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COASTAL FISHERIES IN SRI LANKA: SOME RECOMMENDATIONS FOR FUTURE MANAGEMENT

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ABSTRACT

This paper is an attempt made to study the level of resources exploitation and present organizational and institutional set up of coastal fisheries in Sri Lanka. The paper consists of six parts; an introduction to the problem, an overview of coastal fisheries, some theoretical literature review connected to thge study theme, application of the Schaefer model to coastal fisheries in Sri Lanka, a critical review of the institutional framework of the fisheries sector and finally a discussion, conclusion and some recommendations for future sustainable management of coastal fisheries in Sri Lanka.

TABLE OF CONTENTS

1. INTRODUCTION

Sri Lanka is an island state in the Indian Ocean, south-east of the Indian sub-continent between latitudes 6-10° N longitudes 80-82° E. The island is approximately 66,000 km^2 with a 1340 km long coastline. Sri Lanka claims sovereign rights of 223,000 km^2 of Exclusive Economic Zone (EEZ) of the Indian Ocean (Figure 1).

Figure 1: Geographical location of Sri Lanka.

There is evidence that shows fish has been harvested in Sri Lanka since ancient times (Wickremasinghe 2001). The fishing industry in most developing countries emerged during the Second World War. In Sri Lanka, the Department of Fisheries was established in 1940 (Sivasubramaniam 1997).

Successive governments since independence in 1948 have accorded greater emphasis on the fisheries sector as a feasible development arena to meet increasing demands for employment, food security and foreign exchange earnings.

1.1 The problem

In the 1940s, the Sri Lankan fishery was confined to inshore waters. The traditional crafts are made out of timber and use gear such as beach seines and stake nets made out of coir.

The fish production in the 1950s was approximately 40,000 t (Anon. 1959) of which 40% was caught with beach seine (Sivasubramaniam 1997).
As can be seen from Figure 2, the phase of rapid development in the fisheries began in the 1960s. The highest recorded catch was in the 1980s, mainly due to motorization of crafts and the introduction of new crafts and fishing gear made of synthetic material. The coastal fish production increased from 38,760 t in 1957 to 114,870 t in 1975 and 183,280 t in 2000. Along with little increase in production, the stable phase of coastal fisheries recorded its levelling off since 1985

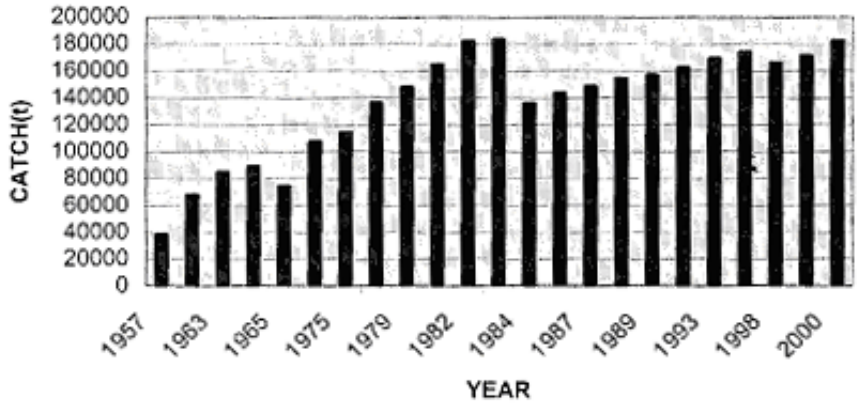


Figure 2: Coastal fish production trend from 1957 -2000.

Thus far, Sri Lanka has implemented seven fisheries development plans. These successive plans suffered from poor and unreliable data and statistics, absence of catch and effort monitoring systems and institutional deficiencies both in designing and implementing stages. Arbitrary introduction of boats through subsidy schemes led to overexploitations of the coastal resources in some areas (Anon. 1994). Recent studies indicate that the level of coastal fisheries production particularly the pelagic species caught with gillnets have either reached or are fast approaching their potential yields (Anon. 1999).

Marine fisheries in Sri Lanka still depend on coastal fisheries, which, according to available information, have reached optimum exploitation levels (Dayaratne 1996). The coastal fisheries are open access common property, except beach seine and stake-net fishery (Atapattu 1994). The beach seine and stake-net fisheries operate under locally sanctioned systems of limited entry based on the customary rights and socio-cultural barriers. The coastal fisheries are also multi species and multi gears. The open access nature has augmented the fishing effort over the years. Population growth in the country and the lack of alternative income generating opportunities has led to more and more pressure on coastal fisheries.

The Six Year Fisheries Development Programme (1999-2004) clearly identifies that fisheries sector institutions have to be strengthened to meet the need of fisheries management (Sri Lanka 1999). It reads:

> "The Government has a vital role to play in the management of fish resources whilst ensuring food security. Unregulated fisheries will lead to user conflicts and resource overexploitation. Over-exploitation of a fishery at the very least means lower returns from the fishery and at worst can lead to the elimination of biological species. Therefore this programme will pay more emphasis in the area of fisheries management through resources management programmes in order to prevent overexploitation and to ensure sustainable utilization of resources." (p.6)

It further indicates:

> "Effort would be made to strengthen the sector institution to achieve good performance standards. This would include restructuring of the Ministry of Fisheries and the department of fisheries in order to enhance their capacity in fisheries management, extension planning, monitoring and evaluation, surveillance of the Exclusive Economic Zone (EEZ) and to improve the delivery of services and facilities to the fisherman, the private sector and all other stakeholders." (p.20-21)

The coastal fisheries exploitation has shown some alarming signals while the necessity of institutional strengthening for sound resource management is identified. This study focuses on institutional strengthening in the fisheries sector and how it could be done in order to bridge the gap between existing and future fisheries management regimes of Sri Lanka. The objectives of the study are to:

- understand the level of resource exploitation,
- explore the role of fishery institutions and organisations
- examine the organisational strengths and the effectiveness of the current managements tools, and
- make suitable recommendations for improvement of the fisheries management system in Sri Lanka.

1.2 Method

The Gordon-Schaefer model (Anderson 1997) is used to estimate the level of resource exploitation. Organizational review is carried out by using Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis. The game theory of the great mathematician John von Neuman is employed with respect to the institutions (McCain 2001).

Data collected from the Ministry of Fisheries and Aquatic Resources Development and its affiliated agencies was used in this study. In addition the Ordinances and Acts and Regulations enacted were also researched to collect necessary information.

2. FISHERIES INDUSTRY IN THE NATIONAL ECONOMY

Fisheries provide 65% of the animal protein consumed in Sri Lanka, provides full time employment for around 120,000 persons and accounts for 2,6% of the Gross National

Production (GNP). Exports of fish and aquatic products were valued at around RS 6750 million (US$ 84 million) in 1988 (Anon. 1999).

Marine fisheries contributed over 90% of the total national fish production of 242,000 t in 1997, of which 152,750 t was from coastal fisheries sub sector. The off shore fisheries are still in a development stage and its production amounted to 62,000 t in 1997.

The coastal fisheries are confined to waters of the relatively narrow continental shelf and its slope area that is 22 km wide on average and rarely exceeds 40 km. The total area of the shelf is about 26,000 km^2 which is approximately 11% of the EEZ of Sri Lanka.

Of the variety of gear used, small-mesh gillnets and beach seines are the main methods used for exploitation of small pelagic fish in the island. Gillnets contributed over 80% of the landings while beach seines account for most of the reminder (Maldeniya 1997). The large-mesh gillnets and ring nets are the main methods used for exploitation of large pelagic fish in the coastal waters of the island. Two type of gillnet are used for catching small tuna varieties. The large mesh gillnet (5''-7'' mesh size) mainly target on large tuna but considerable amount of small tuna varieties are also landed in this fishery. Medium mesh gillnet (2.5''-3.5'' mesh size) are exclusively used to target small tuna.

Table 1 shows that coastal fish production has contributed 68,600 t of the total marine fish production in 1960. During the last three decades, coastal sub sector has contributed over 80% to the total fish production of the country. The prolonged civil war situation in the northeast part of the country has adversely affected the coastal sector contribution to the total production. It has declined to 68% by 2000.

Table 1: Marine Fish Production in Sri Lanka 1960-2000.

Year	Marine fish production (t)	
	coastal	offshore
1960	68600	-
1964	84400	-
1972	90717	2557
1983	184049	689
1984	136642	823
1990	134130	11670
1993	169900	33000
1994	174500	37500
1995	159250	60000
1996	149300	57000
1997	152750	62000
1998	166700	73250
1999	171950	76500
2000	183280	84400

The RV 'Dr. Fridjof Nansen' survey in 1978-1980 estimated the total biomass on the west, south and east shelf to be 400,000-500,000 t with seasonal variation. Of these demersal and semi-demersal fish were estimated at 250,000-350,000 t consisting of emperors, snappers, groupers, sweetlips, Carangidae etc. The potential yield from coastal fish resources within the continental shelf was estimated to be 250,000 t per year of pelagic and demersal species. Coastal pelagic fish were estimated to have a maximum sustainable yield (MSY) of 170,000 t per year and demersal species 80,000 t (Blindheim and Foyn 1980).

2.1 Technical characteristics of coastal fishing crafts in Sri Lanka

The coastal fishery in Sri Lanka is labour intensive as there are many small-scale fishing craft engaged in fishing. Table 2 shows the technical aspect of the coastal fishery. Beach seine (Madel) Paru consists of flat planked hull and its length is 11-14 metres with 7-8 crewmembers. Non-motorised Oru is made out of fibreglass and they are 5-6 metres in length with 2-3 crew. Vallam are typically 8-9 metres equipped with an outboard motor. Theppam is normally 4-5 metres long and operates without a motor. Fiberglas reinforced plastic boats (FRB) are widely spread around the country. The length of the boats is 5-6 metres and powered with outboard motors ranging from15 hp to 25hp. These boats require of 2-3 crewmembers and fishing operations are carried out with gillnets, longlines and handlines. The 3.5 ton fishing boats are 8-9 metres long and equipped with two cylinder diesel engines of 25-30 hp.

Table 2: Technical characteristics of coastal fishing crafts in Sri Lanka (Sri Lanka 1998).

