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Impact of environmental threats on marine fishery resources of coastal Kerala: an economic assessment

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Abstract

Competition and commercialization in marine fisheries have generated discrepancies and imbalances in marine ecology, sustainable production and distributive justice. The private capital investment made on crafts-gears in capture fisheries does not any way compensate the social cost of overexploitation of certain resources, uncontrolled juvenile fishing and discards. The common property nature of marine fisheries coupled with market driven catching strategies and technological changes led to overexploitation of varieties such as elasmobranchs, catfish and goatfish along Kerala coast. However, the analysis of production trends for a period of four decades reveals increasing trends in the landings of species such as oilsardine, anchovies, lizardfish, perches, carangids, tunnies, barracudas, flat fish and cephalapods. The study on the environmental economics of inshore fishery resource utilisation of coastal Kerala has been undertaken in four southern Districts (Ernakulam, Alappuzha, Kollam and Thiruvananthapuram) during the year 2001-2003 with focus on environmental hotspots of industrial pollution and sea erosion along with details of economic loss of juvenile fishing by trawl fisheries. The economic loss due to depletion of stocks for elasmobranches, catfishes and goatfishes has been estimated. If the downtrend for these varieties continues, the possible economic loss in terms of Net Present Value for 30 years discounted to the present level would be Rs.458.5 crore for elasmobranches, Rs.160.6 crores for catfishes and Rs.3.9 crores for goatfishes. Ensuing the primary consequences of intensive targeted fishing, a major threat identified is the landings of juvenile fishes. The differential ratio, which indicates the actual value realised against one rupee at adult stage of the fish, is found to be 0.14 for flat fish, 0.20 for anchovies, 0.21 for threadfin breams and 0.29 for carangids. The annual average profit of various craft-gear combinations is often not sufficient to compensate the overall loss generated by way of juvenile fishing. A gross estimate shows that the economic loss due to juvenile fishing made by trawlers, purse seiners, ring seiners and mini trawlers together along Kerala coast is around Rs. 1850 crores per annum where as the annual revenue generated by these fishing units comes to only Rs.705 crores, thus causing a total deficit of Rs.1,145 crores to the coastal economy. Case studies focusing on the economic loss to the fishery due to pollution in Kochuveli estimated the loss in terms of NPV to the tune of Rs.157.4 crore over a period of 15 years. The estimated loss to fishery sector due to erosion in Alappad regions in terms of NPV is Rs.647 crore over the same period.

***Keywords**: Environmental threats, Fishery resources, Economic assessment*

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1. Introduction

The c-oastline of Kerala is 590 km with 226 marine fish landing centres and equal number of fishing villages with high density of population (2,176 km^{-2}). The natural habitat is under severe threat due to human interventions in forms of excessive fishing in the inshore waters, shallow water mining, lifting of coastal sands, destruction of mangroves, inflow of pollutants in the brackish water and sea, growing urbanization, construction of sea wall and other related activities. These activities are bound to disturb the coastal ecosystem affecting the sustainability of fishery resources and the livelihood security of vast majority of the inhabitants. Besides, the technological changes in fishing methods coupled with the increasing demand for fish and consequent price escalation lead to over-exploitation of the fishery resources. This condition affects the very sustainability of productivity of the inshore ecosystems and increases demand for environmental quality and conservation of resources. This intricate crisis is studied with the following objectives such as a) to examine the extent of recent changes on structure and composition of fishing fleets and production trends of inshore marine fisheries, b) to analyse the economic loss due to juvenile fishing by various destructive craft-gear combinations and c) to estimate the economic impact of environmental degradation on inshore marine fisheries on the basis of two case studies.

The South West Coast of India pioneered many technological innovations in fishing equipment and methods during the last five decades such as the introduction of mechanized trawling in mid sixties and large-scale purse seining in late seventies. Attracted by better catch and returns, more and more trawlers entered the fishing sector with modified technology resulting in disproportionately large-scale removal and destruction of young and juvenile fishes and crustaceans along with a large spectrum of biotic communities. Even though intensive mechanization came into effect, during early eighties, Kerala marine fishery was dominated by traditional fishing methods till mid eighties. Two case studies were also attempted to assess the impact of industrial pollution and sea erosion on fishery production at two selected regions; Kochuveli and Alappad respectively.

