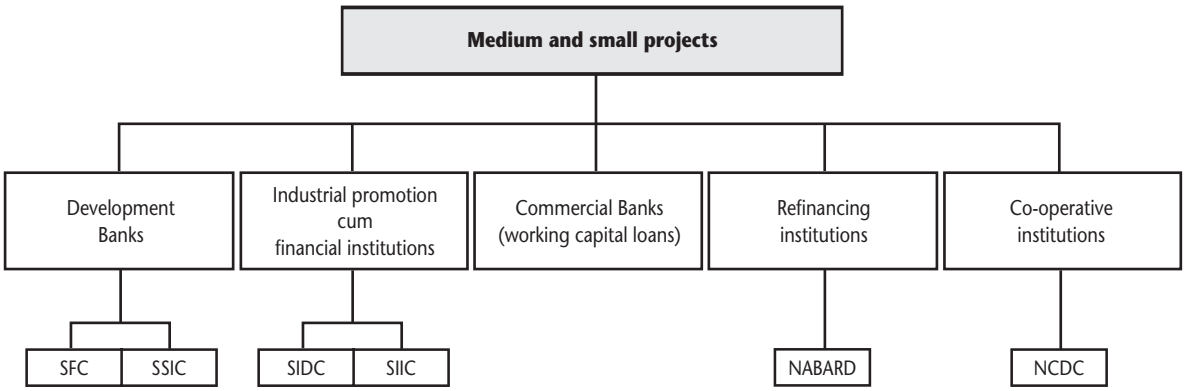
Among the various financial institutions, the role of four institutions currently engaged in providing direct or indirect finance for the fisheries sector is given below:

Shipping Credit and Investment Corporation of India (SCICI)

The involvement of SCICI in the fishing industry is generally confined to providing development finance to deep-sea fishing. In an effort to expand involvement, SCICI has announced its commitment to support shore facilities and processing. In pursuit of its objectives of promoting development, SCICI provides financial assistance to enterprises in the following forms: (i) loans in Indian currency repayable over a period of 15 years; (ii) loans in foreign currencies for acquisition of large fishing vessels, imported capital equipment and technical services; (iii) guaranteeing payments for credit given by Indian and foreign sources; (iv) under-



Annex Fig. 4. Structure of financing institutions for large projects in India.



Annex Fig. 5. Structure of financing institutions for medium and small projects in India. See Text.

writing of public and private issues and offers of sale of industrial securities; (v) direct subscription to such securities; and (vi) credit facilities to indigenous manufacturers for promoting industrial equipment on deferred payment terms, and equipment-leasing facility.

Industrial Development Bank of India (IDBI)

Activities of IDBI may be broadly classified as follows: (i) direct assistance to industrial concerns in the form of loans, underwriting and subscription to shares and debentures and guarantees; (ii) refinancing of industrial loans granted by banks and other financial institutions; (iii) rediscounting of bills arising out of sales of indigenous machinery on deferred payment basis; (iv) finance for exports in the form of direct loans and guarantees by buyers abroad in participation with commercial banks, and refinancing of medium term export credit granted by commercial banks; and (v) assistance to other financial institutions by way of subscription to their shares and bonds.

National Bank for Agricultural and Rural Development (NABARD)

The main objective of NABARD is to extend refinancing support to purchase artisanal and mechanized craft and for the development of infrastructure in the fishing industry with the prime objective of increasing fish production. The majority of schemes submitted by financing banks to NABARD are for financing the purchase of mechanized fishing vessels along with gear and deck equipment. NABARD provides refinance for craft ranging from traditional fishing craft such as catamarans and dugout canoes to deep-sea fishing vessels. However, the majority of refinanced vessels belong to the 8 - 15 m overall length category. Refinance facilities are also available for establishment of ice plants, cold storage, freezing plants, canning plants, fishmeal plants and for transport, distribution and marketing of fish. For instance, refrigerated trucks or insulated trucks, fish stalls and deep freezers are covered by NABARD refinance.

National Cooperative Development Corporation (NCDC)

NCDC has responsibility for planning and promoting country-wide programs through cooperatives by way of additive and supplemental financial assistance to the efforts of state governments. In the fisheries sector, assistance by NCDC is for development of infrastructure facilities. Assistance is provided to fishers cooperatives to set up fish markets and retail booths; for purchase of refrigerated/insulated vans; establishment of processing units, boat-building and repairing yards; and purchase of boats, nets and other equipment. The corporation also implements a central government scheme for introduction of improved beach landing craft for small fishers, and provides assistance in the form of loans and subsidy.