Key characteristics	Craft category	Paru	Oru	Vallam	Thappam	FRP Boat	3.5 ton Boat
	No. of craft	126	9478	2335	2949	8179	1256
Length - ft		20-24	> 24	15-19	10-14	15-19	25-29
Year of manufacture		Before 1989	Before 1994	1985-94	1985-94	1985-94	Before 1990
Hull material		Timber	Fibreglass or timber	Timber or fibreglass	Timber	Fibreglass	Fibreglass
Propulsion method		Oars or paddles	Oars or paddles	Oars or paddles	Outboard motor	Outboard motor	Inboard motor
Engine (hp)		-	<19	<19	-	10-29	30-39
Trip duration (hrs)		>6	6-12	6-12	>6	6-12	13-24
No. of trips per month					25	23	18
Fishing months per year		6	6	7	7	8	8
Crew size		7-8	2	2	2	2-3	4-5
Ownership status of skipper		Sole owner	Sole owner	Sole owner	Sole owner	Sole owner	Sole owner
Fishing gear used		Beach seine	Drift gillnets, handlines	Drift gillnets	Drift gillnets	Drift gillnets	Gillnets, handlines

2.2 Socio-economic status of coastal fishers

Along the 1770 km long coast of Sri Lanka, there were 969 fishing villages sheltering homeland for 58,514 active fishers in 1972. With average family size of 4 to 5 individuals, the total fishing population accounted for 245,062 (Sri Lanka 1972). As per the Marine Census Survey of 1996 (northern province was not included in the survey), the demographic characteristics of the coastal fishers have changed considerably. The total number of fishing villages has increased into 1269 and the total number of fishing families into 72,133, where a number of 83,776 active fishers earned income for a population of 344,497.

Fishing is greatly relied upon. In 1996 there were 72,133 fishing households. Fishing was the sole source of income for 70% of these households and the main source of income for a further 21%. Panayotou (1989) estimated the income of the boat owners and crewmen compared to their costs. Boat owners had an annual average incomes ranging between US$ 1,150 (traditional craft) and over $ 5,000 (3.5 ton mechanised vessel). This was by far a better income than comparable socio-economic groups such as owner- cultivators, share-croppers, office workers and state employees. Similarly, the average daily earnings of crewmen on motorised boat (including indigenous crafts) was $5 per man-day. This is two to three times higher than the daily earnings of agricultural labours and unskilled and semi skilled workers. The earnings of crewmen on non-mechanized traditional craft were comparable to those of agricultural workers ($1.50 per man a day). This status of affair had not changed by the late 1990s (Wijayaratne 1999).

Seventy one percent (55,782) of the fishing families are nuclear families with 4 to 5 household members. Most families live in their own house clustered in villages without better amenities such as drinking water, electricity and roads.

Overall gender distribution in Sri Lanka is on par and it remains so in the fisheries sector too. Almost all active fishers are male. Females are responsible for C-lettered activates such as cooking, child bearing, caring family, clothing, coffering. Collecting fish and collecting money for future and some times fish mongering. Another salient point of the socio-cultural aspect of the fishing community is that, there is a greater ancestral relationship between fishing and fishers. Generational link (relationship of fishing as an occupation pass down from father to son) was reported to be 75% of 83,776 active fishers in 1996. There are three reason for this high generational link. First, low level of education. Second, rare alternative employment opportunities, and third, relatively higher income with independence. As far as education level of fishers is concerned, 80% of the active fishers have attended only primary schools.

When employment in fishing is analysed in terms of an engagement based on fish species and fishing gear, more than 75% of fishermen were estimated to be engaged in pelagic fishing predominantly with sardine nets, beach seines, large mesh and other drift nets. Prawn fishing and related activities with trammel nets and cast nets has become the second major engagement, while bottom fishing with handlines and bottom longlines are in third place.

Of the 83,876 fishers, 61% (51,166) were estimated to be engaged in fishing more than 150 days a year, while 33% reported to be fishing between 50-150 days each year. In the 1996 census, 77% of fishermen used boats for fishing. On the other hand, the main boat types fished from were reported to be Orus and 13-23ft FRB boats. The number of fishermen engaged in fishing with those crafts were estimated 23,188 and 19,645 respectively as per the Marine Fisheries Census of 1996.

2.3 Fisheries organizations and institutional settings

Figure 3 shows the whole organizational set-up involved in fisheries and coastal resources management. The Ministry for Fisheries and Aquatic Resource Development (MFARD) is a cabinet Ministry which has an overall mandate in the sphere of management, development and conservation of fisheries resources. Under the current Ministry of Fisheries & Aquatic Resources there are two departments- Department of Fisheries & Aquatic Resources and Coast Conservation Department- whose chief function is to execute the Fisheries & Aquatic Resources Act No 2 of 1996 and the Coast Conservation Act No 57 of 1981, amended in 1989. Each department is administered by a Director General.

Apart from that there are autonomous corporations- Ceylon fisheries Corporation (CFC), Ceylon Fishery Harbour Corporation (CFHC). National Aquatic Resources Research and Development Agency (NARA), Cey-Nor Foundation Ltd. (Cey–Nor), National Aquaculture Development Authority of Sri Lanka (NAQDA) and National Institute of Fisheries and Nautical Engineering (NIFNE) under control of the Ministry.

In addition to the above public sector fisheries bodies existing under the umbrella of MFARD, there are other government organizations coming under purview of different Ministries involved in the subject of fishery. They are; Department of wildlife, Department of Co-operatives, District Agents/Secretaries and Divisional Secretaries, Provincial Fisheries ministries and Departments Provincial Councils established as per the 13th amendment of the Constitution, Municipal and Urban councils and village level Pradesheeya Sabas. Fishing is a private secor industry with small scale operators. In this sense every fishing household which owns a fishing craft is a business entity. The Government attempted to introduce entrepreneurship to these small business entities establishing limited liability companies registered under the Company Act. Each company's stake was shared by five fishermen who were provided financial assistance to meet the initial shareholdings of those companies to encourage offshore fishing. In addition to these, there are various types of community organizations with different socio-economic objectives, supported similarly and financed by local and foreign non-governmental organizations.

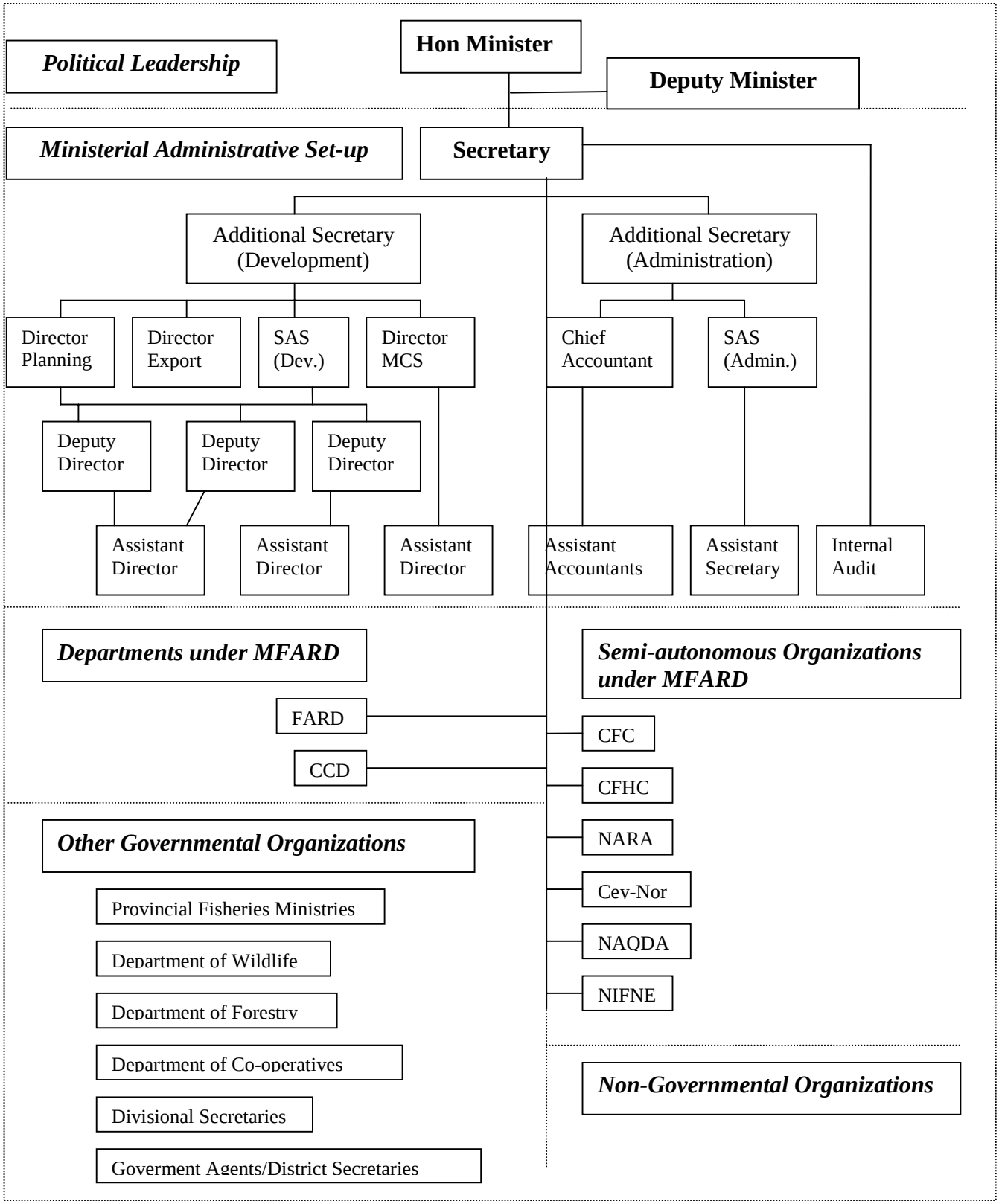


Figure 3: Fisheries Organizational set-up in Sri Lanka.

The Fisheries and Aquatic Resources Act No 2 of 1996 is the prime code of rule for fisheries management in Sri Lanka. The significance provisions of this Act are:

1) setting up a fisheries and aquatic resources advisory council,
2) stipulation of the necessity and importance of preparing a plan for the management, regulation, conservation and development of fisheries and aquatic resources,
3) designation of fisheries management areas,
4) designation of fisheries committees,
5) designation of management authorities.
6) licensing of all types of marine fisheries introduced,
7) inclusion of a section for aquaculture management,
8) inclusion of provisions to collect a cess on all imported fish and fish products,
9) stipulating a course of action to be followed in handling fishing disputes, and
10) inclusion of more types of offences and penalties for them.

Under this Act, so far, twenty three regulations have been imposed.