2. Materials and methods

The study is a part of the research work on Environmental Economic Analysis of Inshore Fishery Resource Utilization of Coastal Kerala funded by Indira Gandhi Institute of Development Research (IGIDR) under the Environmental Capacity Building Project of World Bank implemented through the Ministry of Environment and Forests of Government of India. In order to identify representative sample villages for the study, a preliminary survey was conducted in all the fishing villages from Munambam in the north to Poovar in the south along four coastal districts *viz.*, Ernakulam, Alappuzha, Kollam and Thiruvananthapuram. Based on the survey, 11 coastal villages were selected for the present study. For the economic evaluation of different fishing units, the information on the daily costs and earnings of different craft-gear combinations was collected from the fishing units operating in the selected centres by direct observation on sample days covering all fishing seasons for one year (2000-2001). The fishing units selected for the study were mechanised units (trawlers, purse seiners and gill netters), motorised units (Plank built boats with ring seines, mini trawlers, plywood boats with hooks and line or gill nets) and non-mechanised units (catamarans with gill nets, shore seines and dinghy with gill nets).

Secondary time series data from 1961 to 2003, pertaining to species wise catch obtained from the National Marine Living Resource Data Centre (NMLRDC) of Central Marine Fisheries Research Institute (CMFRI) were used to study the extent of variation in catch composition, production trend of inshore marine fisheries and the impact of technological advances on marine resource base. The analysis of the major technological transition and consequent changes in the overall production and catch composition during the pre-mechanization period, mechanization period and post- mechanization period was also done.

Data on juvenile landings in the catch composition of each unit were also collected from the landing centres. The length of specimens from the tip of the snout to the tip of the longest caudal ray is measured to ascertain the quantity of juvenile landings. The quantity of juveniles landed in each fishing unit is thus recorded along with the corresponding price from the landing centre. The length-weight relationship of the form $W = {}_aL^b$ (where W-weight of the fish, L-length of the fish, a-constant, b-exponent) was fitted to obtain the weight of the adult fish corresponding to the weight of the juvenile fish. Economic loss due to juvenile fishing by different fishing units is estimated using the method,

$$EL = \left(\frac{\sum^{n} V_i Q_i}{N} \right) - \left(\frac{\sum^{n} v_i q_i}{N} \right)$$

where,

EL= Average Economic Loss per unit trip

V = Value of the marketable size fish/trip

Q = Quantity of the marketable size fish corresponding to the quantity of juvenile fish/trip

v = Value of the juvenile fish

q = Quantity of juvenile fish in the catch

N = number of trips/boat

The Net Present Value (NPV) was calculated for discounted economic loss due to waste disposal at Kochuveli and excessive sea erosion at Alappad using the following formula,

$$EL = \left(\frac{b+b_1}{(1+r) + b_2} \right) \Big/ \left(\frac{(1+r)^2 + \ldots bn}{(1+r)^n} \right)$$

where,
b = present net benefit
$b_1, b_2 \ldots bn$ = net benefit for the years 1 to n
r = discount rate
n = number of years

3. Results and discussion

3.1 Technological changes and production trends

Fishing which once depended heavily on the traditional sector has now given way to many technological innovations in fishing equipments and methods. The increasing returns in marine fishing have attracted many advanced fishing fleets thereby grabbing the traditional sector of its hold. Mechanised trawling had come to the scene by 1960s and large-scale purse seining by late 70s. Before the introduction of motorization, the traditional sector in Kerala used the gears such as boat seines (an encircling net known as thanguvala in central Kerala and kollivala in north Kerala), drift/set gill net, hooks and line and shore seines. These nets were operated by plank built boat, dugout canoes and catamarans. During early 80s, some of these traditional craft were fitted with outboard engines and these were known as motorised craft. Subsequently, the traditional fish species have been exploited by those gears (trawl nets and purse seines) with motorised country craft, which were once used solely by the mechanised sector. Kerala's traditional sector adapted to these changes through the operation of ring seine (mini purse seine) and mini trawl nets. Motorised plywood boats with gill nets or hooks and line has been the practice during the 90s, thus intensifying the artisanal fishery. The capital investment in mechanised, motorised and non-mechanised sectors of various craft-gear combinations, on an average, ranges from Rs.23,000 for a small *catamaran* unit in the non-motorised sector to Rs.25 lakh for a small trawler in the mechanised sector. The average operating cost of individual crafts among these categories varies between Rs.8000 and Rs.13 lakh providing returns to the tune of 15 % to 140 % of the capital investment.

The contemporary scenario has witnessed large-scale adoption of mechanised fishing. This is obvious from the comparative increase in the number of fishing crafts during 1995-2003 (Table 1). The total number of boats has increased from 22,744 in 1975 to 55,545 in 2003 and a positive growth rate is recorded in all the accounting period. It should be noted that in all the years except during the 70s, the growth rate in the number of mechanised boats surpasses that of non-mechanised boats. Considering the negative or comparatively lower growth rate of the number of non-mechanised boats and the increase in the number of mechanised boats, it could be inferred that mechanised sector has a higher grip in the gross fish landings. However, the high growth rate in the number of mechanised/ motorised boats is not reflected in the growth rate of gross fish landings over the years, which implies a probable depletion in fish wealth. The decrease in the catch per boat from 18.51 t in 1975 to 11.22 t in 2003, although due to the increase in the total number of boats also reveal the near-optimum resource exploitation. The most recent trend is the concentration of the fishing activities within bigger groups or firms profiting through economies of scale. This has become disadvantageous to the small-scale operators and functions against the idealistic norms of sustaining fishery resources. There is high preference for mechanised boats having overall length (OAL) > 15.24 m. The nature of fishing also has undergone changes, as there is an inclination towards multi-day fishing with extended area of operation.

