SPECIES IDENTIFICATION OF THE SHARK CATCHES LANDED IN THE WEST COAST OF SRI LANKA WITH SPECIAL REFERENCES TO THE SILKY SHARK *Carcharhinus falciformis* (Bibron, 1839)

by

P. D. KAMAL DEWAPRIYA AMARASOORIYA

1999
DECLARATION

"The work described in this thesis was carried out by me under the supervision of Professor J. Jinadasa and Dr. Mrs. C. Amarasiri and a report on this has not been submitted to any University for another degree."

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DECLARATION OF THE SUPERVISORS

“We certify that the above statement made by the candidate is true and that this thesis is suitable for submission to the University for the purpose of evaluation.”

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Thesis submitted to the University of Sri Jayewardenepura for the award of the degree of Master of Philosophy in Zoology on 30 June 1999.
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ABSTRACT

This study was based on the catch sampling of gill net and long line fisheries carried out at Negombo – Pitipana fish landing centre. Additional observations were also made at the Beruwala fish landing center regarding species identification. This study revealed the occurrence of 48 species of pelagic and demersal sharks belonging to 5 orders, 15 families and 26 genera in the catches landed in the west coast of Sri Lanka.

The orders identified were Hexanchiformes, Squaliformes, Orectolobiformes, Lamniformes and Carcharhiniformes.

The most diverse order among them was Carcharhiniformes. It comprised 4 families, 13 genera and 29 species. The identified families of this order were Triakidae, Hemigaleidae, Carcharhinidae and Sphyrnidae.
Among the identified species belonging to this order, there were two *Mustelus* species *M. manazo*, and *M. mosis*, 14 *Carcharhinus* species *C. albimarginatus*, *C. altimus*, *C. amblyrhynchos*, *C. amboinensis*, *C. brevipinna*, *C. falciformis*, *C. hemiodon*, *C. limbatis*, *C. longimanus*, *C. macloti*, *C. melanopterus*, *C. plumbius*, *C. sorrah*, *C. wheeler*, and 3 *Sphyrna* species *S. lewini*, *S. mokarran* and *S. zygaena*. The other genus comprised one species per each, *Hemipristis elongatus*, *Galeocerdo cuvier*, *Lamiopsis temminki*, *Loxodon macrorhinus*, *Negaprion acutidens*, *Prionace glauca*, *Rhizoprionodon acutus*, *Scoliodon laticudus*, *Trionodon obesus*, and *Eusphyra blochii*.

The second most diverse order in the catches was Lamniformes and it comprised 4 families, 4 genus and 8 species. The families were Odontaspididae, Pseudocarchariidae, Alopiidae and Lamnidae.

There were two *Odontaspis* species, *O. noronhai* and *O. ferox*, three *Alopias* species, *A. pelagicus*, *A. superciliosus* and *A. vulpinus* and two *Isurus* species *I. oxyrinchos* and *I. paucus*. There was one species belonging to the genus *Pseudocarcharias* and that was *P. kamoharai*.

The number of families and genera present in the order Orectolobiformes were same as in the order Lamniformes (4 and 4), but the number of species identified were 5. The families of this order were Hemiscylliidae, Ginglymostomatidae, Stegostomatidae and Rhiniodontidae.

Two of the identified species in this order belonged to the genus *Chiloscyllium*. They were *C. griseum* and *C. indicum*. The other three genus comprised one species each namely, *Nebrius ferrugineus*, *Stegostoma fasciatum* and *Rhiniodo typos*.
The order Squalidae comprised 2 families, 4 genera and 5 species. The identified families of this order were Echinorhinidae and Squalidae. The former family comprised one species *Echinorhinus brucus* and the latter comprised 4 species of 2 genera namely, *Centrophorus moluccensis*, *C. uyato*, *Centroschyllium ornatum* and *Dalatias licha*.

The least diverse order in the catches observed was Hexanchiformes. It comprised only one family (Hexanchidae), one genus and one species *Hexanchus griseus*.

Out of the above 2 families, *Psedocarchariidae* and *Squalidae* and ten species *Centrophorus moluccensis*, *C. uyato*, *Centroschyllium ornatum*, *Hexanchus griseus*, *Odontaspis noronhai*, *O. ferox*, *Psedocarcharis kamoharai*, *Isurus paucus*, *Carcharhinus albimarginatus* and *C. plumbeus* were found to be hitherto unrecorded taxa from Sri Lanka.