Coast Conservation Act No 57 of 1981 makes provisions for a survey of the coastal zone and the preparation of a coastal zone management plan. Those provisions are connected to the fisheries management process.

The Fauna and Flora Protection (Amendments) Act 1949 (No 38), 1964 (No. 44), 1970 (No. 1) and 1993 (No. 49) indicate the protected fish species and provisions for the establishment of Natural reserves, Nature reserves and Sanctuaries within which no person shall take fish or other aquatic animals without a permit issued by the Director of the Department of Wildlife.

The National Environmental Act No 47 amended by No 56 of 1988 makes provisions for the protection, management and enhancement of the environment and for the regulation, maintenance and control of the quality of the environment; and to prevent, abetment and control pollution.

The Forest Act 34 of 1951 amended in 1954, 1966 and 1979 covers the large extent of mangrove forest and some of the inland water bodies within the forests fall within the control of this Act executed by the Forest Conservator.

The Fishermen's Pension and Social Security Benefit Scheme Act No. 23 of 1990 is to provide a pension for fishers and to provide insurance against physical disability or death of a fisher for his family. Both fishers and the government contribute to the pension fund and the social security is provided through a group life insurance scheme of the Insurance Corporation.

Marine Pollution Prevention Act provides for the prevention, reduction and control of pollution in Sri Lankan waters and is in part to comply with international conventions to prevent pollution of the sea.

3. LITERATURE REVIEW

3.1 Institutions

There are many approaches for defining institutions. Schotter (1981) defined it as the emergence of rules of conduct by a unconscious process.

Institutions can be defined as the players of a game, for example organisations, banks, and schools. However, this is an unsatisfactory concept because it is devoid of interaction between individuals. Another problem is that defining institutions as players causes a circular argument, since organisations are a product of the institutional structure as well as a source of change in the institutional structure. So, especially when it is asked where institutions come from, such a definition does not allow for an answer (Schonewille 1999).

Institutions can be sub-divided by their degree of formality. Formal institutions are the rules used by authority to shape a particular form of behaviour, informal institutions are the rules that individuals use to shape their own behaviour.

Institutions can also be defined as the rules of the game (North 1991). The rules of the game are composed of formal rules (laws, regulations, constitution) and informal rules (tradition, customs, rules of conduct, taboos, norms).

Institutions can also be defined as the (equilibrium) outcome of the game. Just like in the rules-of-the-game view, institutions are considered to be rules of conduct. The difference, however, is that the rules explicitly are the result of the game itself. So, the rules are endogenously created in the economic process and are the equilibrium result of the game (Schonewille 1999).

All institutions share a set of defining characteristics. They are systems of rules, decision-making procedures, and programs that give rise to social practices, assign roles to the participants in these practices, and guide interactions among the occupants of the relevant roles. Institutions arise in all areas of human endeavour. Where they arise to deal explicitly with matters involving human/environment relations, it is normal to speak of institutions as ***environmental*** or ***resource regimes*** (Schonewille 1999).

From a new institutional economics perspective, institutions exist to minimize transaction costs. Transaction costs are literally the costs involved in negotiating a transaction and have been described as the economic equivalent of friction in the world of physics. Transaction costs are the costs associated with gaining information, making decisions and carrying out decisions (Abdullah et al, 1998).

3.1.1 Institutions vs. organizations

North (1991) prefers to differentiate between organisations and institutions, arguing that institutions are the rules of the game of a society whilst organisations are the players. Organizations play significant roles in administering or operating.

3.2 Open access fishery and over-fishing

Open access fishery inevitably leads to over-exploitation. There are four types of over-fishing; growth over-fishing, recruitment over-fishing, ecosystem over-fishing and economic over-fishing (Pauly 1980).

- Growth over-fishing: occurs when fish are caught before they are mature enough.
- Recruitment over-fishing: reproduction is affected when adult fish are taken in large quantities.
- Ecosystem over-fishing: take place when a particular fish stock level is not compensated due to increased fishing effort which causes other stocks to increase.
- Economic over-fishing: occurs due to economic inefficiency of resource allocation to the fisheries sector as a result of increased fishing effort leading to low profit levels, well below the maximum sustainable level.

3.3 Fisheries management

The Code of Conduct for Responsible Fisheries Guideline No. 4 (FAO 1997) has given a working definition to fisheries management as there are no clear and generally accepted definitions of fisheries management. It reads:

> "The integrated process of information gathering, analysis, planning, consultation, decision making, allocation of resources and formulation and implementation with enforcement if necessary, of regulations and rules which govern fisheries activities in order to ensure the continued productivity of the resources and accomplishment of other fisheries objectives"

From the working definition above, fisheries management can be taken to include the following:

1. Setting policies and objectives for each fishery or stock to be managed.
2. Determining and implementing the actions necessary to enable the management authorities, the fishers and other interest groups, to work towards the identified objectives.
3. Consulting and negotiating with users or interest groups concerned with resources and from areas not directly related to fishery activities but which impact on fisheries.
4. In consultation with the users, regularly reviewing the management objectives and measures to ensure they are still appropriate and effective.
5. Reporting to Governments, users and the public on the state of resources and management performance.

These management measures have been further categorized:

1. Ecologically based management. e.g. marine protected areas, multi species approaches;
2. Indirect economic instruments. e.g. taxes on catches (royalties) or on fishing efforts

3.3.1 Community Property Right. Territorial Use Right of Fisheries (TURF) Fishing Area Zones

The way in which fishermen perceive, define, delimit, ´own´ and defend their right to inshore fishing grounds- or their sea tenure is called territorial use right (Ruddle 1988). TURF is providing exclusive access to a community or to a group of fishermen over a certain area. This is essentially a devolution of management authority to the local level (Christy 2000).

Christy (2000) further argues that TURF is important as a means of management for four major reasons.

1. The most urgent and intransigent problems of fisheries management are related to small scale fisheries in developing countries.
2. TURFs are essential for dealing with these problems.
3. The question of property rights for community TURFs is both complex in detail and broad in scope.
4. There is a significant lack of information on the incentives and conditions that foster the development of community management systems.

3.3.2 Marine Protected Areas (MPA)

> "An MPA can be any intertidal or subtidal terrain, including the overlaying water zones and its associated flora, fauna, historical and culture features, which has been reserved by law or other effective means for the protection of its enclosed environment. it has two basic components: marine sanctuary and marine reserve. Marine sanctuary is a productive marine area wherein the law prohibits all kind of activities that may affect the breeding, spawning, and growth of the flora and fauna within it. In contrast, marine reserve is an area management technique which limit the use and extent of a particular fishing method within the defined space" (Juinio-Menes *et al.* 2000).

3.4 Co-management

Kooiman *et al.* (1999) attempt to define "co–management" since the concept of co-management is widely used but poorly defined. Using statements where co-management is said to be some form of institutional arrangement between government and user groups to effectively manage a defined resource and where responsibility for resource management is shared between government and user groups (Jentoft 1998) they argue that there is no precise definition of the nature of the relationship of the sharing of

responsibility for resources management between government and resource users, although the essential elements of a shared responsibility is clearly identified. The authors describe co-management as a “state of mind” reflecting an unusual degree of mutual respect and trust for each other's aims, expertise, and experience. The quality of the relationship will depend partly upon a willingness to develop greater flexibility in the approach to management, but partly upon each party’s confidence in the organizational strength and integrity of the other.

There is a range of management systems that fall between the extremes of community-based management and government management. Management systems in which government representatives and community members share equal levels of responsibility and authority have been named "co-management." In co-management, both the government and community organizations have specific management responsibilities and authorities, but control of the overall process does not rest with one group. By working cooperatively, all of the tasks related to resource management are addressed.

Charles (2001) describes three major organizational models for co-management.

1) fisher- government model

This reflects the structure of traditional fisheries management. The fisher –government model figures out a blend of top –bottom and bottom- top management styles.

2) multi-party model involving multiple stakeholders and/or public involvement

Many challenges are arising in a coastal resources management such as conflict resolution and decision making with respect to environmental concerns, planning of multiple use in marine areas in addition to fisheries. In such circumstances, a form of multi-party co- management may be desirable, (Charles 2001). This approach is basically related to the Integrated Coastal Zone Management.

3) community-based (fisher-community-government) model

The defining feature of this model is the focus on the geographical unit, which could be a specific area or community or ecosystem, coastal zone or political jurisdiction. Community based co-management of the fishery is a system in which fishers, government and the communities in which they live and work, all have a role to play in the management of the resource. Local community representatives will share in management responsibilities through a community board representing stakeholders in the local fishery and in the coastal community at large.

The various roles will be defined by each local community through consultation among the representatives. The government will introduce the legislation necessary to delegate the authority to the community committees so that they may implement the policies decided by the committee.

4. AN ECONOMIC PERSPECTIVE OF COASTAL FISHERY RESOURCE EXPLOITATION IN SRI LANKA

4.1 Basic theory and surplus production models

Biological theory alone is not sufficient policy planners and managers of marine fishery. Biology is combined with economics to transform it into a usable bio-economic theory (Figure 4)

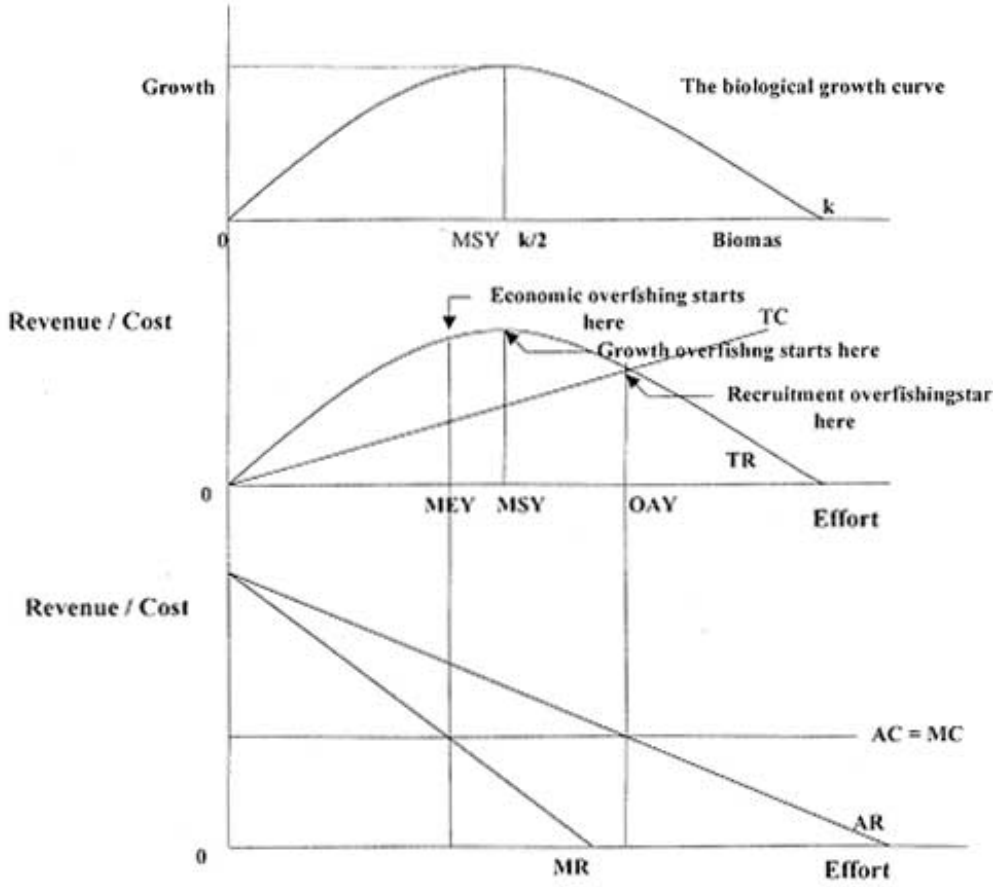


Figure 4: The open access equilibrium.