Table1. Fishing Crafts and Fish Production in Kerala:Comparative Growth Rate (1975-2003)

Year	Mechani-sed (Number)	Growth Rate (%)	Non-mechani-sed (Number)	Growth Rate (%)	Total (Number)	Growth Rate (%)	Fish Landings (Lakh tones)	Growth Rate (%)	Catch per Boat (tonnes)
1975	1026	—	21718	—	22744	—	4.21	—	18.51
1980	983	-4.19	26271	20.96	27254	19.81	2.80	-33.50	10.27
1991	9914	908.55	20545	-21.80	30459	15.11	5.64	101.43	18.51
1995	21568	117.55	28456	38.51	50024	59.48	5.32	-5.67	10.63
1999	23643	9.62	28425	-0.11	52068	4.09	5.81	9.21	11.16
2003	33589	42.07	21956	-22.75	55545	6.68	6.23	7.23	11.22

Source: a) Govt. of Kerala (2000, 2003), Department of Fisheries, b) MFIS (Various Issues), CMFRI For comparative purpose, motorised units are also included in the Mechanised sector.

The gross marine fish landings in Kerala have shown an increasing trend during 1961 to 2003. The overall production has increased from 2.69 lakh t in 1961 to 6.23 lakh t in 2003 mainly due to technological advancements in fishing methods, increased utilisation of extended fishing area and increase in the number of fishing fleets. Though there is a decrease in total landings during 1980s (2.79 lakh t in 1980) compared to its previous years landings (4.21 lakh t in 1975), the gross landings showed a steep increase (to the highest 6.63 lakh t during 1990. Although the landings decreased by 1.31 lakh t in 1995, it has retained a higher landing rate since then compared to the level in 1960s and 1970s (Figure1).

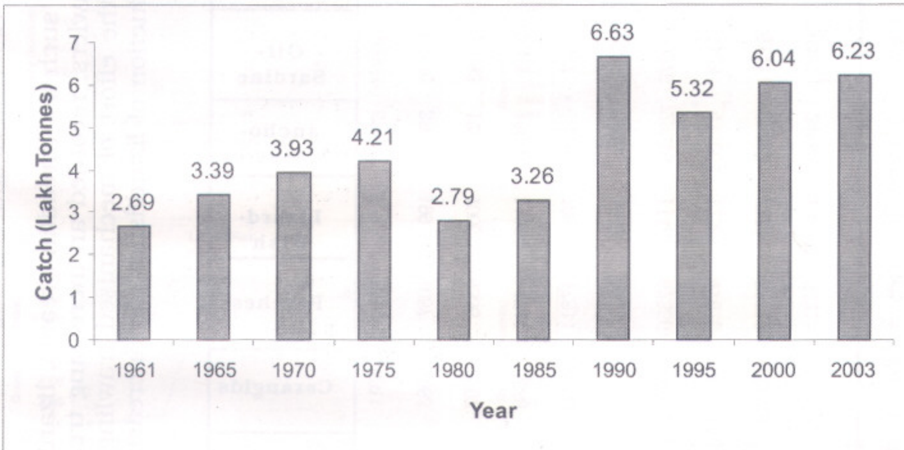

Fig. 1 Gross marine fish landings along the Kerala Coast (1961-2003)

The significant change in marine fish production along the coast for the last two decades was the increase in the landings of the cephalopods, which forms a major share of the Indian seafood exports. Cuttle fish and squids formed the major items among the cephalopods. In 1961, only 28 t of cephalopods were landed which increased to 27,277 t in 2003 with the highest value of 43,475 t recorded in 1995. The penaeid prawn catch in the State also substantially increased. The peak landings of penaeid prawns were observed during the second half of 1970s, which then declined to 26,685 t by 1985. Then onwards it maintained a somewhat steady trend by landing more than 40,000 t till 2003 (Table 2). The recent exploitation of deep-sea prawns by the mechanised trawlers operating from Neendakara, Cochin and Munambam also contributed substantially to the penaeid prawn catches. Irregular trend was observed in the catch of the two important pelagic fishes, oil sardine and Indian mackerel.

Table 2. Annual Landings of Selected Resources *(tonnes)*

Certain less valuable fishes such as, threadfin breams, lizardfishes, ribbonfishes etc, which form the by-catches in the mechanised trawlers, recorded an increasing trend in their catch. The major reason for this increase was the increase in the effort of mechanised trawling for the targeted species such as cuttlefish and *penaeid* prawns. The production of lizardfishes also increased for the last three decades especially by the mechanised trawlers (Figure 2).