Over 90% of the sharks landed were belonged to the order Carcharhinidae with *Carcharhinus falciformis* (75%) being the most dominant species and it has dominated the catch almost throughout the year. The thresher sharks (family Alopiidae) and the hammerhead sharks (family Sphyrnidae) were caught in large numbers during the south-west monsoon periods.

The combination of drift gillnet and longline was the main gear used in the shark fishery and the longline operations declined markedly during the monsoon period. The fishing operations were entirely carried out by the multiday fishing vessels which were over 10m in length. The average fishing days per trip was 5 and no. of operations per day was 01 for these vessels.
Skipjack tuna (*Katsuwonus pelamis*), Silky shark (*C. falciformis*) and Yellowfin tuna (*Thunnus albacares*) were the major species of the large pelagic catches landed. The average CPUE for all the large pelagic species was 266kg per operation and that for the above three species were 71, 67 and 60 kg per operation respectively.

The contribution of the major species of the large pelagics, Skipjack tuna, Silky shark and Yellowfin tuna *Thunnus albacares* to the estimated annual total production was 29%, 25% and 22% respectively. However over 33% of the total catch was made up of the sharks.

Forty three percent of the total number of Silky sharks were caught in gillnets and 57% were caught in long lines. Size of the fish caught by gill nets ranged from 65cm to 255cm and that of the long line from 75cm to 285cm. The mean length and standard deviation for the gill net catch were 125.15cm and 33.8 while those for the long line catch were 160cm and 97.6.

During the south-west monsoon months, most of the fishing operations were carried out relatively closer to the island, while during the other months, there was a tendency to extend the fishing operations more towards the north-western direction, even beyond the Laccadive islands.

The values for asymptotic length (*L*ₐ) and growth coefficient (*K*) estimated for the stock of silky shark were 325cm and 0.3 year⁻¹ respectively. The instantaneous total mortality coefficient (*Z*) was 1.68, the natural mortality coefficient (*M*) was 0.42, and the fishing mortality coefficient (*F*) 1.26. The catchability coefficient for the gill net and longline combination gear was $5.6 \times 10^{-5}$.
The recruitment pattern of *C. falciformis* during the study period shows one peak around late July early August. The estimated exploitation rate (E) was 0.75 for the existing silky shark fishery. As the present level of exploitation seems to be high, it is suggested that management measures are needed to sustain the stock.
Introduction

Sharks first appeared on earth 400 million years ago, and today after about 200 million years of evolutionary trial and error, more than 350 species of sharks are living in the world ranging in size from the less than 30cm long dwarf shark and pygmy ribbontail catfish shark to the 15m long whale shark (Lemonick, 1997).

Shark teeth and fin spines are found in all rocks from upper Silurian deposits to the present time, and while the majority of the genera are now extinct, the class has had a vigorous representation in all the seas, from later Palaeozoic, Mesozoic and Cenozoic, as well as in recent times (Jordan, 1925).

The class of cartilaginous fishes - Chondrichthyes- consist of sharks, rays, chimaeras and ratfishes. Shark and rays have a unique kind of blood, and have upper jaws slung from their skulls, not fixed as with chimaeras and rat fishes, so they are placed in a sub-class, Plagiostomi or Elasmobranchii. Sharks differ from rays because their pectoral fins are separate from the side of their heads. They have free upper eye lids and gill openings on their heads, so sharks are put in the super order Selachimorpha or Selachii (Ellis, 1976, Young, 1981). According to Compagno, 1984, Ellis, 1976, and Smith, 1986 the Selachimorpha comprises eight orders of sharks.

Taxonomically all the living sharks are divided into two broad groups such as sharks without anal fin and sharks with anal fin. There are three orders in the first category, namely Squatiniformes (body flattened, ray like, mouth at front), Pristiophoriformes (snout elongated and sawlike) and Squaliformes (snout not sawlike). The latter two
groups possess ventrally placed mouths and their shape of the body is not ray like (Compagno, 1984).

The sharks of the second category (sharks with anal fin) is divided into two broad groups, such as sharks with 6 or 7 gill slits and one dorsal fin and sharks with 5 gill slits and two dorsal fins. All the sharks in the first group are categorized under order **Heanchiformes**. The sharks in the second group are classified into 4 orders, namely **Heterodontiformes** (sharks with dorsal fin spines), **Orectolobiformes** (sharks with mouth well in front of eyes), **Lamniformes** (shark without nictitating eye lid) and **Carcharhiniformes** (sharks with nictitating eye lid) (Compagno, 1984).

