Review of National Fisheries Situation in Sri Lanka

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Abstract

Fisheries are an important source of protein and employment for Sri Lanka's population. The declaration of the Exclusive Economic Zone (EEZ) in 1976 gave the country a water area larger than its land area. The coastal fisheries resources consist of small and large pelagic fish, demersal and coral reef fish, invertebrates, shrimps and crabs. The small pelagic fish contribute 70% of the catch from coastal waters with an estimated annual production of 152 752 t in 1997.

Some of the fisheries resources in Sri Lanka have been overexploited, although the situation varies across resource types and regions. A major reason for this has been the lack of proper management, particularly at the time of the introduction of motorized craft and synthetic nets which virtually revolutionized the fishing industry. Valuable habitat such as coral reef, mangrove, sea grass and marshland are also extremely susceptible to degradation. Destruction of these critical habitats could lead to reduced coastal fish stocks.

This paper provides a broad review of the national fisheries situation in Sri Lanka, presenting the environment status, coastal capture fisheries situation and fisheries management issues and opportunities. The main objectives for improving the fisheries management in Sri Lanka, as suggested by a national consultative workshop are: (1) promotion of sustainable exploitation of fisheries resources; (2) improvement of habitat protection; (3) maximization of the benefits from the fishery resources; (4) promotion of equitable distribution of the benefits; (5) maximization of the acceptability of interventions; and (6) maximization of the efficiency of institutional/legal system.

Introduction

Sri Lanka is an island state lying between latitudes 5º 30' and 10º 00' North and longitudes 70º 30' and 82º 00' East in the Indian Ocean, bounded on the west by the Arabian Sea and the Gulf of Mannar and on the east by the Bay of Bengal (Fig. 1). It has a coast-line 1 760 km long and a land area of 65 610 km^2. With the declaration of an exclusive economic zone (EEZ)[1], extending up to 200 miles, 436 000 km^2 of ocean have come under national jurisdiction, thus giving Sri Lanka a high water to land ratio.

Over the last five centuries, following foreign occupation, the country's development has been closely related to maritime activities. Prior to this period,

[1] Through Maritime Zones Law No. 22 of 1 September 1976.

its civilization was concentrated in the interior. Today more than half of its population of 18 million live in villages, towns, and cities in the coastal districts. Sri Lanka's coastal area, defined as coterminous with the 67 divisional secretariat areas, contains about 65 percent of the urbanized land area, about 80 percent of the hotel rooms of the tourist industry, and about 67 percent of the industrial facilities in the country.

Coastal fisheries produce about 30 percent of the animal protein crucial to the diet of the populace, and nearly 70 percent of the annual fish production. Coastal habitats are critical for sustained fish production, the maintenance of good water quality, and provide rich bio-diversity reserves including coral reefs, seagrass beds, and mangroves. This paper presents the management issues relative to coastal fisheries in Sri Lanka and recommendations for optimal management.

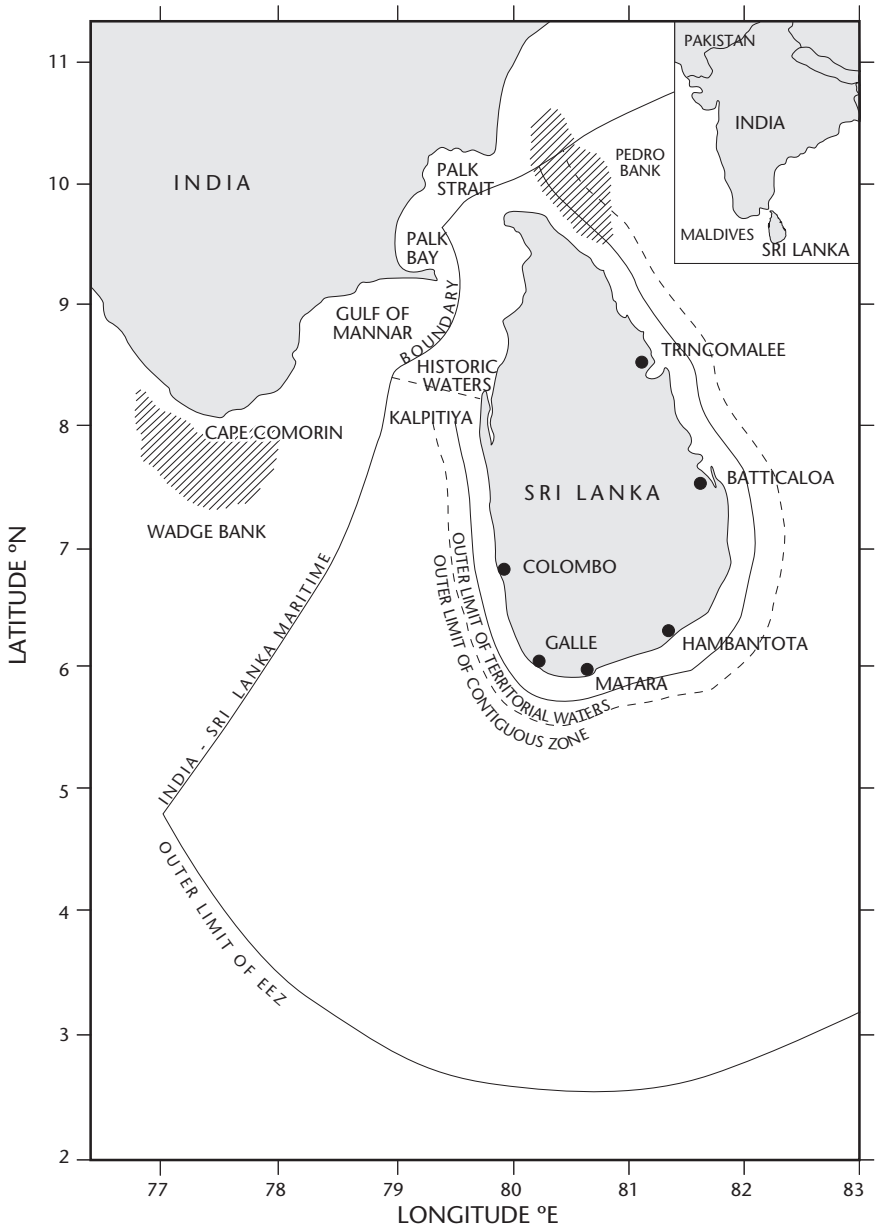

Fig. 1. Map of Sri Lanka's marine waters.

Environmental Setting

The marine area from the shore to the edge of the continental shelf is referred to as coastal waters. The continental shelf averages 15 km wide and 20 - 65 m in depth. The narrowest part is at Kalpitiya, where the width is only 2.8 km. The total area of the continental shelf is about 26 000 km^2, 11% of the EEZ. A large number of submarine canyons, valleys and gullies dissect the shelf and slope. Some of these are seaward continuations of land valleys and some prolonged land fault trends. Many continue down the continental slope, dividing into "tributaries". The largest submarine canyons are confined to the areas of shallow basement rock, opposite areas of Precambrian rocks. Areas of tertiary basin development both on shore and offshore, lack the development of major submarine canyons on adjacent continental shelves and slopes.

The localized drastic depth changes at the canyon heads produce a unique interface between shallow and deep marine hydrodynamic and sedimentary conditions. A complex mixture of sediment types is created by diverse processes. The net movement of sediment in the coastal zone is generally classified as 'long shore movement', movement under the action of waves and currents parallel to the shore line, and 'on shore/off shore movement', sediment transport normal to the coast line. The near shore zone is characterized by the occurrence of reefs, mainly corals, sandstone and crystalline rocks (boulders).

The tidal pattern in Sri Lankan waters is predominantly semi-diurnal and micro-tidal, with the highest amplitudes around the Colombo area and lowest around the Jaffna and Trincomalee coastline (Dassanayake 1994). The tidal range is moderate with an amplitude of 0.6 m, resulting in currents of very low magnitude, up to 0.3 $m \cdot s^{-1}$ in the nearshore area. Wave driven currents are predominant. Hydrographic studies conducted on *RV Dr. Fridtjof Nansen*, identified a water mass of temperature 17° C and salinity 34.9 - 35.1% in the Indian Ocean Equatorial region, which creates a fairly uniform thermo-haline stratification all round the island beyond 150 m depth during August - September and April June, and beyond 175 m during January - February. This survey indicated that the sea surface currents are directly influenced by the monsoons and are often strong at the beginning and end of the south-west monsoon (May to September), and during the entire north-east monsoon (December to February).

During the south-west monsoon the general oceanic circulation is from west to east, with current velocities of 2 - 3 knots near the shelf. The circulation is reversed during the north-east monsoon and current velocities are only 1 - 2 knots in this period. In general, the currents are stronger off the east coast during the north-east monsoon and off the west coast during the south-west monsoon. The strongest currents are recorded off the southern coast. The depth of the thermocline is also dependent upon the prevailing monsoon. It is about 100 - 125 m deep on the west coast during the north-east monsoon and 40 - 60 m deep during the south-west monsoon. On the east coast, the thermocline reaches a depth of 50 - 70 m during the October - November inter-monsoon period and 20 - 40 m after the March - April inter-monsoon period.

Natural ecosystems found within the coastal zone of Sri Lanka are diverse and include lagoons and estuaries, coral reefs, mangrove forests, sea grass beds, salt marshes, beaches and dune systems (Table 1). These habitats play an important role in the daily lives of coastal communities in terms of livelihood and food production. However, the valuable habitats found within the coastal zone are extremely susceptible to degradation, and measurable declines have occurred in the extent and quality of a number of biologically productive coastal ecosystems.

Coral reefs in Sri Lanka can be found along only 2-3% of the total shoreline and they are mostly fringing reefs. Barrier reefs are found in Vanakali and Silvathurai in the north and are very rare. Both fringing and barrier reefs dissipate wave energy and are important for coastal stability and as a source of beach material. Surveys have recorded 171 species of reef building corals in Sri Lanka. The staghorn coral (*Acropora* spp.) is the dominant genus.