Year	Ribbon fish	Mackerel	Seerfish	Penaeid prawn	Oil-Sardine	ancho-vies	Lizard-Fish	Perches	Carangids	Tunnies	Barra-cuda	Flatfish	Cephal-opods	Elasmo-branchs	CatFishes	Goatfishes
1961	4047	20044	2885	20627	166005	6742	5	1316	5311	4503	234	5882	28	8515	3114	226
1965	13826	18048	1513	14327	219170	3567	199	1057	4083	1831	902	7312	174	5969	3565	305
1970	4922	54659	1731	36940	191683	12558	1066	4336	2797	1226	79	10212	86	7490	16380	279
1975	15175	14930	4065	77207	97183	13070	11294	14741	7539	5845	396	6932	3342	10292	32603	23
1980	12937	18474	3763	52633	69667	10013	7080	17814	4760	10611	330	4394	4244	6803	13936	1
1985	25146	18115	8459	26685	79237	38045	5695	30710	12899	10009	921	11332	8308	6013	5184	100
1990	9751	78335	5372	45483	179276	29219	11469	67356	69068	32860	3842	15427	24206	6968	2739	6919
1995	4641	78515	5910	43224	13328	41406	12581	47620	102762	11088	4677	12385	43472	4109	308	174
2000	19264	33854	4998	56462	241411	25643	7779	50819	29368	16763	2996	16769	30627	2832	103	63
2003	15107	35026	8554	42862	264372	24644	10609	34215	37423	23325	4413	21692	27277	4856	261	1