Order **Hexanchiformes** comprises 2 families, 4 genera and 5 species, order **Squaliformes** comprises 3 families, 19 genera and 73 species, order **Pristiophoriformes** comprises one family, two genera and 5 species. The number of families, genera and species for the orders **Squatiniformes**, **Heterodontiformes**, **Orectolobiformes**, **Lamniformes** and **Carcharhiniformes** are 01, 01 and 13; 01, 01 and 08; 07, 13 and 31; 07, 10 and 16; and 08, 48 and 193 respectively. Therefore, the total number of identified species of sharks at that time were 344 (Compagno, 1984), but within the last one and half decades at least 6 new species have been identified (Lemonick, 1997).

In Sri Lanka sharks are becoming increasingly important as a source of fish protein. Their annual production has been estimated at 10,000 to 11,000 tons (Sivasubramaniam, 1991) and it makes around 6% of the total marine fish production (Anon, 1992.a). With the widespread introduction of synthetic gillnets in the early Sixties, fishery expanded well beyond the continental shelf into the oceanic range, and catches of oceanic pelagic shark increased significantly (P.Dayaratne & R.Maldeniya, 1988 and Sivasubramaniam, 1992).
This production now mainly comes from the developing oceanic fisheries as well as from the coastal fisheries carried out by the multiday fishing boats.

In late sixties sharks were considered as predators of the hooked tuna fish in tuna longlines and as an agent which can reduce the income of fishermen. Therefore, the fisheries scientists suggested that, there is an urgent need for innovation of the existing longline gear in-order to increase the fishing efficiency for hooking the tuna species, with a corresponding reduction in its efficiency for hooking sharks (Sivasubramaniam, 1969).

At the beginning of the longline fishery, hooked sharks were discarded at sea. Later the liver and fins were taken and the carcasses were discarded. Presently the sharks are also brought along with the tuna catch. Though the shark meat has a very low market value it is brought to shore in order to compensate for the declining tuna catches. Thus it has become very necessary to increase the demand for shark meat by developing products or by-products utilizing shark meat and ensuring the successful continuity of the tuna longline fishery (Sivasubramaniam, 1969)

According to the sampling programme conducted by National Aquatic Resources research and Development Agency (NARA), the situation has been changed in contrary way during the last two decades. Sharks became a target group in drift gillnet cum longline fishery (Dayaratne and Maldeniya, 1995).

In other countries in the Bay of Bengal region pelagic shark catches are generally incidental to, or a by-catch of, fisheries mainly targeting tuna and seer. In Sri Lanka, the driftnet cum longline combination fishery target both tuna and pelagic sharks because of the equal value
and demand for both. The present level of production of pelagic shark in the Bay of Bengal region is estimated at 11-13000 mt/year of which more than half is taken by Sri Lanka. However, there is a shift to shark longlining prompted by the difficulties of obtaining cheap and good quality whole bait fish for tuna longlining, which has been initially attempted (Sivasubramaniam, 1992).

Flying fish was found to be as good as imported bait for tuna but no actions was taken to utilize this resource for tuna longline fishery (Jinadasa, 1990).

The offshore fisheries has developed rapidly during the last decade and over 1700 small boats of 10.5 - 20m range are currently engaged in the fishery. Over the years, the operational area has extended more and more beyond the Exclusive Economic Zone (EEZ) (Dayaratne and Maldeniya, 1995).

For instance, it was stated in the “SHARK NEWS” the newsletter of the shark specialist group of International Union for Conservation of Nature (IUCN), that “Sri Lankan fishermen visit the Chagos illegally.

Two Sri Lankan fishing boats from Negombo were arrested by the British Indian Ocean Territory (BIOT) fisheries patrol vessel at the end of January 1996. Both had large catches of sharks on board” (Anderson et.al, 1998).

Fish production from offshore has increased from 11,600 mt in 1990 to 57,000 mt in 1996 and now contribute about 28% to the total fish production. Out of this amount 35% was contributed by shark catches (Maldeniya, 1997).
Processed shark fins are used in Asia for shark-fin soup, a delicacy that fetches up to $150 a bowl. The market for shark-fins is incredibly profitable. The trade has grown dramatically since commerce with China began expanding in the 1980s: some 12 nations are now involved (Lemonick, 1997).

Fins are the first items to be removed from the shark carcass. Four fins are normally taken: first dorsal, both pectorals and the lower caudal lobe. The second dorsal, pelvics and anal may be taken from large sharks, or from those species with particular large fin sets.