A study of eight coral reef areas (NARESA 1991) showed that due to destructive fishing practices and environmental impacts such as siltation and pollution, only two out of eight (i.e Kandakuliya and Talawila) had live coral coverage of greater than 50 %. Two nearshore reefs, Weligama and Polhena, showed a significant proportion (> 50 % and > 80 %, respectively) of dead coral, while at Hikkaduwa and Akurala about 25 % dead corals were noted. Most of this damage is believed to have occurred over a 10 to 15 year period. The percentage of dead corals at Hikkaduwa is now likely to be even higher as a result of a bleaching event in April 1998, probably caused by high water temperatures associated

Table 1. Extent (ha) of coastal habitats in Sri Lanka by district.

District	Mangroves	Salt Marshes	Dunes	Beaches, Barrier Beaches, Spits	Lagoons, Basin Estuaries	Other Water Bodies	Marshes
Colombo	–	–	–	112	–	412	15
Gampaha	122	497	–	207	3 442	205	1 604
Puttalam	2 264	3 461	2 689	2 772	39 119	3 428	2 515
Mannar	1 261	5 179	1 458	912	828	2 371	308
Kilinochchi	312	4 975	509	420	11 917	1 256	1 046
Jaffna	260	4 963	2 145	1 103	45 525	1 862	149
Mullativu	463	517	–	864	9 233	570	194
Trincomalee	1 491	1 401	–	671	18 317	2 180	1 129
Batticaloa	1 421	2 196	–	1 489	13 682	2 365	968
Ampara	292	127	357	1 398	7 235	1 171	894
Hambantota	539	318	444	1 099	4 488	1 526	200
Matara	6	–	–	191	–	234	80
Galle	187	185	–	485	1 144	783	561
Kalutara	70	–	4	77	87	479	91
Total Extent	8 687	23 819	7 606	11 800	15 017	18 839	9 754

Source: Coastal Conservation Department. Coastal Zone Management Plan, Sri Lanka 1997.

with El Niño. Even within the two marine protected areas declared by the Department of Wild Life Conservation (Hikkaduwa and Bar reef) destructive fishing practices continue.

Coral is one of the sources of lime for the construction industry. In parts of the southwestern coastal sector, coral has been mined for almost 400 years, aggravating coastal erosion. Historically, coral is mined from inland deposits of relic coral that are 5 000 to 6 000 years old. More recently, due to reduced supplies and general population pressure, coral mining activities have extended to live corals. Mining of inland deposits outside the coastal zone is allowed by a permit, however mining of live corals, is strictly prohibited. In the southwestern coastal area, the restriction may have played a role in reducing the mining of live corals in 1994.

Mangrove forests in Sri Lanka occur as a narrow inter-tidal belt and extend less than 1 km landward from the mean low water level due to the low tidal amplitude. There are 14 species of true mangroves and 12 species of mangrove associates in Sri Lanka. The most extensive mangroves occur in Puttalam, Batticaloa, Triuncomalee, Jaffna, and Gampaha Districts. Mangroves are absent along exposed shore-lines affected by seasonally high wave energy in the south-western, southern, and north-eastern coastal sectors. Some dense localized stands occur in association with lagoons at Koggala, Rekawa and Kalametiya, which are more or less separated from tidal influence.

Most of the mangrove forests in Sri Lanka are being eliminated, through a combination of encroachment of human settlement, firewood cutting, and clearing of coastal areas for intensive shrimp culture. Mangrove coverage was estimated at about 12 000 ha in 1986, reduced to 8 687 ha by 1993, and estimated to be around 6 000 ha in 2000. Mangrove areas of more than 1500 ha between Chilaw and Puttalam

have been developed for shrimp culture. In Negombo, mangrove areas were cleared and filled in the mid 1980s for a national housing project. Loss of mangroves leads to increased shore erosion in coastal areas.

Seagrasses and seaweeds are inter-mixed in 'seagrass' beds. Seagrass beds have an important nursery role for many species and are also a habitat for several endangered marine mammals including sea turtles and dugongs. Seagrass beds occur along the open coast as well as within estuaries and lagoons. A large seagrass bed covers Dutch Bay to Jaffna Lagoon and Mannar to Rameswaran Island, India. Though not well studied several activities are known to impact seagrass beds, including digging of polychaetes for broodstock feed in shrimp hatcheries, sewage disposal, and use of destructive fishing gear such as bottom trawls and drag-nets. Less extensive damage is caused by beach seining and dragging of propellers.

There are over 23 800 ha of salt marsh lands in Sri Lanka. In the Mannar district where tidal flats are extensive, marsh vegetation contains up to 56 species. In the vicinity of Mundal lake, there are salt marsh and mangrove associates. Salt marsh areas are utilized for small scale grazing, hunting of waterfowl, and collection of milkfish fry for aquaculture. There has been increasing interest in tourism for nature appreciation and bird watching.

Destruction of salt marshes is brought about by certain uses, including conversion for saltpans in Hambantota and Palavi area, conversion for shrimp culture ponds in Puttalam area and conversion for reclaimed lands in Muthurajawela area. In Puttalam lagoon 50 % of the marsh land was lost in a ten-year period (Dayaratne et al. 1997).

Barrier beaches, spits, and dunes are prominent natural features found within the coastal zone. Spits and barrier beaches have been formed as a result of the long shore transport of sand deposited at the discharged points of rivers and estuaries. Spits are projections of sand that are free at the end farthest from the prevailing current. They are usually unstable, and shifting sands may result in changes in the physical location of estuarine outlets (e.g. Negombo). In the case of a barrier beach, the beach structure spans the length of a coastal water body and completely isolates it from the sea (e.g. Koggala lagoon). Dunes are wind-blown accumulations of sand, which are distinctive from adjacent landforms. Unvegetated dunes are unstable and may continue to shift in the wind. Extensive dune systems occur between Ambakandawila, and Kalpitiya, between Kirinda and Sangamukanda point in the Hambantota area and across Mannar island. Some of the country's beaches (e.g. Kandakuliya, Kosgoda, Rekawa, Bundala, Kirinde) are important nesting grounds for sea turtles.

Beaches, spits and dunes have been degraded due to exploitation of sand for construction purposes and reclamation of land. In addition, dune areas are cut and houses are built on sand dune areas (e.g. Hambantota). Grazing of cattle on vegetated dunes and removal of vegetation in sand dune areas also degrade the coastal dune system in Sri Lanka.

Lagoons and estuaries, partially enclosed water bodies connected to the sea, cover about 160 000 ha. Estuaries support many commercially important organisms that contribute both to estuarine and nearshore fisheries. Some 90 % of organisms of commercial importance captured in estuaries and lagoons arrive as migrants from the sea. Lagoons have tremendous socioeconomic importance as major settlement sites for urban and rural communities. They provide natural harbours and anchorages, and sustenance for thousands of people.

The major threats to lagoons and estuaries are pollution and siltation, which are exacerbated by water diversions. Water flow reduction causes accelerated accumulation of sediments within the basin and canals. At Negombo lagoon, the effective water area was reduced by 791 ha between 1956 and 1981 due to high siltation rates (NARESA 1991).

Fishery Resources and Potential

Over 15 fishery resources surveys have been conducted in Sri Lanka since 1920, mostly on demersal resources. Some of the potential yield estimates made in the past based on these surveys are shown in Table 2. However, the accuracy of these estimates is unclear particularly given the fact the surveys did not always follow reliable statistical data collection processes. Under the CRM Project, Sri Lanka (TA No.3034-Sri), an attempt was made to estimate the maximum sustainable yield (MSY) of the exploitable resources, and determine whether the fishing effort of different fleet categories had already reached the point of harvesting the MSY of the coastal resources. Compiled in Table 3 are the

catch and number of operating craft belonging to three different fishing craft categories over the 1979 - 87 period. Applying the surplus production model, the MSY (in t) and the fishing effort (the number of fishing craft) at MSY can be determined. The estimated aggregate MSY for the three categories is about 172 000 t•year^{-1}. The number of boats to attain the MSY for different categories are: 2 715 for inboard motorized craft; 7 839 for outboard motor craft; and 22 146 for artisanal craft (Table 4).

Table 2. Estimates of fisheries resource potential in Sri Lanka.

Resource	Potential Yield (t•year^{-1})	Survey method	Source
Demersals	60 000	Exploratory trawl fishing. Organic productivity	
Demersals	52 000	Acoustic survey	Jones and Banerji (1973)
Demersals	80 000 (70 000 + 10 000 for the Northern Region)		Blindheim and Foeyn (1980)
Demersals	74 000 (44 000 + 30 000 for the Northern Region)	Acoustic survey and swept area survey	Sivasubramaniam (1983)
Pelagics	90 000	Organic productivity	Jones and Banerji (1973)
Pelagics	170 000	Acoustic (inshore + offshore)	Blindheim and Foeyn (1980)
Large Pelagics	29 000	For the EEZ: Production trend and offshore survey of catches	Sivasubramaniam (1977)

Source: Sivasubramaniam 1995.

Table 3. Catch and effort data of the coastal fleet of Sri Lanka, 1979 - 87 (from Atapattu 1991).

Category of Fishing Crafts	Year								
	1979	1980	1981	1982	1983	1984	1985	1986	1987
Inboard motorized Craft									
Annual catch (t)	50 105	54 825	56 454	60 379	57 375	46 625	47 862	49 249	50 960
Number of craft	3 109	2 305	2 209	3 347	2 861	2 781	2 727	2 766	2 657
Catch•craft^{-1}•year^{-1}(t)	16.1	23.8	25.6	18.0	20.1	16.8	17.6	17.8	19.2
Outboard Motorized Craft							49 950		
Annual catch (t)	43 848	57 432	65 512	66 727	70 539	48 660	11 515	47 684	49 341
Number of crafts	9 723	8 020	8 865	9 745	10 086	10 800	4.3	10 340	10 543
Catch•craft^{-1}•year^{-1}(t)	4..5	7.2	7.4	6.8	7.0	4.5		4.6	4.7
Traditional Artisanal Craft									
Annual catch	54 598	53 007	53 109	55 426	56 135	41 454	42 454	47 333	48 977
Number of crafts	15 330	15 721	12 855	14 101	14 312	14 404	13 303	13 412	13 865
Catch•craft^{-1}•year^{-1}(t)	3.6	3.4	4.1	3.9	3.9	2.9	3.2	3.5	3.5
Total Coastal Production	148 551	165 264	1 750 075	182 532	184 049	136 739	140 266	144 266	149 278
Artisanal Fisheries (%)	37	32	30	30	31	30	30	33	33

Table 4. Estimates of MSY and effort at MSY of different fishing craft categories operating in coastal waters.