Source: Central Marine Fisheries Research Institute, Cochin-682018

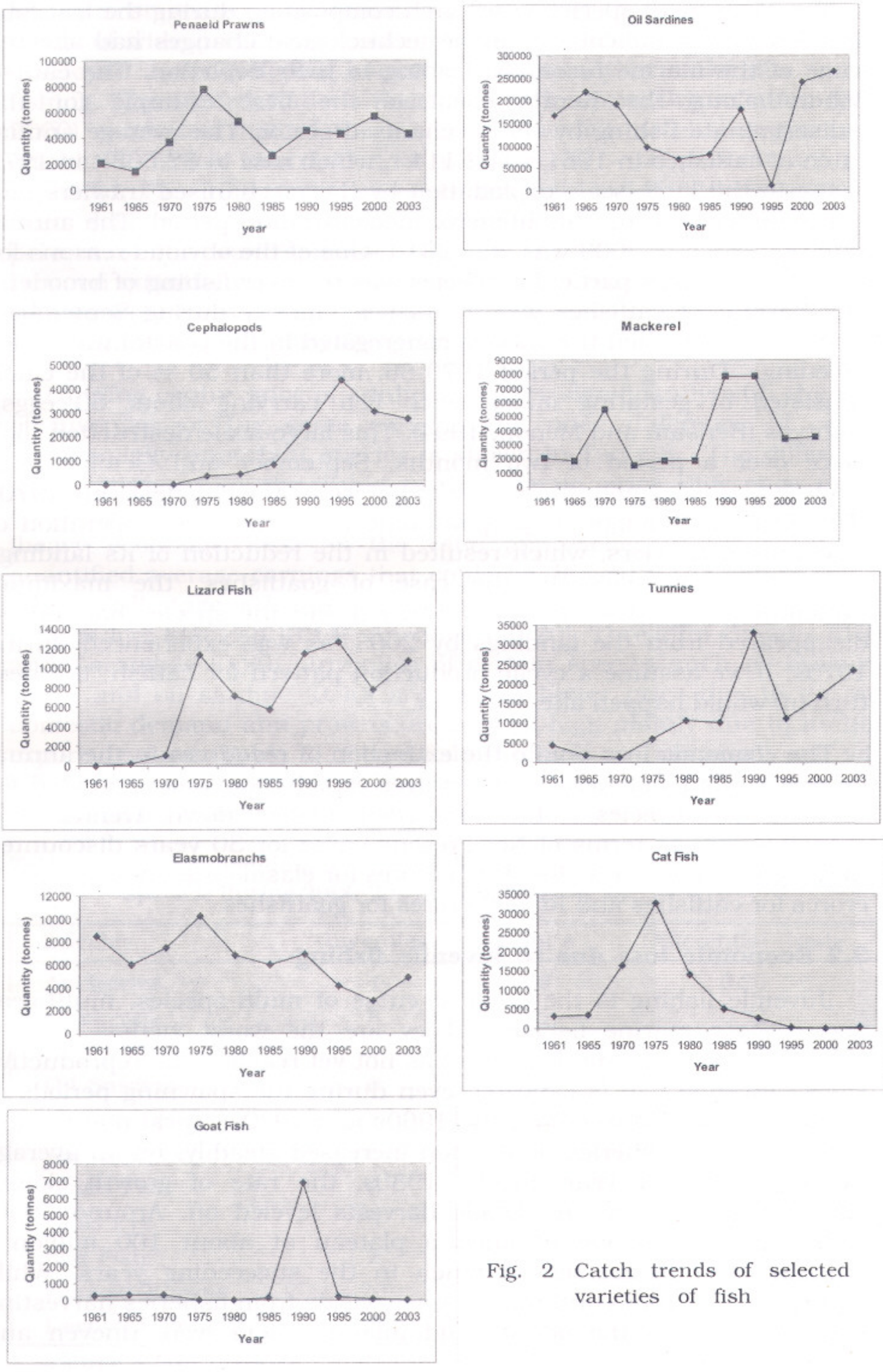

Fig. 2 Catch trends of selected varieties of fish

The analysis of species-wise catch composition during the last four decades clearly indicates that the technological changes had affected some of the marine resources leading to their depletion. The catfish fishery along the Kerala coast is the best example for the indiscriminate fishing by the mechanised sector. The average annual catch of catfishes in 1961 was 3,114 t, which rose to 32,603 t in 1975 owing to the large-scale exploitation by the mechanised trawlers and purse seiners during the intensive mechanization period. The annual catch recorded in 2003 was only 261 t. One of the obvious reasons for the decline of this particular species was the over-fishing of brooders. The harvest of catfishes was at its peak mostly during September-October period when the species congregated in the coastal waters for breeding. During the period 1979-86, more than 50 % of the catch consisted of gestating males, each fish carrying about 50 eggs/embryos (Bensam and Menon, 1994). This large-scale destruction took place over a period of two months, September and October. The landings of elasmobranch resources were the highest in 1970s (10,292 t). This might be proportionate to the intensive operation of mechanised trawlers, which resulted in the reduction of its landings in subsequent years. In the case of goatfishes, the maximum exploitation took place in 1990 (6,919 t), but the species has almost disappeared from the landings by 2003, as was experienced during 1970s. If we assume a cyclic production pattern for catfish, the next turn up would happen after 30 years.

The economic loss due to the extinction of resources in the annual marine landings of Kerala due to over exploitation was estimated for three major species, which recorded higher down trends. The economic loss in terms of Net Present Value for 30 years discounted to the present level was Rs. 458.5 crores for elasmobranches, Rs.160.6 crores for catfishes and Rs. 3.9 crores for goatfishes.

3.2 Economic loss due to juvenile fishing

Juvenile fishing is the greatest curse of multi-species, multi-gear open access marine fisheries. They are the worst victims of over fishing. Juvenile is any fish that has not yet reached the reproductive stage. Juvenile fish is captured even during the spawning periods of specific species. Throughout the 1960s and 1970s, world marine and inland capture fisheries production increased steadily, on an average by 6 percent per year. In the 1980s, the rate of growth slowed considerably, and in the 1990s harvests leveled off. Around 1990, global fish production attained a plateau at about 100 million t annually and hasn't moved much in the succeeding years. While aquaculture output continued to grow, yields from fisheries harvesting wild stocks from the oceans and inland waters were uneven and began to stagnate. A consensus emerged that the stagnation was the result of widespread over fishing (Somma, 2002). Fish stocks both in developed and developing countries are equally at stake due to over fishing. The United Nations Food and Agriculture Organization (FAO, 2000) estimates that of the major marine fish stocks or groups of stocks for which information is available, 47 - 50 percent are fully exploited, 15 - 18 percent are over-exploited, and 9 - 10 percent have been depleted or are recovering from depletion. Thus, close to 75 percent of the world's major fisheries are fully exploited, or worse. Data on quantity and value of juvenile fish landings in all the selected centres were collected and analysed to reach a conclusion on the gross economic loss due to juvenile fishing.

Landing centre price of adult fish varies significantly with the price of juveniles of the same variety. The price difference of certain commercially important species is shown in Table 3. The differential ratio estimated in the Table is read as no price difference (or no economic cost) if ratio is '1' and price difference is more significant (heavy economic loss) as the ratio approaches '0'. It shows the quantified average earnings that could be derived if the fish is caught at its adult stage. The severity of economic loss is more prominent for species like Flat fish (0.14), Anchovies (0.20), Threadfin Breams (0.21) and Carangids (0.29). Juveniles of certain species such as bulls-eye (0.41) and oil sardine (0.40) are getting better price due to its high domestic demand and prawns are ranked high mainly due to its high export demand (Table 3). Some fishes, which are too small and with lower or even negative economic gains like flat fishes, are even discarded for lack of market.