The dried shark fin is one of the most highly valued marine products from the Bay of Bengal countries. Sri Lanka plays a major role in the field of dried shark fin production in the region. The main market is in the main consumer countries such as Thailand, Malaysia and Singapore.

The main consumer countries also re-export unprocessed and processed fins in various forms to Western markets as well as trade extensively with Hong Kong further to the east. The price per one kilo was 110 $ in 1992 (Anon, 1992.b).

A well stable international market for the dried shark fin product still exists and in 1995, 126.9 t of shark fins have been exported by Sri Lanka, valued at Rs. 162.8 million (Maldeniya, 1997).

The only shark based export product other than the dried fins is liver oil which is extracted from deep water Gulper sharks. This oil contain high amount of squalene and has high demand and high value in international market. However, this fishery is limited to the
intermonsoonal climate and restricted to Beruwala and Thalawila areas. Unfortunately
statistics relevant to this industry are not available.

Although the shark fishery in Sri Lanka is improving rapidly, sharks are among the least
known component of the Sri Lankan large pelagic catches. Taxonomy of sharks too,
remains a much neglected subject in Sri Lanka. The only notable contribution in the past
being limited to those of Munroe(1955), Gunawardena(1971), Amarasekara and Joseph

Information regarding the shark fishery in Sri Lanka is not well documented. Statistics
relevant to the shark fishery have not been recorded by species. The available information
is grouped under a broad category “shark” in all the fisheries statistics publications.
The Silky Shark *Carcharhinus falciformis*, much of it immature, contributes to more than
half the Sri Lanka shark catch (Sivasubramanium, 1991). It was mentioned that the
contribution of Silky shark to the total shark catch was 73% and it being the most dominant
species (Amarasekara & Joseph, 1987). But in Sri Lanka, no studies have been carried out
on this important species.

Each year between 30 million and 100 million sharks are caught in the world for their meat,
fins, hides, jaws and their internal body parts. Largely as a result of this relentless fishing,
the populations of some shark species have plummeted an estimate 80% over the past
decade and some species will reach ecological extinction within 10 years (Lemonick,
1997).
Compared to the hundreds or thousands of eggs per spawn produced by small and large bony fish, the number of young produced in each litter by pelagic shark are very, very small. This is critical from the viewpoint of exploiting shark.

The low shark birth rate and the fact that long-living shark reproduce after several years make them more vulnerable to overfishing than other fish, for this leads to insufficient numbers to produce enough young ones to maintain the population size for a sustained fishery (Sivasubramanium, 1992).

Therefore, killing a relatively small number of females can dramatically limit the reproductive potential of an entire species.

Large scale shark fisheries have never been known to be successfully sustainable. In part, this is because of the sharks’ general life history. It has been estimated that some shark species may only have a capacity to increase their population by 2% annually; at least for those species that have been mathematically modelled to determine such values, the maximum ability to increase may be only 10%-15% annually. Thus, given the biological constraints of the resource to rapidly replenish itself because of low fecundity, slow growth, and late maturation, populations have little flexibility to withstand excessive fishing mortality (Branstetter, 1997).

Sharks have been the focus of much attention within CITES (the Convention on International Trade in Endangered Species) at the 9th CITES meeting in 1994. Sharks were again on the agenda at the 10th CITES meeting which took place in Zimbabwe in June 1997. The shark resolution passed at the 9th CITES meeting (1994) mandated the CITES
Animal Committee to undertake a study of the biological and trade status of sharks (Camhi, 1997).

In 1994, the Ninth Conference of CITES adopted a Resolution on the Biological and Trade status of Sharks, requesting *inter alia* that

1. FAO and other international fisheries management organisations establish programmes to collect and assemble the necessary biological and trade data on shark species; and

2. All nations utilising and trading specimens of shark species to cooperate with FAO and other international fisheries management organisations.

In the last CITES meeting in Zimbabwe in June 1997, sharks have been the focus of much attention. The main concern was the need for improved species specific fishery, trade, and biological data by all parties and UN FAO, and an increase in research and management efforts for Elasmobranchs (Fowler & Musick, 1998).

At its session in 1997, the FAO Committee on Fisheries (COFI) suggested that FAO organise a consultation of experts to develop and propose guidelines leading to a Plan of Action for shark conservation and management.