The total revenue (TR) is derived when catch or yield is multiplied by the price of fish. Total cost (TC) is derived by multiplying effort made to fish with cost of effort. If a constant price and effort level is taken into account, the resulting TR curve will be U-shaped and the TC curve will be a straight line with upward slope. This is because initial increase in effort brings good catch resorting increased revenue and later TR will increase with decreasing rate. Thus, the point on x axis Maximum Economic Yield (MEY) in association with the widest gap between TR and TC curves is the optimum economic

yield or maximum economic yield, where profit is maximised. In an open access fishery, both new entrants and existing fishers are further attracted to be engaged in fishing with higher effort by increased profits and continued fishing beyond MEY, pushing into next optimal level Maximum Sustainable Yield (MSY) which is the biological optimum level of the fishery. At the MSY level, it still generates positive profits. So it induces further fishing till finally, the open access yield (OAY) is reached where there is the long term equilibrium point of the fishery. At this point total revenue equal total cost. No profits are earned in the fishery.

Surplus yield models have been developed on the assumption of natural equilibrium of an unexploited stock where the net growth rate of the stock is related to its biomass. The biomass growth is zero at the carrying capacity of the environment. Therefore surplus production is maximized at a lower value of biomass. Thus, if the stock yield is less than surplus production, the stock biomass will increase, but if yield is greater than surplus production, biomass will decrease. For this study, a single species and constant price model was selected due to data constraints.

4.2 Application of basic theory and surplus production models to coastal fisheries in Sri Lanka

4.2.1 Catch and Fishing Effort Data

The data was extracted from official documents of the Ministry of Fisheries and Aquatic Resources Development to develop a Surplus Yield Model to estimate maximum sustainable yield (MSY), optimum sustainable yield (OSY) and open access equilibrium (OAE).
In this analysis, fishing effort is estimated in horsepower hours (hpH). Both man and motor contribute to fishing effort so a conversion of manpower to horsepower is needed. Manpower hours are converted into horsepower hours on the basis that one horsepower hour is equivalent to the output of 5 to 7.5 men engaged in manual labour and 1 kW equals 1.341 hp. Table 4 is derived by applying the numbers in Table 3 to Table 2 in the Appendix.
To estimate the total annual horsepower hours of each craft category, the annual manpower hours employed in fishing by a craft of each category is divided by six and added to annual horsepower hours (Table 3). The sum of the annual horsepower hours of each craft category is estimated by multiplying the annual horsepower hours of each craft category by the total number of crafts in each category.

One could argue that the method applied above (total catch divided by total horsepower hours, which were estimated incorporating both motor horsepower hours and converted manpower hours into horsepower hours) provide no realistic basis for estimating MSY, MEY and OAE levels. To test the validity of this argument, an alternative method was used, where the estimated catch of each type of craft is divided by total horsepower hours. The two methods of estimation give very similar results.

In order to estimate the cost of unit effort (a horsepower hour), the cost data shown in Table 5 has been extracted from an economic analysis (unpublished) conducted by the Department of Fisheries and Aquatic Resources in 1998. Dividing the cumulative total annual cost of Table 5(a), by the cumulative total annual horse power hours of Table 4, the unit cost of hors power hour as at Table 5 (b) has calculated to Rs. 26.05

Based on the Table 4 in the Appendix- marine fish production by major species 1995-2000, the weight of the each species in terms of their percentage value to the total fish production has been calculated. These quantity percentage values have been multiplied by the annual average wholesale fish prices of Colombo Fish Market of 1995-2000. The sum of the total annual weighted average fish prices of 1995-2000 thus estimated has been divided by the number of years (6) to work out a common weighted average fish price. As this is the wholesale price pertaining to the Colombo Fish Market, fifteen percent was subtracted to arrive at selling price at landing sites. The unit price was estimated as Rs. 68.00.

Table 3: Conversion of manpower hours to horsepower hours for each craft category.

Craft Category **1**	**Fishing Hours** **2**	**Fishing Days** **3**	**Fishing Months** **4**	**Crew** **5**	**Horse Power** **6**	**MPH** **7 = 2*3*4*5**	**MPH into HPH** **8**	**HPH** **9 = 2*3*4*6**	**Total HPH** **10 =8+9**
3.5 Ton	6	18	7	4	30	3024	504	22680	23184
FRP	6	23	7	3	25	2898	483	24150	24633
OB TD	4	21	7	2	10	1176	196	5880	6070
NM TD	6	23	6	2	0	1656	276	0	276

Table 4: Estimate of total horsepower hours employed in coastal fisheries in 1989-2000.

Total HPH for all craft of each category					**Total HPH for all craft of all category**
Year	3,5 ton	FRP	OB	NM	
1989	183,060,864	85,993,803	21,211,316	3,573,096	293,839,079
1990	226,229,472	23,967,909	5,911,948	4,024,080	260,133,409
1991	230,727,168	25,174,926	6,209,672	4,192,992	266,304,758
1992	201,909,456	24,928,596	6,148,912	3,693,156	236,680,120
1993	194,328,288	24,854,697	6,130,684	3,749,460	229,063,129
1994	205,016,112	25,027,128	6,173,216	3,715,512	239,931,968
1995	198,547,776	26,110,980	6,440,560	4,043,124	235,142,440
1996	193,215,456	33,254,550	8,202,600	4,022,148	238,694,754
1997	192,427,200	43,625,043	10,760,596	3,926,100	250,738,939
1998	183,385,440	25,741,485	6,349,420	4,045,884	219,522,229
1999	199,915,632	31,382,442	7,740,824	4,124,544	243,163,442
2000	201,468,960	34,609,365	8,536,780	4,170,084	248,785,189
TOTAL					2,961,999,456

Table 5: Annual Total Production Cost per Craft Category (Rs.) (Sri Lanka 1998).

Craft Category	FC (Rs)	VC (Rs)	TC (Rs)
3.5 ton	290,418	394,614	685,032
FRP	168,671	284,350	453,021
OB TD	97,480	400,050	497,530
NM TD	19,855	40,680	60,535

Table 5a: Cumulative Total Cost of Fishing Fleet 1989-2000 (Rs.)

Year	3.5 ton	FRP	OB	NM	Total cost
1989	939,863,904	3,577,053,816	1,736,877,230	783,686,110	7,037,481,060
1990	939,863,904	4,420,578,918	484,096,690	882,600,300	6,727,139,812
1991	939,863,904	4,508,464,992	508,475,660	919,647,720	6,876,452,276
1992	939,863,904	3,945,359,889	503,500,360	810,018,835	6,198,742,988
1993	939,863,904	3,797,222,022	502,007,770	822,367,975	6,061,461,671
1994	871,360,704	4,006,064,703	505,490,480	814,922,170	6,197,838,057
1995	929,588,424	3,879,671,844	527,381,800	886,777,215	6,223,419,283
1996	1,057,004,376	3,775,477,014	671,665,500	882,176,555	6,386,323,445
1997	925,478,232	3,760,074,300	881,125,630	861,110,375	6,427,788,537
1998	1,023,437,808	3,583,396,110	519,918,850	887,382,565	6,014,135,333
1999	1,010,422,200	3,906,400,083	633,853,220	904,635,040	6,455,310,543
2000	1,006,997,040	3,936,752,490	699,029,650	914,623,315	6,557,402,495
					77,163,495,500

Unit Cost per Horsepower Hour (Rs) = Total cost / Total hpH
= 77,163,495,500 / 2,961,999,456 = **26.05**

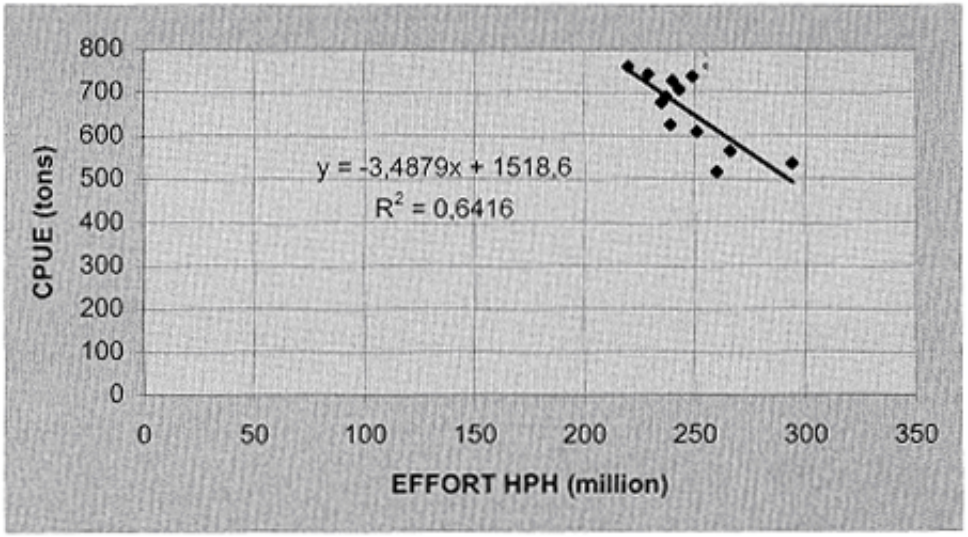
Table 6: Catch Per Unit Effort (CPUE) for Coastal Fisheries in Sri Lanka.