Category	MSY (t)	Fishing effort at MSY (in number of boats)
Inboard motorized fishing crafts	53 463	2 715
Outboard motorized fishing crafts	60 939	7 839
Traditional artisanal fishing crafts	57 931	22 146
TOTAL	172 333	32 700

Caution should be exercised, however, in the use of these values since they were computed using statistical data that are not reliable. Nevertheless, while the aggregate value may not be the exact MSY, it provides a figure to refer to, and adopting a precautionary approach, the figure can serve as a basis for determining optimum exploitation levels. Also, since there are resource overlaps in fishing activities among the different fleet categories, the estimated fishing effort should not be taken as a fixed value for each category. Instead a moving range should be adopted.

Demersal Resources

In the coastal region, demersal species caught include emperors (F. Lethrinidae), snappers (F. Lutjanidae), groupers (F. Serrandiae), sweetlips (F. Haemulidae), sciaenids (F. Sciaenidae), carangids (F. Carangidae), breams (F. Nemipteridae), goatfishes (F. Mullidae), and leiognathids (F. Leiognathidae) as well as invertebrates like squids, prawns, crabs and lobsters.

The results of the two seasonal surveys conducted by RV Dr. Fridtjof Nansen during 1978/80 (Saetersdal and de Bruin 1979), using primarily the acoustic survey method, are being used in nearly all development plans/ programs in Sri Lanka to this day. Based on the results of that survey, the potential yields from the coastal resources were estimated as 170 000 t for small pelagics and 80 000 t for the demersals. The bottom long-line trials conducted by the Bay of Bengal Programme (BOBP), failed to yield catch rates in keeping with the potential yield estimated on the basis of RV Dr. Fridtjof Nansen surveys (BOBP 1986).

Since the analysis of the original acoustic survey data was based on subjective interpretations, the survey data were re-analyzed, using acoustic survey results and trawl survey data, to identify the species composition of the catch and determine the composition of commercial species in the catch. Density distribution and biomass estimates were obtained by using the swept area method, with stratification based on depth and bottom conditions. The stratum-wise estimates of biomass were separated into species groups with distinctly different natural mortality values before estimating their potential yields. This yielded a potential yield of 44 000 t, which was 37 percent less than the result of Blindheim and Foeyn (1980) acoustic survey analysis, for the total area excluding the north. Of this amount, only around 25 000 t would be high-value, large demersals such as snappers, groupers, emperors and breams. Further, it was considered that the demersals in the north were predominantly much smaller species such as the *Leiognathus* spp. and hence, a higher potential of 30 000 t was allocated to the northern region, as against the 10 000 t estimated by Blendheim and Foeyn (1980).

In 1981, just prior to the civil disturbance in the country, the total demersal production was around 48 000 t. The north and east areas contributed 70 % of total demersal production at this time, however they do not contribute any significant quantity at present. That means that only 14 250 t were produced in the Kalpitiya to Dondra area. Estimates of the present levels of production in this area are shown in Table 5 and are similar to the previous estimates. These figures do not indicate that the demersal stocks are under intensive exploitation. With the extremely reduced fishing pressure in the north and in the east, the stocks in those regions may have been replenished.

The existence of potential unexploited stocks on the continental slope beyond 100 m depth and in the deep waters (200 - 300 m) has been discussed elsewhere (Sivasubramaniam 1985). The deep-water species are not always popular varieties and therefore have to be processed and marketed in appropriate form to increase demand. The cephalopods

are another under utilized resource because of the absence of commercial trawlers capable of capturing them in deep waters.

Table 5. Current estimate of production by demersal gear on the west, southwest, and southern coasts of Sri Lanka, 1997.

Area	Production (t)
West coast	4 500 - 5 500
Southwest coast	1 500 - 2 000
South coast	3 000 - 3 500
Shrimp trawl by-catch	7 000 - 10 000
TOTAL	16 000 - 21 000

Small Pelagic Resources

There are 100 species of small pelagics around Sri Lanka, of which not more than 25 contribute significantly to the commercial production. The dominant sardines and herrings are *Amblygaster sirm, Sardinella gibbosa,* and *Sardinella albella.* Important anchovies are *Stolephorus indicus* and *S. heterolobus.* Among the mackerels, Indian mackerel *(Rastrelliger kanagusta)* dominates the catch. Several species of flying fishes (Family Exocoetidae) are found in the coastal waters. In terms of the small pelagic catch Amblygaster sirm is the dominant species, followed by other *Sardinella* species and *Rastrelliger kanagurta* and *Selar crumenophthalmus.*

Gillnetting is the primary fishing method, contributing about 80 % of the production. Other fishing methods include beach seine, bottom trawl and other forms of entangling/encircling nets and handline. The purse seine came into use in recent years but its future is uncertain because of severe objections from gillnet operators. Fiberglass reinforced plastic boats (FRP), 17'/18' long with open deck and outboard motors, log-rafts *(teppam)*, outrigger canoes, and simple dugout canoes are commonly used in the fishery. Beach seining contributed nearly 40 % of the small pelagics catch prior to the 1960s, but declined with the reduction in the number of beach seines in operation. The present contribution may be around 10 000 t. Purse seining for small pelagics increased rapidly but declined within a decade due to the intensive campaign against its usage by gillnet and beach seine fishers. Purse seining with light lure is prohibited and daytime purse seining is restricted to areas beyond 7 miles from shore, and the license fee is Rs. 20 000.00 (US$28.41)[1].

Catch rates determined by various authors, have varied widely and do not show a clear trend although they are considered to be higher on the northwest and west coasts. The catch rate for motorized craft is generally double that of non-motorized craft. Time series data compiled for about 13 years have been analyzed (Sanders and Dayaratne 1998) and a fall in catch with increasing effort level was described; however there was a high degree of variability in the catch rates without any clear trend. Another source indicated that the overall catch rate showed signs of increasing in Kalpitiya to Dondra. There is a strong feeling that some carangid species such as *Selar crumenophthalmus* and *Megalaspis cordyla* are appearing increasingly in the catches. Some of the carangids (i.e *Decapterus russelli*), scombrids (i.e *Rastrelliger kanagurta*) and Exocoetidae (i.e *Cypselurus oligolepis*) maybe underutilized at present.

Most of these species live up to one or two years, except the roundscad and Indian mackerel which may live up to three or four years. Flying fish, particularly the genus *Hirundichthys*, spawns only once in its lifetime and thus it may not be able to sustain as high fishing effort as the other major species groups. In comparison, *Decapterus* and *Rastrelliger* species tend to migrate towards the bottom in deeper water (100 - 130 m) when their ovaries start ripening, and are thus not available to any of the existing fishing methods in Sri Lanka. The spawning stock is hence unlikely to be subjected to overfishing. The exploitation rates determined by various authors (e.g. Siddeek et al. 1985; Dayaratne 1985; Karunasinghe 1990; Karunasinghe and Wijeratne 1991; Dayaratne and Sivakumaran 1994) do not indicate any over-fishing, even at the present levels of production because the yield levels have not increased significantly since the assessments, as shown in Table 6 below.

These results are not robust due to limitations in the sampling design and reliability of statistical information collected. The effort statistics require greater input into the sampling program particularly for establishing baseline information of craft numbers and craft-gear combinations in use, in different areas and different seasons.

[1] 1US$ = Rs 70.392 (Annual average 1999)

Table 6. Estimated small pelagics landings from gillnets 1986 - 95.

Year	Production (t)	Remarks	Source
1986	41 462	Gillnet catches on northwest, west and south coasts	Sanders and Dayaratne (1998)
1993	48 337	Gillnet catches on northwest, west and south coasts	
1985	60 578	Estimated landings of small pelagics	Dayaratne (1996)
1995	63 443	Estimated landings of small pelagics	

Large Pelagic Resources

Oceanic large pelagics such as tuna (*Thunnus* spp.), marlins (*Makaira* spp.), sharks, sailfish (*Istiophorus* spp.) and swordfish (*Xiphias* spp.) are also caught in coastal waters. Common oceanic pelagics are the yellow-fin *(Thunnus albacores)*, skipjack (*Katsuwonus pelamis)*, kawakawa *(Euthynus affinis)*, frigate tuna (*Auxis* spp.) and seer fish (*Scomberomorus commersoni)*.

Though the catch statistics are not very accurate in many of the countries fishing in the Indian Ocean, the tunas and related species account for not less than 800 000 t of fish caught in the area, of which not less than 600 000 t may be attributed to the offshore and oceanic fisheries. The large pelagics are the tuna species, especially skipjack tuna, yellowfin tuna, big-eye tuna *(Thunnus obesus)*, billfish, and pelagic sharks. They are exploited mainly in the offshore and oceanic ranges. Relatively smaller tuna species such as the frigate tuna, bullet tuna *(Auxis rochei rochei)* and eastern little tuna *(Euthynnus affinis)*, and Spanish mackerel, are concentrated on the continental shelf.

The species on the continental shelf are exploited by outrigger canoes, small FRP craft, and 3.5 GRT (gross registered tonnage) boats, using trolling lines, drift gillnets, and small purse seines. The offshore and oceanic species are primarily caught with drift gillnets and drift long-lines mainly operated from 3.5 GRT boats at the edge of the continental shelf and by the multi-day boats in the EEZ and beyond. The traditional but highly seasonal pole-and-line (live bait) method for skipjack tuna, conducted with large outrigger canoes, is fast disappearing because of the problem of insufficient live bait. The entire catch of the smaller coastal tuna and a small amount of oceanic tunas such as skipjack and yellowfin, is caught in the coastal waters.