The ultimate aims of this endeavour are:

(1) to determine the specific requirements for sustainable global and regional management of shark species; (2) to develop guidelines for such management; and, (3) to develop a plan of action aimed at promoting the widespread use of these guidelines by appropriate management bodies and arrangements (Fowler & Musick, 1998).
Although the need for studies on sharks is great the knowledge on sharks landed in Sri Lanka is still meagre. Therefore, the principal objective of the present study was to identify the taxonomic status of the landed sharks up-to their species level, to get a better understanding about the species composition of the shark catches, relative abundance and seasonal variations of the species in the large pelagic fishery in Sri Lanka. The second objective of the study is to estimate population parameters of *C. falciformis* such as asymptotic length (*L*∞), curvature parameter (*K*), natural mortality (*M*), fishing mortality (*F*), total mortality (*Z*), exploiting rate (*E*), relative yield per recruit, probability of capture and recruitment pattern.
Materials and Methods

Collection and analysis of data

I. Species identification

a. Collection of morphometric data and morphological information

The dichotomous key (Fig. 01) proposed by Compagno (1984) for the identification of the different Orders of the living sharks was used to identify the Orders of the sharks present in the catches. Therefore to identify them up to order level the following observations were made and morphometric measurement were taken accordingly.

1. Presence of the anal fin.
2. Shape of the body (to check whether it is ray like or not).
3. Shape of the snout (to check whether it is sawlike or not).
4. Number of gill slits present.
5. Number of dorsal fins present.
6. Presence of dorsal fin spines.
7. The ratio of preorbital length/ preoral length, POB/POR (Fig. 01).
Fig. 1. Classification of Sharks up to Order Level (after Compagno, 1984)
All species were identified using the identification keys formulated by Compagno (1984).

The jaws and teeth of some specimens which were needed for further investigation in to their taxonomy were collected and brought to the laboratory for further studies. Photographs of some sharks were also taken and necessary drawings of important taxonomic features such as the characters of teeth, relative placements of fins, shape of fins, colour markings, shape of the labial furrows and nasal flaps, and the lateral and ventral views of heads were made at the landing sites.

Numbers of individuals landed were counted and recorded by species and by sex with special attention to the gear in which they were caught, to estimate the relative abundance, sex ratios and to define the gear vulnerability for each species.

After identification of a specimen up-to a species level, new characters were also investigated to upgrade the above keys.

Measurements were taken according to Fig. 02.
TOT = TOTAL LENGTH
PD1 = PRE-FIRST DORSAL LENGTH
PD2 = PRE-SECOND DORSAL LENGTH
FS1 = 1ST DORSAL FIN SPINE HEIGHT
FS2 = 2ND DORSAL FIN SPINE HEIGHT
D1H = 1ST DORSAL HEIGHT
D2H = 2ND DORSAL HEIGHT
CDM = DORSAL CAUDAL MARGIN
HDL = HEAD LENGTH
POB = PRE-ORBITAL LENGTH
EYH = EYE HEIGHT
POR = PRE-ORAL LENGTH
PPI = PRE-PECTORAL LENGTH
PP1 = PRE-PECTORAL LENGTH
PP2 = PRE-PECTORAL LENGTH
DPI = PELVIC INSERTION-FIRST DORSAL MID POINT
DPO = FIRST DORSAL MIDPOINT-PELVIC ORIGIN
PP2 = PRE-PELVIC LENGTH
PAL = PRE-ANAL LENGTH
HDL = HEAD LENGTH
POB = PRE-ORBITAL LENGTH
EYH = EYE HEIGHT
POR = PRE-ORAL LENGTH
PIH = PECTORAL HEIGHT
MOW = MOUTH WIDTH

GS3 = HEIGHT OF THE 3RD GILL SLIT

Fig. 2. Measurements taken for the study and appropriate abbreviations used
II. Shark fishery

a. Collection of catch and effort statistics:

The shark catches together with the other large pelagics in the commercial fisheries were monitored fortnightly at Negombo - Pitipana fish landing centre, from February 1993 to March 1995. Each visit was confined to two successive days and the collection of data and other relevant information were carried out usually from 4.00am to 7.30am.

On each sampling day more than 35% of the landed fishing vessels of all categories were sampled randomly. Information such as, the number of boats landed, weight of the catch in each sampled boat, duration of trips, number of fishing days, average speed of boat, directions sailed, number of hours sailed in each direction, specifications of gears used and the species composition were recorded separately.
Analysis of catch and effort data

i. Catch per unit effort (CPUE) and total production of the fishery

Fishing effort is estimated as the total number of fishing operations conducted during a month, using the formula.

\[ E = V_{av} \times D_{av} \times F_{av} \]

Where,

- \( E \) = Total monthly effort,
- \( V_{av} \) = Average number of vessels operated during the month,
- \( D_{av} \) = Average number of fishing days / vessel / Trip
- \( F_{av} \) = Average number of fishing operations per fishing day

CPUE is calculated as the mean monthly catch per operation, using the formula

\[ CPUE = \frac{P_{1} + P_{13} + P_{3} + \ldots \ldots \ldots P_{n}}{N} \]

- \( P \) = catch per operation of a sampled vessel (as weight in kg)
- \( N \) = total number of boats sampled

The monthly total production was calculated using the following formula.