Year	Catch (t)	Effort HPH (million)	CPUE (t)
1989	157410	294	536
1990	134130	260	516
1991	150150	266	564
1992	163170	237	689
1993	169900	229	742
1994	174500	240	727
1995	159250	235	677
1996	149300	239	625
1997	152750	251	609
1998	166700	220	759
1999	171950	243	707
2000	183280	249	737

Table 7: Effort, Yield, Cost and Revenue.

Effort HPH (million)	**$Y = af+bf^2$ (tons)**	**Total Revenue (TR) Rs (million)**	**Total Cost Rs (million)**	**Profit Rs (million)**
0	0	0	0	
20	28,984	1,971	520	1,451
40	55,175	3,752	1,040	2,712
60	78,574	5,343	1,560	3,783
80	99,180	6,744	2,080	4,664
100	116,994	7,956	2,600	5,356
120	132,015	8,977	3,120	5,857
140	144,244	9,809	3,640	6,169
160	153,681	10,450	4,160	6,290
180	160,325	10,902	4,680	6,222
200	164,176	11,164	5,200	5,964
220	165,235	11,236	5,720	5,516
240	163,501	11,118	6,240	4,878
260	158,975	10,810	6,760	4,050
280	151,657	10,313	7,280	3,033
300	141,546	9,625	7,800	1,825
320	128,643	8,748	8,320	428
340	112,947	7,680	8,840	-1,160
360	94,458	6,423	9,360	-2,937
380	73,177	4,976	9,880	-4,904
400	49,104	3,339	10,400	-7,061
420	22,238	1,512	10,920	-9,408
440	7,420	-505	11,440	-11,945

A



B

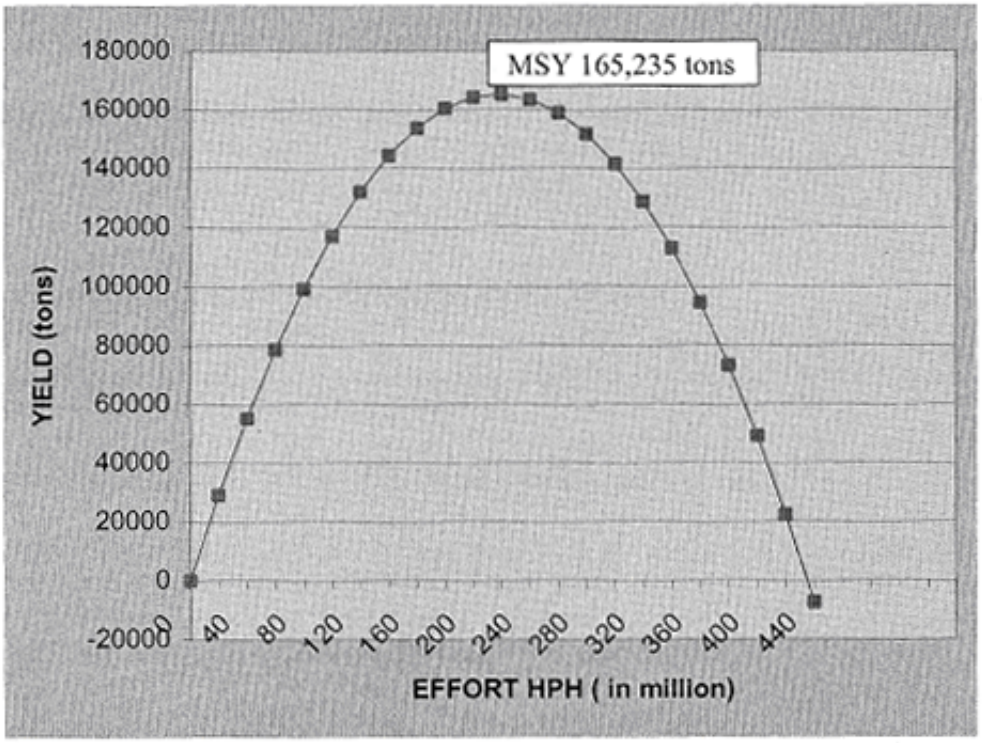


Figure 5: Surplus Yield analysis of data for the coastal fisheries in Sri Lanka showing A) catch per unit effort (ton per million horse power hours) against fishing effort (in million horse power hours), and B) Yield (t) against fishing effort.

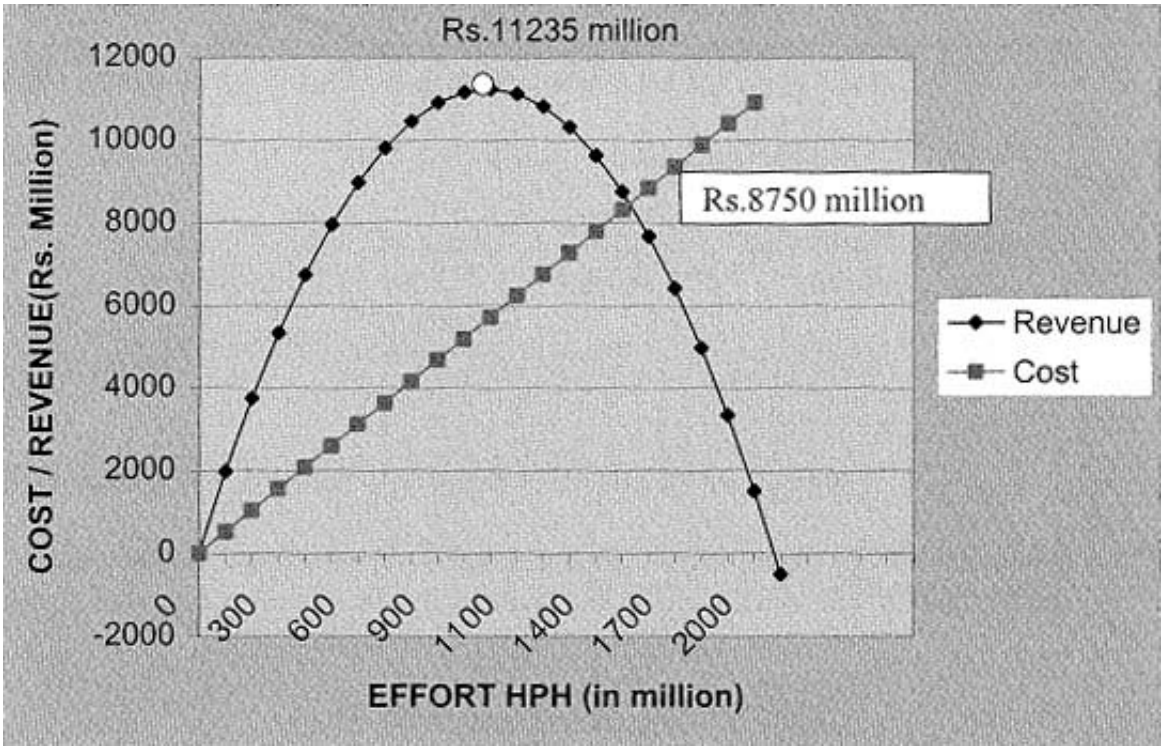


Figure 6: Maximum Sustainable Yield, Maximum Economic Yield and Open Access Equilibrium points of Coastal Fisheries in Sri Lanka.

4.3 Results for Coastal Fisheries in Sri Lanka

The results of estimation of the Gordon-Schaefer model for coastal fisheries in Sri Lanka are presented in Tables 8, 9, and 10.

Maximum Sustainable Yield for Coastal Fisheries in Sri Lanka

The Maximum Sustainable Yield was at 165,235 tons valued at Rs 11,236 million and attained at effort level of 220 million horsepower hours compared with the catch and effort level (number of fishing crafts) as appeared in table 7, the MSY in the coastal fisheries in Sri Lanka was reached by 1992.

Table 8: Maximum Sustainable Yield

Effort HPH million_Yield_Revenue Rs million_Cost Rs. million_Profit Rs. million__220_165235_11236_5720_5516

Maximum Economic Yield for Coastal Fisheries in Sri Lanka

The Maximum Economic Yield was indicated at 153680 tons valued at Rs 9809 million at the effort levels of 140 million horsepower hours.

Table 9: Maximum Economic Yield

Effort HPH million_Revenue Rs million_Cost Rs. million_Profit Rs. million__140_9809 _3640_6169__

Open Access equilibrium of Coastal Fisheries in Sri Lanka

The open access equilibrium of coastal fisheries in Sri Lanka will be reached at 320 million horsepower hours with a yield of 128,650 tons valued at Rs 8,748 million.

Table 10: Open Access equilibrium
Yield
(t)_Effort HPH million_Revenue Rs million_Coast Rs.
million__128650_320_8748_8320__

Current exploitation level

The yield in the year 2000 was 183,280 tons at the effort level of 249 million horsepower hours. This indicates that year 2000 effort level has overtaken the MSY level by 29 million horsepower hours. As 61,464 horsepower hours equals the total horsepower hours employed by four crafts of each category, there were 1200 excessive fishing crafts.

Conclusion

An MSY level of 165,235 tons supports the premise that the coastal fisheries in Sri Lanka are fully exploited, and further exploitation will cause a decrease in catch, which in turn reduces the profits for the coastal fisheries of Sri Lanka.

5. A CRITICAL REVIEW OF THE FISHERIES SECTOR, ORGANIZATIONS AND INSTITUTIONAL SETTINGS IN SRI LANKA

5.1 A SWÓT analysis

The fisheries organizations coming under the MFARD and the laws and regulations (institutional settings) executed by the same was reviewed using the strategic management tool - SWOT analysis- strengths (S), weaknesses (W), opportunities (O) and threats (T) (Table 11). The weaknesses were examined in detail.

Table 11: A SWOT Analysis on Fisheries Organizations and Institutional Settings.