Catches of small tunas such as frigate tuna and kawakawa, have declined from about 15 000 t in the early 70s to 8 000 t in recent years, with the decline in the multi-hook troll line fishery. Between 600 to 8 000 3.5 GRT craft are engaged in tuna and shark fishing with drift gillnet, and it is reported that 25 000 - 28 000 t are landed by them, while the offshore/oceanic multi-day fleet contributes around 60 000 - 70 000 t. Landings by the former category are generally in the afternoon and it is not convenient for sampling the catches. There used to be about 45 foreign tuna vessels licensed to operate from bases in Sri Lanka and to trans-ship their catches to their respective countries, but this fleet has been reduced to about 8.

The offshore and oceanic fisheries for large pelagic species is rapidly expanding and the production is increasing. The fleet of multi-day boats has grown very rapidly to about 1 750 boats, the average size of the boat has steadily increased from 32 ft to 60 ft, endurance has increased from one to three weeks, and the fishing grounds have expanded from 100 to > 600 miles from Sri Lanka. The common EEZ boundaries that Sri Lanka has with the Maldives and west coast of India have made it difficult for Sri Lankan boats to sail the high seas of the Arabian sea without the approval of those nations. The only open sea area available beyond the EEZ is on the southern and eastern sides of Sri Lanka, but sailing on the eastern side is restricted by the civil disturbance on the north and east coasts.

According to recent estimates of the production from the offshore/oceanic ranges and the information from the exploratory fishing survey conducted, the yield by multi-day boats was 41 473 t by gillnetting and 2 545 t by long-lining in 1997. The total fishing effort in 1996 was estimated to be 264 fishing days, of which 77 % was in the Kalpititiya-Dondra area and the rest on the east coast; the western area alone produced 47 % of the total effort. Species composition is shown in Table 7.

Table 7. Relative abundance and average total weight of species caught by gillnet and long-line.

Species	Gillnet		Longline	
	%	Average weight (t)	%	Average weight (t)
Skipjack	53.5	3.9	5.6	3.1
Yellowfin	16.8	4.6	10.3	9.9
Big eye	3.2	11.8	19.8	27.5
Other tuna	4.6	1.0	0.5	1.1
Marlin	4.2	48.1	3.9	35.7
Sailfish	2.8	16.6	1.5	15.7
Swordfish	3.2	16.6	9.2	19.8
Shark	7.2	14.7	47.3	18.7
Wahoo	0.4	5.7	0.1	6.3
Others	6.2	4.9	1.8	8.7

The results of (Joseph et al. 1995) suggest that if gillnetting is developed, the yield may be increased. However if the contemporary effort is doubled, the increase would be 60 percent, for both skipjack and yellowfin and the proportion of other species is likely to decline. For the potential yield, 1 000 t of yellowfin and 1 500 t of big-eye have been recommended as sensible upper limits (Joseph et al 1995). If other species have the proportion observed during the survey, the yield from all the species is expected to be 6 700 t. For these predictions to remain valid, it is assumed that competition for these stocks from other fishers would not result in an increased effort. There is no guarantee of this, because there is substantial exploitation of these tunas in the Indian Ocean, by distant nations like France and Spain with purse seines, and Korea, Taiwan, and Japan with tuna long-line. Expansion of the Sri Lankan gillnet fishery could influence only the recruitment of yellowfin to the long-line fishery. Increase of skipjack catches will not have any bearing on the long-line catches of other nations.

The pelagic shark catch rates are declining in the Indian Ocean, and the management measures for pelagic sharks have to be implemented quickly because this resource is more vulnerable to over-exploitation than the tunas. Sri Lanka considers pelagic shark as a targeted species in the gillnet and long-line fishery, but almost all other nations conducting tuna long-line fishing take the fins of sharks and throw the carcass into the sea. Some data collection and analysis is being undertaken by Sri Lanka at present but more in-depth studies on the biology of pelagic sharks have to be undertaken at national and international levels.

Shellfish Resources

In the past, pearl oyster *(Pinctada radiata and P. vulgaris)* fisheries in the pearl banks off Silavathurai on the northwest coast, window pane oyster *(Placuna placenta)* fisheries in the Tampalagem Bay on the east coast, and chank *(Turbinella pyrum)* fisheries on the northeast and north coasts, were covered by special regulations gazetted under ordinances other than the Fisheries Ordinance. These fisheries dwindled in the 1970s but the chank appears to be reviving at present.

Crusteanean Resources

Over 27 species of shrimps, six *Penaeus* spp., 11 *Metapenaeus* spp., 10 *Parapenaeiopsis* spp. and others, have been recorded in Sri Lanka and fished in various lagoons, estuaries, and the sea using traditional methods such as cast nets, stake nets, and set nets. The price of shrimp was not historically high and the catches were entirely for local consumption. The shrimp fishery developed and then declined with the outbreak of civil disturbance on the north and east coasts, areas that used to contribute significantly to this production. Unlike crabs and lobsters, the shrimp resources have not been subjected to such intensive exploitation because of the commencement of shrimp culture activities.

The assessment of the status of shrimp stocks was not properly executed in the past, and has been attempted only recently. Some studies on the shrimp stocks in the Chilaw lagoon, Negombo lagoon, Bolgoda lake, and Rekawa lagoon on the west and south coasts, have been undertaken but those of other regions have yet to be done. Hence, very little can be said on the status of shrimp stocks, except that two cohorts occur. Sri Lanka does not have disputes between small scale and large scale fisheries for shrimp because of the absence of any large scale shrimp trawling.

Lagoon crab or mud-crab *(Scylla serrata)* is found in almost all the lagoons and is also a popular seafood item among Sri Lankans, with most housewives preferring them alive before cooking. A sub-

stantial proportion of the production is also exported. With the decline in the supply of lagoon crab to the local market, the sea crab *(Portunus pelagicus)* has gained popularity in the domestic market, but no estimates on the production of the latter species are available. Mud-crabs from the Batticaloa lagoon used to be very large and fetch very high prices in the international market, but the average size of this crab has declined in recent times. Extremely small quantities of the mud-crab and spiny lobster enter the domestic market at present. The mud-crab has been subjected to intensive exploitation until recently.

The spiny lobsters *(Panulirus homarus, P. longiceps, P. ornatus, P. penicillatus, P. polyphagus, P. versicolor)* were not widely preferred around the island but were collected by diving and handpicking from reefs and rocky areas. With the development of tourism and a heavy demand for export, the price of these crustaceans increased rapidly and the lobsters with relatively small stocks were the first to be intensively fished. The collection of immature lobsters was therefore banned for local consumption and export. According to NARA scientists, lobster resources in the south are exploited with a catch of around 800 t•year^{-1}. The species composition of the catch is: *P. homarus*, 75 %; *P. penicillatus* 15 %; and the other four species, 10 %. In the west, where fishing has been intensive for a long time and management measures introduced very early in the history of the fishery, the production is reported to be poor. On the northwest coast, the fishery is reported to be good; in Puttalum, Kalpitiya and Kalpitiya islands, the potential is considered to be 500 t and the yield of *P. ornatus* is considered to be around 200 t. On the north and east coasts, the production is around 500 t, with Batticaloa, Kalmunai, and Jaffna as the main areas. The catches were brought to Colombo when the flights between Jaffna and Colombo were operational.

Among the cephalopods, *Sepia pharaonis, S. aculeata, S. latimanus, Loligo duvauceli, L. singhalensis* are some of the common species caught around Sri Lanka. With the suspension of commercial finfish trawling, the catches of *Sepia* species have declined. The *Loligo* species are traditionally caught using small outrigger canoes at night with carbide lamp and scoop net. Purse seine operations also resulted in significant catches of cephalopods. No other modern techniques (such as squid jigs) are being used to exploit this resource, which could be an export item.

Coastal Fisheries in Focus

The capture fisheries of Sri Lanka is subdivided into three components: (i) Estuarine fisheries; (ii) Coastal fisheries and (iii) Offshore fisheries. However these three categories may not be enough to establish a definitive delineation of fishing area or the deployment of fishing crafts and gear. Also, the connectivity between different ecosystems means there may be overlap in the stocks they are exploiting.

Fishing Structure Aspects

The concentration of fishing activities in Sri Lanka has slowly expanded from the traditional fishing grounds in lagoons, estuaries, and inshore waters towards the oceanic waters. Larger craft have tried to extend their radius of operation and smaller crafts have tried to fill the void and likewise operated farther from shore. This has been primarily because of motorization and improvement in engine efficiency. Fishing crafts used by Sri Lankan fishermen range from indigenous log rafts *(teppam and kattumaram)*, dugout canoes *(vallam)*, and outrigger canoes *(orus)* to modern boats made of fiberglass reinforced plastic (FRP). The different types of fishing crafts used in the country are shown in Table 8.

Due to the combined influence of monsoon-driven climatic conditions, seaworthiness of fishing crafts, accessibility of resources, and economic value of exploited stock, the fishing pressure has become concentrated in the nearshore area and brackish lagoons and estuaries. In inshore estuarine waters, fishing gear are deployed with or without fishing craft. In waist-deep shallow waters, fishing by push-nets, cast nets, and pull-nets without boats is very common. Gillnets and trammel nets are operated on board traditional dugout and modern FRP boats of all sizes. The fishing pressure in lagoons and estuaries also changes seasonally.

Changes in fishing activities have been influenced by recent significant events, as shown in Table 9. In 1995, the average age of boats comprising the offshore fishing fleet of Sri Lanka was about 2.5 years (see Table 10, Joseph et al 1995). Over 90 % of the boats were built after 1990, which means that the Sri Lankan offshore fishing fleet is made up of relatively new fishing boats. Most boats (84%) were less then 34 - 36 footer class size.