Table 3. Average landing centre price of juvenile and adult fish (select species) during 2000-2001 *(Average-Rs. kg^{-1})*

Species	Juveniles	Adults	Differential Ratio
Anchovies	4	20	0.20
Mackerels	8	25	0.32
Carangids	8	28	0.29
Oil Sardine	6	15	0.40
Cuttle Fish	25	75	0.33
Threadfin Breams	6	28	0.21
Lizard Fish	5	14	0.36
Bulls Eye	9	22	0.41
Flat Fish	2	14	0.14
Penaeid Prawns	20	60	0.33
Deep-sea Prawns	18	45	0.40

Source: CMFRI (2003)

The catch composition of some selected gears is also assessed. About 50 % of the flat fish landed by mini trawlers are juveniles and 30 % each of *penaeid* prawns and anchovies landed by mini trawlers are juveniles. Within the total landings of anchovies by ring seiners and shore seiners, about 40 % are juveniles (Table 4)

Table 4. Average percentage share of juveniles in the catch composition of some selected gears (2000-2001)

Species	Mini trawl	Ring Seine	Mech. Trawl	Purse seine	Shore seine
Anchovies	30	40	—	—	40
Mackerels	—	15	—	20	15
Carangids	—	15	—	15	—
Oil Sardine	—	30	—	25	20
Cuttle Fish	—	—	20	—	—
Threadfin Breams	—	—	25	—	—
Lizard Fish	—	—	20	—	—
Bulls Eye	—	—	10	—	—
Flat Fish	50	—	—	—	—
Penaeid Prawns	30	—	—	—	—
Deep-sea Prawns	20	—	30	—	—

Source: CMFRI (2003)

The gross economic loss occurred due to the capture of juveniles of different species is recorded for each fishing craft (Table 5). The total economic loss due to juvenile fishing is worked out for each fishing vessel. It is found that while the annual revenue generated by mechanised trawl units is Rs.31.2 lakh, it caused an economic loss of Rs.28.26 lakh due to juvenile fishing along the study region. For purse seine, the economic loss is Rs.39.57 lakh against its gross revenue generation of Rs.20.7 lakh. Ring seine units create gross revenue of Rs. 12.4 lakh, at the same time; they are responsible for an economic loss of Rs.19.1 lakh by way of juvenile fish catch. The gross revenue generated by mini trawl and ring seine are Rs.4.47 lakh and Rs. 4.31 lakh respectively, but the gross economic loss created by these units are Rs.6.89 lakh and Rs.5 lakh respectively (Table5).

The average revenue and the deficit generated by each fishing unit could be used for estimating the gross revenue and deficit along Kerala coast. This is estimated for a select set of fishing crafts such as, trawlers, purse seiners, mini trawlers and ring seiners. The gross estimate shows that the economic loss due to juvenile fishing made by trawlers, purse seiners, ring seiners and mini trawlers together along Kerala coast during 2001 - 02 is around Rs. 1,850 crore where as the annual revenue generated by these fishing units comes to only Rs.705 crore. Mechanised trawlers made almost 70 % of the economic loss. There are altogether 4,484 mechanised trawlers in Kerala which create a gross economic loss of around Rs.1,264.40 crore due to juvenile fishing, where as, these crafts generate an annual revenue of Rs.508.88 crore, thus causing a deficit of Rs.758.52. The next largest contributor of the economic loss is 2351 ring seiners causing Rs.286.54 crore to the economy. A total of 1,500 mini trawlers debit an amount of Rs.85.20 crore where as the 76 purse seiners debit Rs.15 crore from the economy (Table 6).

Table 5. Average gross revenue and economic loss *(in Rs)* due to juvenile fishing by various gears [2001-2002]

Species	Mini Trawl	Ring seine	Mech. Trawl	Purse seine	Shore seine
Anchovies	67,872	5,84,832	---	---	1,10,208
Mackerels	---	2,07,909	---	35,14,797	3,27,366
Carangids	---	1,00,452	---	---	---
Oil sardine	19,527	10,15,956	---	4,43,187	64,377
Cuttle fish	---	---	14,62,300	---	---
Threadfin Breams	---	---	10,12,370	---	---
Lizard fish	---	---	49,187	---	---
Flat fish	96,220	---	---	---	---
P Prawns	4,75,720	---	---	---	---
Deep-sea Prawns	29,187	---	3,02,634	---	---
Gross Economic Loss	6,88,526	19,09,149	28,26,491	39,57,984	5,01,951
Gross Revenue	4,47,000	12,40,000	31,20,000	20,70,000	4,31,000

Source: CMFRI (2003)

Table 6. Gross economic costs of juvenile fishing along Kerala coast (Rs. Crore)