Estimated total Production = CPUE \times E
ii. Estimation of the catchability coefficient

The catchability coefficients for the gears used in the shark fishery were estimated using the formula, \( F = q*f \), proposed by Sparre and Venema (19914).

\( F = \) fishing mortality, \( q = \) catchability coefficient, \( f = \) fishing effort (annual)

III. Species abundance

The species composition of the catches were analyzed for each month separately to study the variation patterns and the relative abundance of the species. For the identification of tuna and bill fish species the species catalogues prepared by Food and Agriculture Organization (FAO) were used (Collette & Nauen, 1983; Nakamura, 1985).

IV. Defining of fishing areas

Using the information collected (directions sailed, time sailed in each direction and speed of craft) from fishermen in each sampling day, the positions they fished were defined and those were marked in a map for every sampled boat. Eight maps were prepared for the entire period of study and each map indicated the data collected in three successive months (Fig. 3).

V. Population parameters of *Carcharhinus falciformis* and status of the fishery

a. Collection of length frequencies data

According to the previous studies *Carcharhinus falciformis* has been identified as the dominant species of the shark catches (Sivasubramaniam, 1992 and Amarasekara and Joseph, 1987). Therefore, some population parameters of this species were studied in detail.
Total length (from the apex of the snout to the tip of the upper lobe of the caudal fin, Fig. 2) of over 40% of the total number of individuals of Silky shark, caught by long-lining and gillnetting were separately obtained by random sampling, on each sampling day. The measurements of total lengths were taken at to the nearest 0.1cm using measuring tape and grouped into 10cm length classes for the analysis of the population parameters.

b. Analysis of data

The monthly length frequency distribution data of *C. falciformis* were analysed using the complete ELEFAN computer programme (Gayanilo et al. 1988) which was incorporated into “FAO-ICLARM Stock Assessment Tools” (FiSAT) computer programme (Gayanilo et al. 1994) to estimate the parameters of Von Bertalanffy growth equation. The fitting of the best growth curve was based on the same programme which allows the line to pass through the maximum number of peaks of the length frequency distribution. With the aid of the best growth curve the growth constant (K) and the asymptotic length (L∞) were estimated.

The instantaneous total mortality coefficient (Z), natural mortality coefficient (M), fishing mortality coefficient (F) and the exploitation rate (E) were estimated using the length converted catch curve method which has been incorporated into the FiSAT computer programme.

Exploitation rate was calculated as the ratio between fishing mortality coefficient and total mortality coefficient (Gulland 1975). The recruitment pattern was also derived using the combined data for the two year period. The probabilities of capture of *C. falciformis* were estimated according to the length converted catch curve.
RESULTS

1. Identification of the taxa present in the shark catches

A. Identification of the Orders

A total of 21483 of sharks landed from both, drift gill net cum longline combination and deep long line fisheries (which is the gear used in deep water gulper shark fishery, the length of branch lines extend over 150m in depth while that of the ordinary longline varied from 8 to 50m) were observed and five different orders of shark were identified. The main characters used for this identification are listed with the number of individuals observed in each order (Table 1).

Out of 21483 shark specimens landed 350 individuals did not possess anal fins. Sharks with this character were identified as the members of the Order Squaliformes (Table 1). These fishes were observed only at the Beruwala fish landing centre.

All the other individuals (21133) possessed the anal fins just behind their cloacal openings. One individual observed in this group possessed one dorsal fin (all the other sharks possessed two dorsal fins), It was the only specimen observed with six gill openings, and was identified as a species belonging to the Order Hexanchiformes (Table 1). It was reported only at Pitipana fish landing centre.

It was observed that the relative placement of the mouth was well in front of eyes in 34 individuals (POB/ POR >2), while in the others (21098) mouths were placed behind the eyes (POB/ POR <2). This group of shark was identified as the Order Orectolobiformes. This group was reported from both Pitipana and Beruwala fish landing centres.
Within the 21098 sharks (sharks with preorbital length(POB)/preoral length (POR )<2) 1434 did not possess the nictitating eye lids. This group of sharks was identified as the Order Lamniformes and was reported from both Pitipana and Beruwala fish landing centres.