Table 8. Type of fishing crafts used in Sri Lanka. (from Maldeniya 1997 with inputs from the author).

Craft Type	Local Name	Length (m)	Operating Radius (km)	Remarks
Indigenous Craft				
Log rafts	*Teppam* *Kattumaram*	3 - 4 4 - 7	1 - 2 1 - 3	non-motorized/outboard motor non-motorized/outboard motor
Outrigger canoes	*Oru* *Thony*	3 - 5 10 - 12	1 - 3 1 - 15	sail/paddle/outboard motor sail/paddle/outboard motor
Plan beach seine	*Paru, padu*	10 - 12	1 - 3	paddle
Dugout beach seine craft	*Karavalai*	10 - 12	1 - 3	said/paddle/outboard motor
Dugout with outrigger	*Vallam*	3 - 6	1 - 5	outboard motor, 8 - 12 hp
Introduced Craft				
Fiberglass reinforced boat	FRP boat	5.2 - 6.2	1 - 20	inboard engine, 39 - 54 hp
3.5 - 4.5 GRT boat	3.5 GRT boat Abu Dhabi	8 - 10.3	> 20	inboard engine, 54 - 75 hp
11 GRT boat		10.4 - 18	> 20	inboard engine

Note: hp = horse power.

Table 9. Significant events in the development of the Sri Lankan fishery.

Year	Event
1928	Large scale bottom trawling was introduced by a private company which subsequently went bankrupt in 1935 because it could not find a market for the catch.
1941	The Fisheries Department was established to look after the fisheries sector.
1945	Fisheries Department re-started a trawl fishery program which became the forerunner of the large fleet operated by the Ceylon Fisheries Corporation; Wadge Bank was the main fishing ground.
1951	An attempt to introduce purse seine fishery failed because the existing vessels were not ready for it. Mothership operation was initiated for the demersal fishery. Ceylon Fish Sales Union was organized and played an important role in fish marketing.
1958	The motorization program started, which resulted in the introduction of 28 footer (3.5 GRT) boats with inboard engines and inboard motor plank boats which replaced many of the orus and vallams.
1960s	Log rafts (teppam and kattumaran) were replaced with 17 - 18 ft craft with outboard engines. This increased the range and subsequently expanded the coverage of fishing grounds for gillnetting for small pelagics and demersals and handling of demersals.
1970s	Purse seine operation was demonstrated around the country by FAO, which led to the commencement of purse seining for sardines in the southwest coast in the 1980s. Newly designed 3.5 GRT, 8 - 10 m long boats with inboard engines started fishing for small pelagics and small tunas without venturing far from shore and performing only day trips.
1976	Sri Lanka claimed its 200-nautical mile EEZ, adding to its territorial waters a total of 437 000 km^2. Wadge Bank was lost to India as a result of the demarcation of the EEZ boundary between India and Sri Lanka.
1980s	Sardine purse seining commenced on the southwest coast. Abu Dhabi boats equipped with insulated fish hold and crew accommodation allowing trips lasting for several days, were built by the Northwest Coast Fisheries Development Project. The boats were equipped with large-meshed gillnets for catching tunas and used frequently in combination with long-lines for catching larger tunas and sharks.
1990s	With the construction of larger boats for multi-day oceanic fishing, some of the 28-ft boats, FRP open-deck crafts, and outrigger canoes extended their operating radius to exploit small pelagics and small tunas on the outer ridge of the continental shelf.

Table 10. Size profile of the offshore fishing fleet of Sri Lanka 1981 - 95.

Year of Construction	Length Overall (ft)					
	28 - 32	34 - 36	38	40 - 45	> 50	Total
1981 - 83	–	2	–	–	–	2
1984 - 86	1	2	–	–	–	3
1987 - 89	2	3	–	–	–	5
1990 - 92	4	29	1	1	1	35
1993 - 95	2	67	4	4	–	77
TOTAL	9	103	5	4	1	122

Sources: Joseph et al. 1995.

There was a drastic decrease in the number of non-motorized traditional fishing craft in the late 1970s and a drastic increase in the number of fishing craft powered by outboard motors in the same period (see Table 11). This increase was sustained and may be attributed to the liberalization of the country's economy. The number of fishing craft powered by inboard engines has more or less remained within the range of 2 200 to 3 400 boats throughout the years, and around 3 250 boats were recorded in 1996. At present, the Sri Lankan fishing fleet consists of around 26 600 fishing craft, 48 % of which (12 730) are motorized (Table 11).

Though modern craft of varying designs and sizes have been introduced, the original 28' long wooden craft with inboard engine (popularly known as "E 26" design) and the 17'/18' open deck FRP craft with outboard engine have become the popular modern type of fishing craft. The popularity of larger size craft (> 30 ft; popularly known as 11 t, Abu Dhabi boat, BOBP design) introduced by the State for multi-day fishing for large pelagics offshore, lasted a few years. In the 1980s an extended version (32 - 34 ft) of the E26 design as a multi-day boat for offshore fishing quickly gained popularity. With the increasing popularity and entry of more boats of this type, the demand for even larger sizes (up to 60'ft) are being constructed presently for operating drift gillnet and drift long-line for tuna and shark in the Indian Ocean. At the same time, traditional craft such as the log-rafts *(teppam)* of the northwest coast and outrigger canoe *(oru)* on the southwest and south coasts are being rapidly replaced by the 17/18 ft FRP craft with outboard motors.

As updated statistical data are available only for the Northwestern, Western, and Southern Provinces (see Table 12), it is difficult to portray the distribution of fishing effort for the entire country. Non-motorized traditional craft, constituting 48 % of the number of boats, still top the list. FRP boats, which are mostly based in the Northwestern, Western, and Southern Provinces, rank second. Recently the country has tried to expand its offshore fishing industry by building more multi-day boats; a steady increase has been observed from the early 1990s to the present (Table 12).

The fishing craft population has changed significantly from a combination of traditional non-motorized fleet and industrial scale bottom trawlers to the present structure with a combination of traditional and modern types of non-motorized and motorized small scale fishing craft, as shown in Table 13 and 14.

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Table 11. Number and category of fishing craft from 1972 - 96.

Year	Inboard	Outboard	Non-motorized	Total
1972	1 895	3 120	29 240	34 255
1973	2 870	3 182	31 521	37 573
1974	2 959	3 144	33 909	40 012
1975	3 075	3 752	35 634	42 461
1976	–	–	–	–
1977	1 008	5 281	13 594	19 883
1978	2 265	8 265	13 800	24 330
1979	3 109	9 723	15 330	28 162
1980	2 305	8 020	15 722	26 047
1981	2 209	8 865	12 855	23 929
1982	3 347	9 745	14 101	27 193
1983	2 864	10 086	14 312	27 262
1984	2 781	10 800	14 404	27 985
1985	2 722	11 515	13 303	27 540
1986	2 766	10 340	13 412	26 518
1987	2 657	10 543	13 865	27 065
1988	–	–	–	–
1989	–	–	–	–
1990	–	–	–	–
1991	2 459	9 645	14 578	26 682
1992	–	–	–	–
1993	2 336	9 920	14 896	27 152
1994	3 185	10 720	15 444	29 349
1995	2 996	9 713	14 560	27 269
1996	3 253	9 473	13 880	26 606

Table 12. Number of fishing craft by category and by district of Northwestern, Western, and Southern Provinces.

District	Non-motorized Traditional Craft	Motorized Traditional Craft	FRP Boats	3.5 GRT Boats	Multi-day Boats
Puttalam	1 921	128	2 512	48	32
Chilaw	1 624		1 217	57	114
Gampaha	1 607	11	1 160	126	187
Colombo	39		156	65	14
Kalutara	748		189	44	240
Galle	658	278	303	83	150
Matara	848	155	281	199	375
Hambantota	889	353	518	100	199
TOTAL	8 334	925	6 336	722	1 311

Table 13. Number of fishing craft by category from 1993 - 97 (from different sources). Note that the 1993 data include information from Northern and Eastern Provinces.

Year	Non-motorized Traditional Craft	Motorized Traditional Craft	FRP Boats	3.5 GRT Boats	Multi-day Boats
1993	14 896	1 986	7 934	1 907	429
1995	7 153	692	6 826	850	1 098
1997	8 334	925	6 336	722	1 311

Table 14. Structure of the fishing fleet in the marine subsector with probable numbers.

Category	Types of Fishing Craft	1996	Average Crew Size	Endurance
Industrial Scale	Bottom trawlers	(not in operation)	5	1 week
	Tuna long liners	(not in operation)	12 - 15	1 - 2 months
Small scale (traditional)	Outrigger canoe	9 478	2	day-boat
	Log raft	2 949	1 - 2	day-boat
	Paru	126	9	day-boat
	Vallam	2 335	2 - 6	day-boat
Small scale (modern)	FRP	8 179	2 - 4	day-boat
	3.5 GRT	1 256	3 - 5	boat-day
	> 3.5 GRT	1 750	4 - 6	1 - 3 weeks

Although there has been an increase in the introduction of motorized craft and a reduction in the utilization of traditional craft in fishing activities, this is not reflected in the craft population. There is a growing concern about the large number of traditional craft that are not used in fishing but instead in ferrying provisions, crew and catch, between the shore and motorized craft anchored outside anchorages and harbours. According to the Administration Report of the Department of Fisheries and Aquatic Resources, the number of operational inboard engine craft has been fluctuating annually between 2 300 and 3 300 since 1973. The outboard engine craft population also appears to have been fluctuating between 8 000 and 11 500 since 1978. The non-motorized craft population declined from about 31 500 in 1973 to 13 800 in 1978, and has been fluctuating between 12 850 and 15 722 since 1978. The total population stands at 27 765 (NARA, Fisheries Year Book 1998).