Strengths (S)	**Weaknesses (W)**
• Fisheries act for applying bottom up approach for management	• Lack of science and culture policy • Roles of organizations ambiguous • Vague policy focus • Vast array of organizations and institutions, and poor interagency coordination • Overlapping mandates • Weak law enforcement and lack of compliance with regulations • Lack of sound data and information compilation systems • Lack of competent staff
Opportunities (O)	**Threats (T)**
• Untapped offshore fishery • Claim for resources on the seabed beyond the 200 nm. Towards this an exhaustive seismic survey is undertaken • Island-wide inland water bodies	• Poaching by other countries • Different and contradictory provisions in other Acts and Regulations

a) Lack of science and policy culture

The fisheries sector has not been made part of an intergrated coastal management programme (ICM) in Sri Lanka, since the first phase of the ICM programme has attached high priority to coastal erosion. An integrated coastal management programme or separate fisheries management programme has to be built using of the best science and the best information available as the understanding of complex and dynamic coastal and marine ecosystems is limited and there are large gaps in our knowledge due to non-availability or lack of information. International agreements in fisheries emphasize responsible fishing and the adoption of a precautionary approach (FAO 1995). Information and data may be kept in various places since the compilation was not

coordinated. Sivasubramaniam (1997) argued that growth of fisheries research does not commensurate the growth of the industry and the present reliability level and details in the fisheries statistics is insufficient for determining management measures such as licensing. An adaptive management culture of science and policy is needed to make use of available information.

One of the problems has to do with the different culture to which the two sides belong. Scientist and resource managers are often worlds apart in their value system. Table 12 gives examples of these different views (Cicin and Knecht 1998).

Table 12: Behaviour and points of view typically associated with the culture of science and policy.

Factor	Science	Policy
Valued action	Research, scholarship	Legislation, regulation, decisions
Time frame	That need to gather evidence	Immediate, short-term
Goal	Increase understanding	Manage immediate problems
Basis for decision	Scientific evidence	Science, values, public opinion, economics
Expectations	Understanding is never complete	Expect clear answer from science
Grain	Focus on details, contradictions	Focus on broad outline
Worldview	Primacy of biological, physical chemical mechanisms	Primacy of political, social interpersonal, economic mechanisms

Sivasubramaniam (1997) offers a description concerning the behavioural differences of policy makers and research scientist in Sri Lanka as follows;

> "The use of available research findings, for management purposes has not been satisfactory. The scientists claim that the research findings available are not being used by the administrators/managers. The latter claim that the output of the scientists is not directly relevant to their management needs. The decision to ban shrimp trawling in certain area in the north-west coast and to ban purse seining in the south- west coast, were made on the basis of socio-political factors, without the benefit of scientific findings."

For sound fisheries management, knowledge expansion only in natural sciences is not adequate since fishery systems are encapsulated with many disciplines such as physical oceanography, biological oceanography, biology and ecology, chemistry, engineering, food science, mathematical modelling, economics, sociology and anthropology, political science, law, history and business administration (Charles 2001). It is neccessary for fisheries management to understand the resource-fishermen distribution continuum and of

the linkage among fishers, fishing communities, and other rural sectors, and institutions, including government (Smith 1979). Jentoft (1998) argues that fisheries is an industry and fishing is a human activity, and it is through regulatory measures of fishing behaviour that we attempt to secure the viability of fish stocks. Therefore, the social scientist would argue the obvious: to manage well, you need to know not only fish, but also fishers and fishing.

b) Role ambiguity of the organizations

The role of MFARD is acceptably bound with the process of policy formulation needed for achieving its objectives through executing various programmes so designed by its allied organizations. Thus, it has to play the roles of macro-planner and final decision maker, advocate, advisor, consultant as well as promoter and facilitator rather than direct implementer of service programmes. But at present, MFARD plays irrational roles. For example, the Monitoring, Control & Surveillance division (MCS) is directly under the auspices of MFARD. Its main objective is to ensure proper management of fishing activities with searches on illegal fishing, coral and sand mining etc. Thus, the role of MCS is mainly regulatory, and to provide support for law enforcement. Another department of MFARD is the Social Development (SD) division, which is responsible for executing the Fishermen's Pension and Social Security Benefit Scheme Act No 23 of 1990, in addition to a number of social welfare programmes such as housing, drinking water, health and hygienic facilities, providing equipments for nursery schools for fishing communities.

On the other hand it was planned to established a separate department for executing the activities relating to Monitoring, Control and Surveillance.

c) Vague policy focus

In most countries fisheries management is a political battlefield of conflicting interests, and management goals have the character of delicate compromise. Consequently, one also needs to understand the political process of fisheries management (Jentoft 1998). A fisheries management system is an institutional set up, and an effective management system is based on finding the appropriate organizational mechanisms, i.e. the rules, procedures, and incentives that will help fulfil management goals.

Maximizing exploitation: Fisheries sector organizations coming under purview of MFARD in Sri Lanka were established with the goal of increasing fish production from 1950, and this policy focus still continues. However this policy focus must now also include sustainability since the coastal fishery is no longer in the developmental phase. The current mission statement of the Ministry is to promote and facilitate sustainable utilization of fisheries and aquatic resources for the benefit of the people. The mission statement of an organization is the core of that organization. Developing a national programme for the exploitation of fisheries and aquatic resources on a sustainable basis is a main area of concern of the Ministry. Consequently, the Six Year Fisheries Development Programme 1999-2004 was designed. It is therefore of prime importance to know the sustainable harvesting level of the fishery in question. This suggests that policy

intervention should always focus on the effort level, because setting multi dimensional objectives and their achievement totally rely on the level of the fish stock to be harvested.

At this juncture one could argue that what is the level of the sustainable exploitation in the absence of proper scientific advise and what is remained is to leave the room for status quo. In any discussion of sustainability, it is difficult to clarify what is being sustained, at what level, for how long, for whose benefit, over what area and measured by what criteria. Therefore, Management of Sustainable Coastal Fisheries (MSCF) offers in realistic term as use it tentatively as maintaining the current level of exploitation unless extreme positive or negative factors are identified as sustainable level. On the other hand what might be appropriate for this stage of transition to sustainable fisheries is to define conditions alleviating the current excessive fisheries input on the depleting fisheries resources The first action that governments may take is to co-ordinate policies and institutions more clearly (Annon, 2001).

Common property and Open access: Except for beach seine and stake netting there is open access to coastal fisheries in Sri Lanka. Hardin (1968) explained how a scarce common resource "open to all" leads to overexploitation. He used a pastur open to all herdsmen for cattle grazing as an example. The pasture will become overgrazed since each herdsman can capture all the benefits of adding more cows, while sharing only a fraction of the costs. The damage caused by excessive grazing is caused by the intention of maximising individual benefit against to shared costs. The tragedy is that each individual is locked into a system of competition for grass that leads to ruin.

This is valid for all common resources utilisation including an open access fishery where each fisher receives all the benefits of harvesting more fish, having no concern about the sustainability of both fishery and fishing, which provide their livelihood.

Although, the new Fisheries Act was passed in 1996 and subsequently number of regulations with a view to managing the fisheries by issuing licence for boats and fishing operations, designating fisheries management areas and fishing committees, this course of actions is not expeditiously in operation in the absence clear vision for Department of Fisheries and committed staff due to frustration on the administrative set backs.

Ambiguity of political and administrative power sharing: As per the 13th amendment to the Constitution of Sri Lanka the subject of fisheries is a matter of concurrence list; which means that both central government and provincial councils have the power and authority to engage in fisheries activities particularly in coastal waters. While the Ministry of Fisheries and Aquatic Resources Development as a central government institution is encouraging offshore fishery to reduce the pressure of resource exploitation near the shore, the Provincial Fisheries Ministries implement their development programme in coastal waters since they have no authorization in offshore fishery affairs and can only afford small scale fishery development activities in coastal waters.

d) Vast array of organizations and institutions and poor interagency coordination

Of unconventional constraints relating to the fisheries management in the south-east Asian region (Marr 1982.), some are valid to the fisheries in Sri Lanka. According to Marr (1982) the responsibility for various components of fishery management is widely spread throughout the government. It may be difficult or impossible to put a management plan into effect. This state of affairs has further been made difficult since there would be infrequent communication between the fishery department and other departments. Sometimes they may actually be in conflict.

There are more than ten government departments or agencies which have some legal or administrative responsibility for the coastal zone and management of its resources. Insufficient collaborative management action by the institutions concerned with fisheries, coast conservation, environment, wildlife, and forestry at the central and provincial governmental levels resulted in serious damage to the wetland mangrove of Sri Lanka (Sivasubramaniam 2000).

As so many organizations are involved in the subject of fishery, it is difficult to plan and implement coastal resources management programmes on the one hand due to overlapping and contradictory mandates and on the other hand poor co-ordination among the agencies of different interests.

Crutchfield (1980) pointed out the problem of rational utilization of marine fisheries is not scientific ignorance. The real weakness lies in our institutional mechanisms for getting something done, and for making the regulated fishing industry itself a part of the analytical and decision making process.

e) Overlapping mandates

Mandate for carrying the coastal sector development, management and conservation activities has overlapped among the existing organizations within and outside MFARD. The secretary to the Ministry of Fisheries and Aquatic Resources shall have *a plan for the management, regulation, conservation and development of fisheries and aquatic resources* prepared under the Fisheries and Aquatic Resources act No 2 of 1996. This act gives a mandate to the Minister in charge of the subject of the fisheries for designation of special management areas, fisheries committees and management authorities in connection with the fisheries.

The Coast Conservation Act No. 57 of 1981 amended in 1981 makes provision for a survey of the coastal zone and for the *preparation of a coastal zone management plan*. Even though, marine and coastal resources include all renewable and non-renewable resources situated in marine and coastal areas, such as water, lands, minerals, and animal and plant species, fisheries components has not been integrated properly into the Coastal Zone Management Plan in Sri Lanka.

The Provisions of the NARA Act were not clear enough about the research functions of the NARA. It repeatedly refers to development and management role, which are the main functions of the Ministry and the Department of Fisheries and aquatic Resources (Sivasubramaniam 2000).

Underdahl (1980) offers a definition to "integrated policy". To integrate means to unify- to put parts together into whole. Thus, integrated policy is a policy in which the constituent elements are brought together and made subject to a single unifying concept. To qualify as integrated, a policy must achieve 1) comprehensiveness, 2) aggregation, and 3) consistency at thee successive stages in the policy process.

f) Non availability of sound data and information compilation system

Non-availability of good data in the fisheries sector is a chronic issue. This defect has been cited in authoritative documents from 1950 to 2000.

> "It would be appropriate right at the outset to stress the importance of having accurate statistics, both from the point of view of planning and evaluating progress. The inquires made for preparation of this report revealed how little statistical information is available regarding the fisheries of the island and it was found that what was available was itself not always reliable nor complete enough to enable definite decisions to be taken" (Sri Lanka 1959).