Craft	Total Number of Boats	Gross economic loss due to juvenile fishing	Annual revenue of crafts	Economic deficit
Trawler	4,484	1,264.40	508.88	758.52
Ring seiner	2,351	448.84	162.30	286.54
Mini trawler	1,500	103.30	18.10	85.20
Purse Seiner	76	30.08	15.13	14.95
Total	8,411	1,849.62	704.41	1,145.21

Source: CMFRI (2003)

Source: CMFRI (2003)

4. Case studies

4.1 Economic loss to the fishery due to pollution in Kochuveli region (Case Study-1):

The titanium dioxide factory situated at Kochuveli, Trivandrum, Kerala, the only one of its kind in South Asia, manufactures Titanium dioxide pigment using the locally available mineral sand; ilmenite and concentrated sulphuric acid. The factory discharges its effluent into the Arabian Sea through a tunnel formed across the beach. The rate of discharge is estimated as about 4,000 m^3 day^{-1}. The temperature of the effluent varies from 45 °C to 50 °C, its pH from 0.8 to 1.0 and it has a pungent odour. The discharge consists of a mixture of sulphuric acid (20 %), Ferrous sulphate (7 %), Titanium oxysulphate and some trace elements like Aluminium, Magnesium, Vanadium, Zinc, Chromium and Zirconium in the form of sulphates (Vijayamohanan *et al.*, 2000). On mixing with seawater, the ferrous sulphate gets oxidised to ferric form causing oxygen depletion and imparting a reddish brown colour in the seawater. Constant exposure to the suspended matter from the effluent present in the seawater results in the depletion/death of the fauna owing to prolonged sub-lethal effects such as slow choking of the respiratory and feeding organs of the animals (Qasim and Rao, 1980). Studies on the effect of titanium effluents on the respiratory movements of some aquatic organisms have shown that drastic reduction in the movements was observed when exposed to the media containing more than 1 % of the effluent (Vijayamohanan *et al.*, 1984). From the above studies, it is evident that the discharge of untreated effluent from the titanium dioxide industry to the coastal waters of Kochuveli is adversely affecting the fishery of that area. Moreover, the waste is liable to be harmful to human health and the environment.

According to the fishermen of Kochuveli, the plankton and the benthos in this area were being killed off, bottom sediments drastically polluted and in consequence this area was no longer capable of maintaining its former production. There are many health problems such as itching, breathing problems and eye diseases. Qasim and Rao (1980) found that the pH of the well water near Kochuveli beach varied between 2.02 and 3.4 indicating the seepage of the industrial effluent in the neighbouring wells. To avoid this it is suggested that a closed and buried pipeline right from the factory outlet and across the beach should discharge the effluent.

Table 7. Average annual catch/unit at Kochuveli and Poovar during 2001-2002

Unit	Kochuveli(tonnes)	Poovar(tonnes)
Catamaran + Gill net/ HL	5.24	8.66
Shore seine	14.62	35.880

Source: IGIDR (2003)

At Kochuveli, because of pollution problem people are reluctant to adopt improved technologies of fishing. The average annual catch of a catamaran-gill net unit at Kochuveli is only 5.24 t, but at Poovar, in the same district, the catch is 8.66 t and because of the proximity to Thiruvananthapuram city and the scarce availability of fish at Kochuveli, the annual average revenue from a catamaran unit is higher than that of Poovar (Table 7). So also for the shore seine unit, the annual average landings (35.88 t) at Poovar are almost double that of Kochuveli (14.62 tonnes) (Table 7). This low level of landings for these two types of fishing units in Kochuveli and nearby landing centres can mainly be attributed to discharges of the industrial pollutants to the sea from the local Titanium Industry. Due to this the fishing intensity also has come down. Presently at Kochuveli, the existing fishing fleet consists of 9 plywood boats, 150 catamaran and 6 shore seine units with a total annual landings of 996.18 t valued at Rs.3.5 crore, whereas at Vizhinjam and Poovar centres, selected for the study in Trivandrum district, the total production was 22,544.41 t and 9,693.93 t respectively (Figure 3). At Vizhinjam there are 800 plywood boat units with gill net, 10 shore seine units and 100 catamaran units with gillnet under operation. In Poovar also the number of units is high with 600 catamarans with gill net/hooks and line, 11 shore seine and 150 plywood boats with gillnet/hooks and line. The low level of fishing units as well as fish landings and earnings at Kochuveli could be mainly attributed to the pollution of inshore area due to the discharges from the industrial effluents of Titanium factory. Taking into account the major factors influencing the level of effort and the catch and value, the estimated loss to the village due to pollution comes around Rs.23.7 crore. To arrive at this value, it is hypothetically assumed that there is no problem of pollution at present in Kochuveli area and In that case, the annual fish landings by the fishermen households inhabiting the area are estimated.