Fishing Methods

Like most maritime countries in the tropics, Sri Lanka's fisheries sector has evolved into what it is now a multi-gear and multi-species fisheries. The primary fishing gear in the past was the beach seine, considered the backbone of the industry (Sivasubramaniam 1995). It was the single most important contributor to coastal fisheries in the early days. About 3 000 units were in operation and landings were between 19 000 and 24 000 t in 1961 and 1963, respectively. However, many craft also used other gear such as bottom-set gillnets, bottom long-lines, hand-lines, intertidal traps, setnets, set bag nets, and stake nets, targeting mainly demersal species. The commonly used fishing gear in the country's recent history, their mode of deployment, means of propulsion, and typical catch are shown in Table 15.

Most of these gear are still used today, and the most popular ones include the large and small meshed gillnets designed to catch tunas and sardines, respectively. Beach seine fishermen still continue with their traditional gear. Some gear have lost their popularity while others only deployed in limited areas. Sri Lanka suspended oceanic long-lining in the early 1980s. Trawls are banned in some areas and light-lure purse seines are not allowed in coastal waters of the country. Because of their destructive effects, bottom-set gillnets and trammel nets are also not allowed in coral reef areas.

Table 15. Common types of fishing gear used by Sri Lankan fishermen and their mode of operation (modified from Sivasubramaniam 1985).

Fishing Gear	Mode of Deployment	Boat types	Target Species
Traps	demersal	non-motorized	mixed demersals
Lift-net	pelagic	non-motorized	bait fish
Hand-line	demersal	non-motorized	carangids and demersals
Beach seine	demersal/pelagic	non-motorized	mixed demersals and pelagics
Large-meshed drift gillnet	pelagic	motorized	tuna, king mackerel and sharks
Small-meshed gillnet	pelagic	motorized	sardines, anchovies and Indian mackerels
Bottom-set gillnet	demersal	motorized	large demersals
Trammel-net	demersal	motorized	large demersals
Trawl	demersal	motorized and non-motorized	shrimps and demersals
Trolling	pelagic	motorized	tuna and king mackerel
Pole and line	pelagic	motorized	tuna
Bottom-set long-line	demersal	motorized	large demersals
Tuna long-line	pelagic	motorized	tuna and shark
Purse seine	pelagics	motorized	sardines and small pelagics

Because of the migratory nature of pelagic stocks, pelagic fishing gear are operated in wider areas, targeting specific species. Demersal fishing gear have specific areas of operation. Some fishing gear are operated all throughout the year in specific areas, especially in the Northern and Northwestern Provinces. Others are frequently operated during specific monsoon seasons. Hand-line and bottom-set long-line are more often used during the northeast monsoon while the gillnets are typically used during the southwest monsoon. Because of the relatively shallow and flat bottom topography, demersal fishing gear are more or less concentrated in the northern and northwestern parts of the island.

Motorization and improvement of hull design have enhanced the capability of fishing craft to operate in offshore fishing grounds. This development has significantly altered the mode of pelagic fishing operations. Pelagic fisheries can be conveniently subdivided into small and large pelagic fisheries. Small pelagic species such as sardines, anchovies and mackerels are caught primarily by small-meshed gillnets and to a lesser extent by purse seiners. On the other hand, large pelagics like tunas, sharks, marlins, sailfishes, and Spanish mackerels are caught by large-meshed drift gillnets, long-lines, and hand-lines.

Production

The total annual fish production of Sri Lanka in 1996 was 228 550 t, around 65 % of which was landed by the coastal fisheries, 25 % by the off-shore or deep sea fisheries, and only 10 % by the inland fisheries. The total annual production is practically double the figure recorded in 1972 (101 712 t). However, this general trend was marked by a sudden drop in 1983 (169 347 t) because of the civil disturbance in the country at that time, a recovery during the second half of the 1980s as a result of the increase in production by the inland fisheries sector, and a further rise in the 1990s due to an increase in the offshore fisheries production.

The steady increase in production between 1972 and 1983 is attributed to the introduction of more efficient engines, more reliable fishing craft, and improved synthetic fibers. Although 65 % of the total production comes from coastal waters, this proportion is relatively low compared to the sector's 90 % contribution in the 1970s. However, this does not mean that coastal water production has diminished; the decrease in relative value was due to the increase in production by other sectors. In the late 1980s, the increment was primarily due to inland fisheries, in the 1990s much of the increase

Table 16. Fish production (t) from the coastal subsector, by major varieties, 1991 - 97

Variety	1991	1992	1993	1994	1995	1996	1997
Seer	3 916	3 524	3 369	3 200	2 993	2 170	2 400
Trevally	8 975	8 526	8 378	8 000	6 910	6 090	6 900
Skip jack	16 690	18 359	19 316	20 475	23 548	25 630	27 600
Tuna	10 664	11 730	11 981	13 180	12 050	12 740	14 600
Other blood fish	9 325	10 258	10 681	11 215	17 642	15 940	14 800
Shark	19 045	18 306	19061	19 500	14 017	7 110	8 800
Mullet	8 658	9870	10 277	10 585	7 088	8 970	9 100
Beach seine varieties	33 426	35 097	37 379	38 870	49 785	48 220	42 700
Prawns	5 176	6 470	6 737	7 000	–	–	–
Lobsters	789	828	862	1 000	400	–	–
Others	42 486	40 202	41 859	41 475	23 067	22 430	25 850
TOTAL	159 150	163 170	169 900	174 500	157 500	149 300	152 750

Sources: Department of Fisheries.

was attributed to offshore fisheries while coastal production has more or less remained constant throughout the period.

In the coastal subsector, the production of skipjack and other tuna species has shown some increments (see Table 16). Although there was an apparent decline in the catch of sharks starting in 1996, there were no data entries for prawns in 1995 and for both prawns and lobsters in 1996 and 1997. It will have to be verified whether this is due to a data collection problem or to the disappearance of the resource.

The present value of fish production from the three subsectors is shown in Table 17. The total value of highly priced commodities reached Rs. 17 billion in 1997, while that of low-priced species was Rs.1.0 billion. The average price of all species of fish increased by 10 % to Rs.110•kg^{-1} in 1997. Average retail price increased by eight % from Rs.143•kg^{-1} to Rs.154•kg^{-1} in 1997. The highest price was Rs.297•kg^{-1} for Spanish mackerel (seerfish) and the lowest price was Rs.65•kg^{-1} for sardines (Central Bank Report 1997).

Table 17. Present value of production from different fisheries subsectors.

Sector	Production (t)	Value (Rs. billion)
Coastal and marine subsector	152 750	15.7
Offshore/oceanic	62 000	4.1
Brackish and freshwater	24 200	2.7
TOTAL	228 550	22.5

Marketing Channels

Fish, on being unloaded from the boat, are purchased by wholesalers, beach assemblers, and various categories of retailers. Even consumers congregate at the beach to buy the daily quota of fish. Normally, the boat owners who consign fish to the wholesalers obtain loans from them when they are short of cash to buy the boats or to repair the vessel and at times of distress. The wholesalers can be the commission agents who are at St. John's Fish Market (SJM) in Colombo or those operating from various out-station market centres. The beach assemblers operating from the villages also finance the fishermen. Sometimes, the wholesaler finances the assembler so that he is assured of a continued supply of fish. These are non-institutionalized credit arrangements operating on trust without any guarantees or mortgages.

The beach assembler consigns the fish to the wholesalers at SJM or other market centers. Fish mixed with ice is normally packed into wooden boxes, which are transported in lorries or vans to the wholesalers. SJM is the biggest wholesale market for fish in Sri Lanka and receives supplies from all parts of the country. Hundreds of vehicles transporting fish from out-stations congregate at SJM beginning at the crack of dawn. Apart from these wholesalers, there are the retailers who buy their daily market requirements from the numerous fish landing centres along the coastal strip or from SJM. These include those who operate fish stalls at market places or at wayside locations, institutional suppliers, push-bicycle traders, motorcycle traders, pingo carriers, head loaders, and basket carriers.

The entire marketing operation is based on trust and mutual understanding. No elaborate docmentation, paper transactions, or built-in securities exist in the marketing transactions. The beach assemblers and boat owners send fish by weight without any price indications. These are the main risk takers in the marketing chain. The wholesalers sell the fish at a price to be determined by them based on market intelligence and supply levels at the time of opening of the market. These prices are subject to change in the levels of inflow of supply. Normally, the wholesaler retains a commission of up to 10 % and remits the balance to the supplier, as and when he calls for money. The small traders such as push-bicycle traders and *pingo* carriers are fairly poor and do not belong to the fishing community. They reside in distant places and come to the market place to buy the fish. Most of them obtain money on interest from moneylenders operating in the market places. The motorcycle traders deal in larger volumes.

Demand for Fish

The fish landed from the larger multi-day boats are sold at the harbor sites or near anchorages and, in the case of small day boats, at beach landing centres found along the coastal strip. There is seasonal and geographical variation in the supply since weather conditions and lunar phase affect the fishery. Apart from exporters, the rest of the par-

ticipants in the marketing chain are all individuals. The only organization in fish marketing is the Ceylon Fisheries Corporation, a government agency which used to play a dominant role in the capture, marketing, and export of fish and fishery products, but which has been reduced to total insignificance against the private sector. The private sector is able to handle the totality of the fish landed by the fishermen all over the island. Though these individuals are borrowers, the marketing activity is highly organized and the marketing chain functions quite efficiently.

There is no information available on the total demand for fish and fishery products in Sri Lanka but it is believed that the supply is far below demand levels and that this gap is filled through imports of dried and canned fish. Per capita consumption of fish is about 16 kg annually, including domestic production and imports. Traditionally the demand is high for cheaper inshore varieties such as sardines, herrings, mackerels, frigate tuna, bonito, mullet, etc. Among the high-income groups seer, trevally, tuna, and shellfish are in greater demand. The variation in demand for quality is evident in fish-producing areas and in fish markets where prime quality fish always fetches a higher price. Long-line and shore-seine fish command higher prices as compared to gillnet caught fish. Among the poor, price is a foremost consideration and quality is secondary.