> "By general agreement, coastal resource and fisheries data are weak and patchy. fishery statistics are based on incomplete original surveys of vessels, gear, and fishermen, and on sometimes doubtful estimates of fish landings at different sites." (Sri Lanka 2000)

Over fifteen fishery resources surveys have been conducted in Sri Lanka since 1920, mostly on demesal resources. However, whether the maximum sustainable yield has already been attained or not cannot be sufficiently determined since the surveys were not followed by reliable data collection.

g) Weak law enforcement and lack of compliance with regulations

There is a sufficient number of Acts and Regulations in respect of coastal resources management, but, there is hardly any evidence for number of offensives that have been brought to book. On the one hand the punishment or fine for offence stipulated in the Acts is negligible. These two facts mainly resulted in lack of compliance with regulations. On the other hand, weakness in the provisions of relevant Acts has contributed to regulations not to be very stringent, the offence less specific and punishment less severe. Such major weak areas are the registration of fishing crafts, inability to regulate fishing effort, inability to prohibit destructive fishing gears and methods, demarcation of fishing grounds for various categories of fisheries. However, lack of compliance with regulation is reported sufficiently in terms of destructive fishing, discharging industrial effluents, mangrove cutting etc.

Estuaries and lagoons are among the most productive ecosystems supporting a large number of fish and crustaceans in the adjacent coastal waters. Overfishing, use of destructive fishing gears, degradation of water quality as a result of pollution from industrial effluents, agrochemicals and pesticides, and siltation are changing the ecosystem environment in estuaries and lagoons. (Dayaratne *et al.* 1995). Due to the lack of enforcement, the use of dynamite to attack pelagic fish schools has become a threat, particularly along the southwest and south coasts (Dayaratne 1996).

The development of shrimp farming along the north-western coastal belt has resulted in many environmental problems. There was a tremendous increase in the number of farms and the total land allocated for shrimp culture exceeded 3000 ha by the end of 1995. Even though, there are governmental regulations to control this development, the number of unauthorized farms increased resulting in environmental and social problems in the area. (Dayaratne 1996)

Coral reef ecosystems are under severe threat as a consequence of reef mining, destructive fishing, discharge of industrial effluents, sewage etc.(Rajasooriya 1995). Mangrove ecosystems, which provide breeding and nursery grounds for commercially important fish species, are threatened from cleaning for construction of aquaculture ponds, collection of fuel wood and pollution (Amarasinghe 1995).

Sutinen (1996) explains that individuals generally tend to consider four factors when faced with the decision whether to comply with a law or regulation or not: the amount of illegal gain or benefit, the expected penalty, moral obligations, and social influence. In Becker's model from 1968, an individual commits a crime if the expected utility from committing the crime exceeds the utility from engaging in legitimate activity (Sutinen and Kuperan 1997). The expected penalty works to deter individuals from committing a violation if large enough to offset the illegal gain and thus remove the incentive to violate. Unfortunately, this is rarely the case (Sutinen 1996).

5.2 The Fisheries and Aquatic Resources Act No 2 of 1996: An institutional analysis

Institutions – rule of the game – can be studied applying different theoretical approaches as stated in the literature review. Those approaches mainly treat customs, rules and regulations as 1) a source of growth, 2) a transaction cost, 3) substance created by supply and demand model and 4) as a product of historical process. The Fisheries and Aquatic Resources Act No 2 of 1996 could be seen as a product of historical process. The objective of fisheries for most coastal states from the 1950s to 1980s was to increase resources utilisation through modern technology. The attention was shifted to pollution control at a later stage, which can be viewed as a shift in attitude from development to management. With the UN Conference on Environment and Development (Rio de Janeiro 1992) the focus was further shifted towards conservation. As a result of this global orientation, with FAO assistance, the new Fisheries Act was passed in Sri Lanka. This is on the one hand a source of (overexploitation or pass approaching to MSY)

fisheries growth and on the other a result of historical process. This Act repealed the fisheries Ordinance of 1940 along with all amendments, the Chank fisheries Act, Pearl Fisheries Ordinance, and the Whaling Ordinance. So it is an alternative product based on past institutions.

To this Act, some new sections and provisions have been added. The following are some of them: 1) advisory councils, 2) preparation of plan for the management, regulation, development and conservation, 3) Aquaculture regulation, 4) designation of special management areas, fisheries committees and management authorities 5) licensing of all type of marine fisheries, 6) conflict handling, 7) a cess on import and 8) changes in offences and penalties. These are the institutional supply to the demand made by fishing and fishery. For example, major conflicts took place following the introduction of new technology from 1950 to 1990, so they led to provisions for conflict settlement. The pollution problems and heavy economic losses incurred in the sub-sector due to uncontrolled development of shrimp fisheries in the North-western province, demanded institutional measures to manage aquaculture industry. Accordingly new regulations have been imposed.

5.2.1 Some weaknesses in the Fisheries and Aquatic Resources Act No. 2 of 1996

There are no provisions in the FAR Act of 1996 relating to a management division of DFAR, especially regarding responsibilities and directly assigned authorities for management.

The FAR Act of 1996 has provisions to establish fishermen committees and to assign management authority to them, but there is no clear indication on the envisaged managerial work domain of these Fisheries Committees.

It is not clear that on what ground a management area is selected and designated and on what ground fisheries committees are combined where there is more than one fishing committee.

According to the regulation of fisheries committees, both resident and migrant fishermen can become members with no other restraints. This may lead to proliferation of Fisheries committees in an area. However, having too many or too few fishers in a fisheries committee may not be appropriate for reaching a fair decision.

6. DISCUSSION, CONCLUSION AND RECOMMENDATIONS

6.1 Discussion

In developing a sound fisheries management system for Sri Lanka one should look into the specific conditions and successive practices already available in the fishing sector. Since coastal fisheries are small scale and labour intensive, it essentially demands an effective mechanism, which could tackle the problem of a resource bounded with too

many people. To credit successive practices, there have been community based management approaches in the fisheries sector in Sri Lanka. Although the common law - Roman Dutch law- upholds the right to fish in the sea being open to all, in many places fisheries have been operated in terms of territorial use rights guaranteed by customary law. Customary rights are limited to beach seine, stake nets and fish weirs (Atapattu, 1994).

In the past the mainstay of coastal fisheries was beach seines but their use was restricted to 890 beach seines for the entire coastal belt by 1985 due to multiple use of coastal are such as tourist and hotel industry and construction of protective bolder ridge barriers against sea erosion.

The beach seine regulation of 1985 is a significant legal instrument to examine the property rights related to fishing in Sri Lanka. According to this regulation, no person shall engage in beach seine operations within any part of the territorial sea other than places specified and demarcated in this regulation. Thus the beach seine owners have been given exclusive rights to utilise and manage the fishing in designated locations without outside interference.

Owners of beach seines need to be registered with the ministry of fisheries. They will be issued a licence subject to annual renewal securing the right to have complete certainty for fishing. The regulation limits the transferability of property rights, but every owner may appoint an heir to carry on beach seine fishing in his place. This implies that if beach seine owner carries on fishing operations without any disputes or disobedience with regulations, his right to fishing is permanent.

Co-management or community management can be seen in the stake net fishery in the Negambo Lagoon in Sri Lanka. This fishery is carried out by limited number of fishers throughout the year. According to the Negambo Lagoon stake fisheries regulations, any person who is a fisherman by occupation and is a member of any of the four associations of fishermen stated in the regulations may fish in specified areas of the lagoon. Accordingly, every third day starting from a reference date, each association gets an equal chance to fishing. The Roman Catholic churches in the area assist fishermen in organizing themselves, controlling fishing and resolving disputes.

The development of the Rekawa Special Area Management (SAM) plan under the coastal resources management programme of the coast Conservation Department stimulated various agencies to take up specific components for implementation. Although the basic objective of the plan was resource management associated with Rekawa lagoon, it also addressed community issues. For example, a causeway structure that formed a physical barrier blocking the free exchange of water and restricting the movement of shrimp in the lagoon was replaced with a bridge. This shows that addressing community issues is a factor essential to assuring the sustainability of a management programme The problems of coastal fishing communities can not solved by MFARD alone, since they are a part of the broader problem of rural development and mere integrating fisheries into the coastal resources management process is also inadequate. The Ministry should commence an

integrated rural development approach with the support of other relevant government organizations, private sector and NGOs to accommodate their problems. For this purpose the ministry could develop detailed profiles of strengths, weaknesses opportunities and threats relevant to such fishing communities and their localities.

The research work carried out by the coral reef study team of NARA led to the declaration of two major sanctuaries; one at Hikkaduwa and the other at the Bar reef in the north-western coastal waters (Dayaratne1996). However, since Hikkaduwa is a popular tourist spot, the corals in the core protected area still suffered due to over-use by boat operators attached to tourist industry. The Bar Reef sanctuary has also been adversely affected by divers collecting fish for the ornamental fish export trade. This example shows the necessity of stakeholders taking part in resource management. The World Conservation Unit (IUCN) has carried out a comparative analysis of resource use patterns and associated economic, socio-political and institutional factors in four Marine Protected Areas (MPA). The Hickkaduwa Marine Nature Reserve was one (Senaratne 2001). In all areas direct involvement of the local community in establishment and management of the MPA and strong commitment by the different user groups to the long term sustainability of the resource are required to successful maintenance of MPAs.

Since it appears to be little difference in the fishing fleet of Sri Lanka, there are no fishing zones for each type of fishing craft. Fishing zones could be a practical measure for community based fisheries management as it ensures community property rights. On the other hand, the coastal fishing is already a subject coming under the jurisdiction of both the Central Government and Provincial councils due to power devolution and decentralized administration exercises stated in the late 1980s. Since the Provincial Councils are not yet enjoying their mandate fully, there are no disputes currently related to power sharing especially in the fisheries subject. The power sharing scenario is expected to be further strengthened in the near future. Hence, there should be a clear demarcation of fishing operation in the waters based on the vertical or horizontal dimension to satisfy both the power devolution process and community based fisheries management. As fish stocks are trans-boundary, zoning based on depth ranges may be beneficial since it prevents potential conflicts among the interactive fishers in distance based on fisheries (Sivasubramaniam 1997). This may help to diversify the fishing towards operations based on key fish species. To this effect, lessons can be learned on zoning from spatial zoning in Malaysia and on fishing jurisdiction between Municipal/ city government and central government through the Philippine fisheries code of 1998 (Philippines 2000)-.