The number of different types of fishing equipments, their fishing efficiency, level of fishing effort, level of adoption of improved technology, labour efficiency, credit facility, proximity to urban markets, transportation and marketing facilitates demand function, water quality, primary productivity and landing centre facility are the major factors which determine the level of fish landings. Vizhinjam and Poovar in Thiruvananthapuram district are two other villages selected for the study where there is no major problem of pollution affecting fishing. Comparing the influence of above-mentioned factors in these two villages, the present level of fish production in the absence of pollution is estimated in Kochuveli. Hence the net benefit is calculated by estimating the excess benefits in the absence of pollution. Since there can be a flow of future benefits in coming years, a cost benefit analysis is done and the NPV is calculated for 15 years with discount rate of 12 %. Since this benefit comes from fishing income, net benefit is the excess over fishing cost. However, all the components of the fishing cost except fuel cost (which constitutes only less than 10 % of the total costs) are value added incomes as these are distributed as income to different stakeholders. Hence, in the calculation of NPV regarding the operating costs of fishing units only the fuel cost is added to the fixed costs for discounting purpose. NPV calculated for Kochuveli is Rs.157.4 crores.

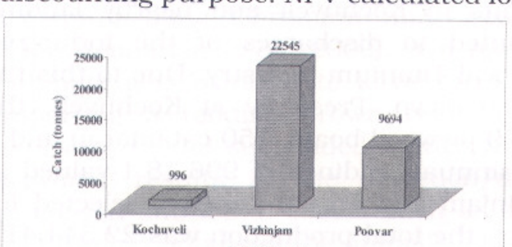

Fig. 3 Average annual fish production at Kochuveli, Vizhinjam and Poovar landing centres (2001-2003)

This loss affects at least thousand fishing families in this region and it has affected the entire economy of the village. Also it´has a recurring effect for the coming years too. Now the fishing is extended to distant fishing grounds due to the effect of pollution in the near-shore area. This makes the fishing more expensive in this area. Moreover, there is a drastic reduction in the pelagic fish landings, which are more affected by pollution.

4.2 Economic loss to the fishery due to sea erosion in Alappad region (Case Study-2):

Sand mining in the Alappad region poses grave environmental as well as livelihood problems. The area has a fragile eco-system, which is highly erosion-prone. It experiences sea rage even in summer. The waves sometimes surpass the seawall and encroaches the residential plots causing serious damages in monsoon season. The construction of seawall obstructs the landings facilities of motorised as well as non-mechanised fishing units operating from this area.

The fishing as well as landing is constrained by the increased sand mining and the consequent sea erosion, which in turn has significantly reduced the fish catch from this area. Fish landing is not viable even in the adjacent landing centres and causes severe troubles to the sole livelihood option of fisher communities in the region. Thus the local economic growth is paralysed due to the negligence of the rich coastal resources. There are about 58 plywood boats with gill nets, 8 shore seine units and 50 non-mechanised dinghy with gillnets in this area, which bring forth a total annual production of 9,536.72 t. The total annual landings estimated from the nearby Thangassery landing centre was worth about Rs.6.6 crores from 1,200 plywood boats. The low level of annual landings from Alappad landing centre is mainly due to the sand mining and sea erosion and the resulting construction of sea wall, which obstructs the landing facilities. The economic loss due to these factors is estimated at Rs.97.4 crores. The Net Present Value calculated for 15 years is Rs.647 crores.

5. Conclusion

The study has explored the technological changes in the marine fishing sector and its phenomenal consequences. The concentration of fishing activities in the hands of a few big enterprises would wipe out small scale and medium scale operators thus pausing crucial socio-economic defacement in the coastal economy. On the other side, a stringent competition between those fishing moguls would not only end up in a cartel that is functioning against the interests of a pure market economy but also would endanger the fishery resources. The downtrends in the catch of some of the species are mainly attributed to acute competition and injudicious application of technologically advanced fishing implements. The targeted fishing by these mechanised fleets has given way to another major problem viz., juvenile fishing. Juvenile fishes, if left to complete its biological course of life, would certainly realise additional revenue. Apart from the analysis of production trends in the marine capture fisheries scenario and the assessment of economic loss due to juvenile fishing, the study has focused on the effects of pollution and sea erosion on marine fish landings in Kochuveli and Alappad regions respectively. The lower level of fish landings in Kochuveli is observed to be due to the excessive pollution in the region. The intensity of the problem in the region is severe and the study estimates the economic loss in 2020 at around Rs.160 crores. Even more severe is the likely loss (valued to the tune of Rs.647 crores by 2020) of landings in Alappad region, which was under-performing due to extreme sea erosion. The study has cautioned that the unchecked sea erosion in Alappad region could wipe off the entire region, if timely preventive measures are not taken. The recent *Tsunami* had proved this, as it became the worst affected region compared to other coastal areas in the State. There is need for an exclusive environmental management system with emphasis on maintaining a bio-shield including the regeneration of mangroves.

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