In general, small scale traders using push-bicycles, motorcycles, and those carrying fish on *pingos* and on baskets go from house to house on their sales rounds. Static dealers sell from market places as well as through wayside stalls and all of them serve urban, semi-urban, rural, and estate customers. Most of these traders buy a mix of varieties and sell these as better quality fish at a high price. These consumers are unable to distinguish between good and poor quality fish. A survey done by the Lanka Market Research Bureau (LMRB) reported that fish is the preferred source of animal protein by the people of Sri Lanka and that:

- the urban sector spends about 40 % of the family budget on food, of which 12 % is spent on fish;
- the rural sector spends around 56 % of the in come on food, out of which approximately 9.2 % is on fish; and
- the estate sector spends around 68 % of their income on food, of which 5.2 % goes on fish.

The degree to which quality preferences influence demand has been clearly established by the recently concluded DFID Post-Harvest Fisheries Project where insulated fish boxes made out of fiberglass were built, demonstrated, and field-tested. The fishermen who used these boxes reported that the ice melt is reduced by 50 % and that the fish stored in them after capture fetched a price premium of about Rs.5 - 15•kg^{-1} on the beach. The petty fish traders selling fish on push bicycles and motorcycles and other bigger traders who used this box for fish transport have all confirmed a similar increase in benefits.

The foreign vessels operating under joint venture arrangements target the export markets. Most of them cater to the *sashimi* market in Japan to which chilled tuna is air-freighted directly. The onboard handling of fish on these boats is good and high quality standards are maintained.

Price Structures

Down the distribution channel beginning with the beach assembler, all the participants keep a profit margin, which results in a snowballing of the prices. The beach assembler's margin depends on the selling price at the wholesale market. As proper records are not maintained by the commission agents, it is not possible to ascertain the actual commission charged by them, although in general, it is believed to be a maximum of 10 %. The retailers keep around 25 - 50 % or more in their selling price. By the time the fish reaches the consumer, its beach price could have increased by 60 - 80 % or more, as transport, icing, handling, and other overhead charges at each level of activity have to be recovered.

There is also a cost at the fish landing centre. If the fish is auctioned, the auctioneer's commission has to be settled in some of the harbours/anchorages and at fish landing centres. In Negombo, where a cooperative manages the anchorage, multi-day boats using the main anchorage have to pay a commission of 1 % for boats from Negombo or 3% for others.

The main contributory factors related to price variations in the local market are: availability of fish, variability of supply, seasonality, quality of fish, and quantity and species availability.

Transport and Post-harvest Practices

The bulk of the fish production is marketed and consumed either in wet form or as iced fish; there is very little production of frozen fish for the local market. The existing marketing system developed by the private sector and proven to be effective can adequately cope with the supplies without recourse to freezing. What is necessary is an adequate supply of quality ice, chill rooms for storage of fish, refrigerated trucks for transport, use of hygienic fish boxes, and improved handling methods. The wooden fish boxes used in the transport of fish are unhygienic and need be replaced by better quality, more durable, hygienic, and easily cleanable plastic-type nestable crates.

Fish transport is normally done in open lorries and vans. These are neither insulated nor refrigerated. The transport vehicles leave the fish producing area by night and reach SJM by crack of dawn. The fish is packed into wooden boxes and stacked inside the vehicle. Ice melting during transport is very high and by the time fish reaches SJM or any other distant market place, most of the ice has melted. Lately, however, some of the bigger traders, boat owners, and beach assemblers have begun to use refrigerated trucks for fish transport. This trend is more visible in the south than in other areas.

A recent study undertaken by NARA's Socio-economic Division showed that of 52 beach assemblers in 7 major fish landing centres, 19 possessed fishing boats and 12 possessed transport vehicles. Seven out of these 31 had a boat and transport vehicle each. This clearly shows the role and influence of the beach assemblers as producers, transporters and traders. The study has also established that out of the 52 beach assemblers, 13 took advances from the commission agent (wholesaler) at SJM, 11 took loans from commercial banks, 5 from money lenders, 2 from fishermen's cooperatives, and from the ADB-funded Fisheries Sector Project's microcredit component. It is recommended that credit lines be provided through commercial banks for those who wish to purchase refrigerated trucks for fish transport. The cost of a second-hand refrigerated truck of reasonably good condition, imported from Japan, ranges from Rs.0.9 - 1.5 million.

The quality of fish landed from fishing boats is generally poor. More than 50 % t of the catch landed by multi-day boats which undertake extended fishing voyages, is of very poor quality. Quality of the produce is a major concern with regard to the ever increasing fleet of multi-day boats whose prime objective is to catch more and more fish with less and less emphasis on the preservation of the catch. Since the scope to expand inshore fish production is limited in the long term due to resource concerns, emphasis should shift towards value addition through improved post-harvest practices. If the spoilage could be minimized and the quality of the fish improved, there would be no need for extended fishing effort. There is thus a need to improve the quality of the catch by educating the fishermen on improved methods of fish handling and on-board storage. Improving the efficiency of post-harvest handling, processing and marketing will also have a significant impact on the incomes of primary producers, processors, and market intermediaries and consumers will benefit through the availability of better quality fish and fishery products. Measures also need be taken to reduce fish wastage and add value to the catch.

Management Issues and Opportunities

Fisheries Management Goals and Objectives

Fisheries management may be regarded as a dynamic resource allocation process whereby the ecological, economic, and institutional resources of a fisheries exploitation system are distributed with value to the society (see Fig. 2). The fisheries management process includes the resolution of normative and empirical debates to determine the direction of resource allocation decisions.

The objectives of fisheries management in Sri Lanka was reviewed in a National Consultative Workshop in 2000. The workshop was conducted under the "Sustainable Management of Coastal Fish Stock in Asia" Project (ADB-RETA 5766). Fisheries resource specialists and managers from the government, academe, and other organizations reviewed the outputs of National level assessment of Sri Lankan Fisheries, identified fisheries resources management issues and formulated recommendation for improved management. Figure 2 presents the fundamental objectives of fisheries management in Sri Lanka and viewed by the workshop participants.

Management Issues and Problems

Except for a few cases of traditional management systems, most fisheries are open access, common property systems. In the 1940s, when the total fish production was in the level of 40 00 t, the contribution was exclusively from traditional fishing gear such as beach-seine nets and stakenets etc. These have existed for a long period and evolved efficient management systems in their operations. The coastal rural communities had fishing methods which were in harmony with the environment. In addition, these systems had important economic features like the distribution of income among the fisher folk communities. There were rotational systems where many had stakes and thereby the income from these operations was distributed among them. These traditional management systems continue to the present. These management systems were not devoid of conflicts, but the conflicts were resolved by the village leaders to the satisfaction of all parties concerned. These traditional methods, of course, could not supply fish to the increasing population. The per capita supply was low and therefore mass production methods had to be adopted taking the experience from more developed countries. Based on this policy, motorization of fishing craft was commenced in 1958 and introduction of nylon nets was done in 1962. These methods brought about a dramatic increase in fish production.

As with the traditional methods, management measures should have been introduced from the very inception of these schemes. Unfortunately, such a management regime was not considered then and that is the main cause of the present day problems in fisheries. With the incentives given in the form of subsidies on capital goods and institutional credit, within an open access common property regime the fishing effort increased substantially in the coastal fisheries. The popular 9 meter (28 ft) boats were introduced without a proper management plan. A major constraint was the lack of reliable information on the available resource. Thus, sustainable exploitation levels could not be determined. Furthermore, a legal framework was not available for the management, especially of coastal fisheries. The Fisheries Ordinance of 1940 was grossly inadequate to undertake any fisheries management. Increased fish production through increasing fishing effort was necessary in the sixties and seventies. What was lacking was a proper management plan.

As a result, there were many fishing conflicts by the mid 1980s among various groups of fishermen in the coastal areas and inland waters. Many fishermen complained to the authorities regarding their inability to get an adequate income and the non availability of catches in inshore areas. Most of the conflicts were between beach-seine fishermen and others using motorized fishing boats. This led to the framing of Beach-Seine Regulations of 1986. Another major conflict was between purse-seine fishermen and others, which led to the Purse-Seine Regulations of 1986. The conflict between prawn trawl fishermen and others was emerging by that time.

A major reason for present day problems in fisheries is due to the fact that proper management measures were not undertaken at the time of the introduction of motorized craft and synthetic nets which virtually revolutionized the industry. Major issues are the excessive fishing effort and over-fishing. Degradation of coastal habitats due to over-exploitation of resources, coastal pollution due to domestic, agricultural and industrial discharges and oil pollution has contributed to the decline in biomass and the productivity of the coastal fishery resources. Another major issue is the post harvest losses due to mishandling and inappropriate post harvest technologies. Surveys have revealed that about 22 - 25 % of the value is lost by inadequate post-harvest practises. Information and research inadequacies and institutional weaknesses and constraints are some of the issues contributing to the low efficiency of coastal fisheries in Sri Lanka.