Catch data collection and analysis process presently undertaken by MFARD has to be entrusted to NARA as it is the organization mandatory for collection, dissemination and publication of information for the development, management and conservation of resources in marine and inland waters. In this connection, a collaborative institutional network could be established for obtaining necessary assistance from other stakeholder organizations. For instance, CFHE can furnish a weekly or monthly return on fish landed at fishing harbours. CFC can produce price of fish at landing sites and consumer prices as they are purchasing fish for their chain of market outlets spread over several districts.

NAQDA is responsible for aquaculture and inland fisheries and it can provide data related to such areas. Catch data collection presently carried out through the Fisheries Inspectors of DFAR could be continued with necessary improvements. For example, at present 40% of the total fish production of the country is classified as "other". This could be rationalized providing necessary training for identification of fish family or species and providing taxonomic handbooks with colour photographs of fish species. The involvement of fishing committees should be sought on catch data collection as there are many landing sites all along the coast other than fishing harbours and anchorages. The fishers´ indigenous knowledge may be useful for fishery research.

To ensure fishers compliance with regulations, fishers' views should be obtained through the co management approach before the regulations are formed. Co-management regimes, in which participants are empowered to play a prominent role in decision making, may be a means of achieving strengthened legitimacy and voluntary compliance (Sutinen and Kuperan 1997). Under the GTZ project on coastal fishery resources management, a community organization formed at Udukiriwela Reservoir in Hambantota District in Sri Lanka was able to create regulations by themselves. Accordingly, it is essential to obtain a licence for fishing in the reservoir, no use of any fishing gear other than gillnets of which mesh size is not less than 10.6 mm, maximum number of net pieces limited to six, fishing hours from 1.00 p.m. to 9.00 a.m. and a fisher can only fish once a day. The community organization was registered as Udukiriwela Reservoir Management Committee under the Fisheries Act No 2 of 1996.

6.2 Conclusion

The basic and interrelated issues in coastal fisheries of Sri Lanka are three pronged - biological, economic and environmental - but they differ in importance. The results of the estimation of the Gorden-Scheafer model shows that the current level of exploitation in the coastal fisheries of Sri Lanka (183,000 t) has surpassed the maximum sustainable yield level (162,000 t) by 21,000 tons. This is a holistic view of the entire coastal fisheries of Sri Lanka with a limited set of data. It vehemently demands a local, thorough analysis on the fisheries exploitation in order to take precautionary measures against the possible depletion in an open access coastal fisheries.

Within the existing organizations coming under purview of the MFARD and the laws and regulations executed by those organizations, the areas discussed in the SWOT analysis, need to be taken seriously for strengthening the institutional set-up which is necessary for sound resource management. In addition, a holistic approach to create a shared vision must be adopted as there are many stakeholder organizations and other laws and regulations connected to fisheries management which are executed by other ministries and departments in the country.

A practical management system is vital in a coastal fishery that has overexploited its resources and where law enforcement and compliance is weak. Establishment of a sound institutional framework, which encourages the participant approach, is the most viable option. By crossing organizational and institutional boundaries participatory fisheries

management system could be achieved. For this, there should be interactive learning between all participants involved in fisheries chain. This interactive learning process gives stakeholders the opportunity to participate in the decision making and management process. It will help generate a sense of common and shared responsibility among the various participants.

6.3 Recommendations

MFARD should develop a policy framework that clarifies and consolidates the following areas:

- access and allocation of fishery resources
- economic and social viability of the industry and management
- conservation of fishery resources

Fishing communities with a history of fishing in nearby waters should be allowed to establish use rights to the waters. The communities should have sole authority to either prevent or restrict entry. As this requires some groundwork, a zoning system must be implemented in the short run.

To create a community base fisheries management mechanism, as envisaged by the Fisheries and Aquatic Resources Act no 2 of 1996, fishing committees should be established in the coastal fishing communities. They are to be strengthened according to the multi party stakeholder approach placing greater responsibilities on the fishers as fisheries managers. This mechanism should be integrated into the coastal resource management process of the Coast Conservation Department.

In keeping with responsible fisheries and precautionary principle of FAO, the present exploitation level of coastal fisheries has to be maintained, adopting a sound management system for ensuring sustainability of food security of people as well as the livelihood of 120,000 fishers in Sri Lanka.

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APPENDIX

Table 1: Coastal fish production 1957-2000.

Year	Total Catch (t)
1957	38,760
1961	68,500
1963	85,300
1964	89,800
1965	74,900
1968	108,500
1975	114,870
1978	136,900
1979	148,851
1980	165,270
1982	182,532
1983	184,050
1984	136,640
1986	144,266
1987	149,278
1988	155,099
1989	157,410
1992	163,170
1993	169,900
1994	174,500
1998	166,700
1999	171,950
2000	183,280

Table 2: Total Number of fishing Crafts and its composition in Coastal Fisheries in Sri Lanka.

Year	Total no. of boats	3.5 ton	FRP	OB	NM
1989	25,705	1,372	7,896	3,491	12,946
1990	26,683	1,372	9,758	973	14,580
1991	27,538	1,372	9,952	1,022	15,192
1992	24,474	1,372	8,709	1,012	13,381
1993	24,348	1,372	8,382	1,009	13,585
1994	24,593	1,272	8,843	1,016	13,462
1995	25,630	1,357	8,564	1,060	14,649
1996	25,800	1,543	8,334	1,350	14,573
1997	25,647	1,351	8,300	1,771	14,225
1998	25,108	1,494	7,910	1,045	14,659
1999	26,316	1,475	8,623	1,274	14,944
2000	26,674	1,470	8,690	1,405	15,109

Table 3: Human Power Limits (Bent 1978).

Activity	Duration	Power (watts)	Power (kcal/min)	Energy Used Power*Time (kcal)
Single vigorous jump or lift	< 1 sec	4500	64	1
Sprint	20 sec	2200	32	10
Mile run	5 min	1100	16	80
Marathon	2 hr	400	5	600
Manual labour	10 hr	150	2	1200
Rest	24 hr	75	1	1440

The maximum power the body can produce is seen in jumping or in rapidly lifting heavy weights. We can sustain this level of activity for a second or less (the harder one works the sooner one must stop). If we cut down the power output we can go for a longer period of time. Power output of the body is determined by the amounts of different energy stores and by the enzymes that release the energy. ATP and creating phosphate can be broken down very rapidly (high power), but the total amount is small. Burning of fats for energy is very slow (low power), but there are huge amounts.

N.B. According to above Human Power Limit table one horse power is equivalent to the output of between 5 and 7.5 people (where 1 HP = 1.341kW)

Table 4(a): Annual Average wholesale Prices of Colombo Fish Market 1995 to 2000 (Rs/Kg).

Species	1995	1996	1997	1998	1999	2000
Seer	118	137	133	201	183	269
Trevelly	107	189	126	129	126	140
Skipjack tuna	43	60	97	66	60	81
Yellow fin tuna	56	101	104	99	94	127
Other tuna varieties	54	57	96	83	83	139
shark/skate	45	56	82	82	81	100
Rock fish	72	74	83	85	84	95
Sardines/Trenched Sardines	36	53	53	56	46	46
Prawns*	113	163	129	165	155	205
Lobsters	150	150	150	150	150	150
Others varieties**	51	61	73	75	70	80

Sardines/	30.17	40.61	45.49	46.22	33.84	28.63
Tren:Sardines	40.94	64.97	61.39	65.86	58.17	63.81
	71.11	**105.58**	**106.88**	**112.08**	**92.44**	**92.01**
	35.56	52.79	53.44	56.04	46.01	46.22

Prawn price*						
Seer	118	137	133	201	183	269
Trevelly	107	189	126	129	126	140
	226	326	259	329	310	409
	113	163	129	165	155	205
Other variety price**						
shark/skate	45	56	82	82	81	100
Rock fish	72	74	83	85	84	95
Sardins/Trenched Sardins	36	53	53	56	46	46
	153	183	218	224	211	240
	51	61	73	75	70	80

Table 4(b): Marine Fish Production by Major Species 1995-2000 (t).

Species	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Seer	2,990	2,180	2,440	3,150	3,860	3,130
Trevelly	8,910	6,090	7,900	9,520	9,780	10,450
Skipjack tuna	33,500	35,630	37,590	36,200	38,370	49,110
Yellow fin tuna	26,050	22,740	24,570	27,900	28,320	29,320
Other tuna varieties	17,640	15,900	16,790	18,100	21,410	22,890
shark/skate	22,120	22,100	26,920	28,500	29,360	28,790
Rock fish	10,450	12,410	10,080	12,430	12,450	14,910
Sardines/Trenched Sardines	50,610	48,220	52,610	54,800	56,320	61,250
Prawns*	8,000	9,400	7,750	12,000	7,500	10,200
Lobsters	950	1,500	1,000	770	950	1,150
Others varieties**	36,230	30,130	27,100	36,580	40,130	36,480
	217,450	**206,300**	**214,750**	**239,950**	**248,450**	**267,680**

Table 4(c): Quantity percentage of each species to the total catch of 1995-2000.

Species	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Seer	1	1	1	1	2	1
Trevelly	4	3	4	4	4	4
Skipjack tuna	15	17	18	15	15	18
Yellow fin tuna	12	11	11	12	11	11
Other tuna varieties	8	8	8	8	9	9
shark/skate	10	11	13	12	12	11
Rock fish	5	6	5	5	5	6
Sardines/Trenched Sardines	23	23	24	23	23	23
Prawns*	4	5	4	5	3	4
Lobsters	0	1	0	0	0	0
Others varieties**	17	15	13	15	16	14

Table 4(d): Weighted price of each species of 1995-2000 (Rs.).

Species	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Seer	118	137	133	201	367	269
Trevelly	429	568	502	515	505	559
Skipjack tuna	640	1,027	1,743	987	903	1,454
Yellow fin tuna	676	1,114	1,879	1,188	1,030	1,397
Other tuna varieties	431	456	765	666	749	1,247
shark/skate	450	621	1,070	985	971	1,095
Rock fish	362	444	413	427	419	567
Sardines/Trenched Sardines	818	1,214	1,283	1,289	1,058	1,063
Prawns*	452	815	516	825	465	820
Lobsters	0	150	0	0	0	0
Others varieties**	867	305	949	1,125	1,120	1,120
	5,242	6,851	9,252	8,207	7,586	9,592
	52	**69**	**93**	**82**	**76**	**96**