The rest (19664) of the observed individuals were with the nictitating eye lids and this is the main character of the Order Carcharhiniformes (Table. I & II). This group was reported from both Pitipana and Beruwala fish landing centres.

The mean values of POB/POR obtained by this study for the orders Squaliformes, Hexanchiformes, Orectolobiformes, Lamniformes and Carcharhiniformes were 0.60, 0.7, 2.20, 0.85 and 0.97 respectively (Table. II).
Table I. The characters used for the identification of the orders of sharks

<table>
<thead>
<tr>
<th>Order</th>
<th>Common name</th>
<th>Characters used for the identification</th>
<th>No.of individuals observed</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squaliformes</td>
<td>Dogfish sharks</td>
<td>No anal fin</td>
<td>350</td>
<td>1.630</td>
</tr>
<tr>
<td>Hexanchiformes</td>
<td>Frilled &amp; Cow sharks</td>
<td>Six gill slits present</td>
<td>01</td>
<td>0.004</td>
</tr>
<tr>
<td>Orectolobiformes</td>
<td>Carpet sharks</td>
<td>POB/POR &gt; 2</td>
<td>32</td>
<td>0.150</td>
</tr>
<tr>
<td>Lamniformes</td>
<td>Mackeral sharks</td>
<td>no nictitating eye lid</td>
<td>1434</td>
<td>6.674</td>
</tr>
<tr>
<td>Carcharhiniformes</td>
<td>Ground sharks</td>
<td>Nictitating eye lid present</td>
<td>19666</td>
<td>91.542</td>
</tr>
</tbody>
</table>

POB = Pre-orbital length, POR = Pre-oral length
Table II. The means and the range of POB/POR of sharks in the Orders

<table>
<thead>
<tr>
<th>Order</th>
<th>Mean and the range of POB/POR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squatiniformes</td>
<td>0.60 (0.53-0.62)</td>
</tr>
<tr>
<td>Hexanchiformes</td>
<td>0.7 (only one specimen)</td>
</tr>
<tr>
<td>Orectolobiformes</td>
<td>2.20 (2.12-2.27)</td>
</tr>
<tr>
<td>Lamniformes</td>
<td>0.85 (0.66-1.25)</td>
</tr>
<tr>
<td>Carcharhiniformes</td>
<td>0.97 (0.60-1.60)</td>
</tr>
</tbody>
</table>
B. Identification of families, genera and the species of the orders

Identification of the Families of the Order Squaliformes

Among 350 individuals of the Squaliformes sharks, two distinct families were identified. These families were Squalidae and Echinorhinidae and the identification was mainly depended on the ratio of pre-first dorsal length to pre-pelvic length (PDI/PP2), the relative placement of the first dorsal fin and pelvic fin.

The mean value of PDI/PP2 for the family Squalidae was 0.6 (first dorsal fin originating in front of pelvic fin origin) while that for the family Echinorhinidae was 1.07 (first dorsal fin originating behind the pelvic fin origin) (Table. III and IV).

Presence of fin spines on the 1\textsuperscript{st} and 2\textsuperscript{nd} dorsal fins was observed in the family squalidae and they were absent in the family echinorhinidae.

The family Squalidae is hither to unrecorded from Sri Lanka.

Identification of the genera and species of the Family Squalidae

Among 347 specimens of this family, three genera, Centroschyllium, Dalatias and Centrophorus and four species, Cetroschyllium ornatum, Dalatias licha, Centrophorus moluccensis and C. uyato, were identified.

The members of the Genus Centroschyllium. is characterised by three cusped teeth in both jaws while the members of others possess mono cusped teeth (Table. iii).
The ratio of the length of first dorsal fin spine to the second dorsal fin spine was equal to one in the two specimens of this genus (DF1/DF2 = 1), and they were identified as a single species *Centroschyllium ornatum*.

The *Genus Dalatias* is characterised by strongly serrated lower teeth and well pointed mono cusped upper teeth (Table. III). Lower lobe of the caudal fin of these sharks were inconspicuous.

The only species of this genus in the world is *D. licha*.

The rest of the Squalidae sharks observed, possessed broad, blade like upper teeth without cusplets and acutely pointed pectoral fins (Table. III). These are the characters of the *Genus Centrophorus*.