Opportunities

In view of the open access, free entry nature of fisheries in Sri Lanka economically wasteful methods are employed in the exploitation of resources. This could be overcome by the following interventions:

Establishment of Property Rights

It is possible to establish property rights to fish stocks and thus the ownership can be fixed. The owner may be an individual or a collection of individuals like a firm, fishermen's cooperative society, etc. If ownership is allocated, there is an incentive to rational and sustainable exploitation. Examples are seen in the beach-seine fishery and stake net fishery in the Negombo Lagoon in Sri Lanka. However, with property rights, there are certain constraints. For instance in cases like tunas which are either straddling or highly migratory stocks, which

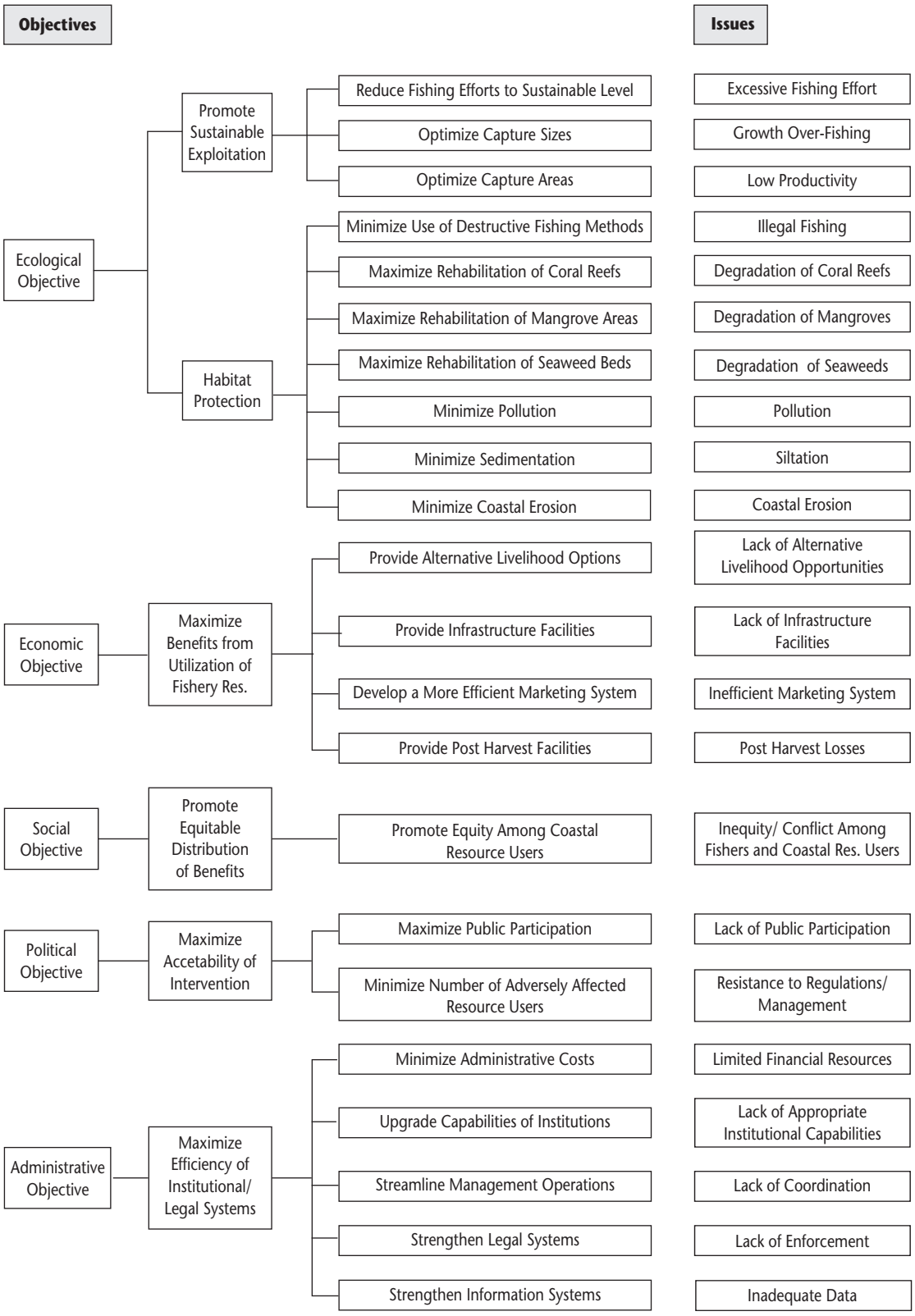

Fig. 2. The objectives for optimal management coastal fisheries in Sri Lanka.

move from one state to another across boundaries, the holder of property rights is at a disadvantage. This could be overcome by either giving exclusive rights to an identifiable fish stock or the implementation of territorial use rights in fisheries (TURFs), whereby full control of an area with reference to stocks is given to the property holders. An example of this is seen in Japan with the fishermen's cooperatives which have exclusive rights to inshore resources and regulate the access of the membership. Bioeconomically, the establishment of exclusive use rights is helpful in breaking the vicious circle of increased supply constraints, which will increase the real price of fish and stimulate more investment in fishing effort, depleting resource leading to additional price increases.

Participatory Fisheries Management

At present, community-based approaches in fisheries management are given high priority. The resource users in a given village participate in the planning and management process in the regulatory system. Participatory management has been successful in beach-seine and stake net fisheries in Sri Lanka. The concept of participatory management is based on the strong human instinct of priority of self-interest over public interest.

There are three methods by which the government can introduce management measures in fisheries. They are: (i) indirect controls through taxation on fishing effort or the landing of fish; (ii) control of fishing capacity and fishing effort and (iii) control of the catch.

Direct control of the catch is widely practiced. The efficiency of this method can be improved by transferable catch quotas. In countries like Australia and New Zealand where fisheries management is comparatively advanced, individual transferable quotas have been introduced. Transferable quotas bring about efficient utilisation of fish stocks, within certain limitations. One such limitation is the misreporting of the catch. This happens mainly with small scale boat operators who supply fish direct to consumers and where proper records are not maintained. Although not perfect, boat-licensing arrangements can also be used as a management tool.

Whatever the controls used in the management process, it is essential to enforce them. It is important to note that the implementation of the management measures themselves incur expenditure. If a management strategy is too expensive to be implemented, it is of little use. A management strategy even with certain limiting factors but applicable at a reasonable cost is more suitable for developing countries like Sri Lanka.

The fisheries policy in Sri Lanka has four main objectives viz, (i) sustainable development of fisheries, (ii) increase in employment opportunities, (iii) socioeconomic improvement of fishing communities and (iv) earning of foreign exchange. For sustainable development of fisheries, sound management measures are necessary. Over the last four decades, the emphasis has been on the development aspect without much consideration for management. This has led to depletion of resources in the coastal waters and decreased incomes. This has also led to low returns on investment, making fishing operations less profitable.

Sri Lanka has attempted fisheries resource management in several ways. The policy has been changed to allow for sustainable development of offshore and deep-sea fisheries and a strict management regime for coastal fisheries has been introduced. Through this policy some fishing effort has been shifted from coastal to offshore fisheries. Legislation has been introduced recently for transforming the open access fisheries to a licensed fishery. Awareness programmes have been conducted to educate fishermen on the importance of fisheries management and a UNDP assisted Marine Fisheries Management Project is being implemented. International conventions and agreements in fisheries management have been ratified and a legal framework drawn up to make provision for these. The value of participation of resource users in the management process has been recognised and legal status given to village fisheries committees. Thus, Sri Lanka is strongly committed to the conservation and management of fishery resources. It is important to apply proper economic principles in management - "Fisheries management is indeed a multidisciplinary subject. Obviously, it must be based on sound biological expertise, but the ultimate objective is economic. Fisheries management that disregards economic aspects may succeed in preserving fish stocks, but it will waste other resources such as investment funds and labor, and it is likely to be distinctly unhelpful for the fishing industry" (Hannesson 1993).

When examining fisheries as a whole in Sri Lanka, we see very efficient traditional fisheries management methods. Beach seine *("madel")* and stake net *("kattudel")* methods are excellent examples. However, there is no proper management regime for the inland fisheries and motorised fisheries which use efficient gear. Under an open access, common property arrangement, efficient fishing methods have been introduced without any limitations.

At present management measures under the Fisheries Act are being instituted. Management measures through limitation of the fishing effort will take time so that socioeconomic ill effects on fishing communities are minimal.

One of the major constraints for the proper management of fisheries is the lack of data on the available resources and the correct level of exploitation. Without these, it is not possible to have a proper management regime.

Based on the above considerations, the following recommendations are made:

- Major constraints on fisheries management have to be resolved. These include the non-availability of data on the resources and the levels of exploitation. Since stock assessment surveys are capital intensive, proper analysis of data from commercial operations should be under taken. These two are not mutually exclusive and stock assessment should be undertaken as soon as possible.
- The fishing effort in the coastal fisheries should be carefully controlled. In this context, producer subsidies to the coastal fishers should be confined to replacements with more efficient craft and gear.
- The fishing effort should be shifted offshore and the necessary infrastructure like fishery harbours built. Other related aspects like training of manpower have to be undertaken.
- Areas where there is heavy fishing pressure have to be identified and alternative methods of employment provided.
- Aquaculture practices have to be intensified with a view to supplement the catch from wild stocks. In this process environmental degradation should be minimized.
- Awareness of fishing communities' concerns in fisheries management has to be increased.
- Areas where the resources are being depleted should be identified and declared as "Fishery Management Areas" under Section 31 of the Act. Suitable management plans for these areas with adequate technical/bioeconomic details should be formulated.
- "Fisheries Management Profiles" are used in many countries with success. Such profiles could be formulated starting with areas where stocks are depleted.
- The most successful approach is community-based fisheries management. Community-based fisheries management plans should prepared on a priority basis.
- To encourage high seas fisheries under the provisions of the Law of the Sea Convention and other international treaties, present day constraints like unlawful apprehensions by neighbouring countries should be addressed.
- Institutional strengthening is of particular importance in fisheries management. National Aquatic Resources Research and Development Agency (NARA) provides information on stocks, National Institute of Fisheries and Nautical Engineering (NIFNE) undertakes awareness and training programmes, Ceylon Fisheries Harbours Corporation (CFHC) oversees infrastructure development and the DOFAR formulates management profiles and enforces policy.
- Management of fisheries should be undertaken in a phased-out manner with the objective of achieving integrated coastal management, incorporating all interests like fisheries, tourism, maritime transport, coast protection and others.
- The species of beach de mer and chanks and other mollusks exploited for export should be identified, and the extent of their resources and exploitation level assessed.
- A project should be implemented to improve onboard handling of fish, facilities at fish landing sites and fish markets, and fish handling and distribution practices to meet the international quality requirements. This should include formulation of necessary regulations.
- Inter-agency cooperation should be strengthened to restore the degraded coastal habitats, including coral reefs, mangroves, sea grass beds, salt marshes etc.
- Awareness of the significance of coastal habitats and their destruction due to man-made causes such as mining, pollution etc. should be promoted among the fishing communities.
- Scientific research on fisheries, aquaculture and coastal habitats should be encouraged and coordinated with the universities and all related research institutions.

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