The species *C. uyato* is characterised by concave rear margin of the pectoral fin while that of *C. moluccensis* is straight and the tip was elongated to form a lobe (Table. III).

Therefore, based on the nature of the rear margin and the rear tip of the pectoral fin, species of the genus *Centrophorus* could be identified.

The genera *Centrophorus* and *Centroschyllium* and species *Centrophorus moluccensis*, *C. uyato* and *Centroschyllium ornatum* are new records from Sri Lanka.
Identification of the genera and species of the Family Echinorhinidae

The three specimens of Echinorhinidae sharks were identified as *Echinorhinchus brucus* and it be brought to the Genus *Echinorhinchus*.

The Genus *Echinorhinchus* is characterised by presence of thornlike denticles on the body surface and on fins (Table. III).

Those dermal denticles were fused in to plates with multiple cusps in *E. brucus* and this is the main character of the Species.

It shows that out of the five identified species belonging to the order Squiliformes, four were vulnerable to deep long lines.
<table>
<thead>
<tr>
<th>Species identified</th>
<th>Mean and range of PD1/PP2</th>
<th>Shape of the first teeth, left halves/upper &amp; lower jaws</th>
<th>Shape of the caudal fin</th>
<th>Shape of the pectoral fin</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Centrophorus moluccensis</em></td>
<td>0.52 (0.50 - 0.53)</td>
<td><img src="image1.png" alt="Diagram" /></td>
<td><img src="image2.png" alt="Diagram" /></td>
<td><img src="image3.png" alt="Diagram" /></td>
</tr>
<tr>
<td><em>C. uyato</em></td>
<td>0.55 (0.51 - 0.54)</td>
<td><img src="image4.png" alt="Diagram" /></td>
<td><img src="image5.png" alt="Diagram" /></td>
<td><img src="image6.png" alt="Diagram" /></td>
</tr>
<tr>
<td><em>Centroschyllium ornatum</em></td>
<td>0.68 (0.67 - 0.69)</td>
<td><img src="image7.png" alt="Diagram" /></td>
<td><img src="image8.png" alt="Diagram" /></td>
<td><img src="image9.png" alt="Diagram" /></td>
</tr>
<tr>
<td><em>Dalatias licha</em></td>
<td>0.61 (0.61 - 0.61)</td>
<td><img src="image10.png" alt="Diagram" /></td>
<td><img src="image11.png" alt="Diagram" /></td>
<td><img src="image12.png" alt="Diagram" /></td>
</tr>
<tr>
<td><em>Echinorhinnus brucus</em></td>
<td>1.07 (1.04 - 1.08)</td>
<td><img src="image13.png" alt="Diagram" /></td>
<td><img src="image14.png" alt="Diagram" /></td>
<td><img src="image15.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>

PD1/PP2 = pre dorsal length / pre pelvic length

Star marks indicate the most prominent characters used for the identification of the respective species;
Table IV. Identified species of the order Squaliformes (Dog fish sharks), their names, gear vulnerability, sex ratios, maximum length and number observed.

<table>
<thead>
<tr>
<th>No</th>
<th>Order</th>
<th>Family</th>
<th>Zoological name</th>
<th>English name</th>
<th>Local names</th>
<th>M/Fm</th>
<th>Max. L</th>
<th>Gear used</th>
<th>No. observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Squaliformes</td>
<td>Squalidae</td>
<td><em>Centrophorus moluccensis</em></td>
<td>Smallfin gulpershark</td>
<td>Katu mora</td>
<td>1:1</td>
<td>82cm</td>
<td>DSLL</td>
<td>328</td>
</tr>
<tr>
<td>02</td>
<td>- DO -</td>
<td>- DO -</td>
<td><em>C. uyato</em> (rafinesque, 1810)</td>
<td>Little gulper shark</td>
<td>Katu mora</td>
<td>1:2</td>
<td>70cm</td>
<td>DSLL</td>
<td>15</td>
</tr>
<tr>
<td>03</td>
<td>- DO -</td>
<td>- DO -</td>
<td><em>Centroscyllium ornatum</em> (Alcock, 1889)</td>
<td>Ornate dogfish</td>
<td>-</td>
<td>1:0</td>
<td>25cm</td>
<td>DSLL</td>
<td>2</td>
</tr>
<tr>
<td>04</td>
<td>- DO -</td>
<td>- DO -</td>
<td><em>Dalatis licha</em> (Bonnaterre, 1788)</td>
<td>Kitefin shark</td>
<td>-</td>
<td>0:1</td>
<td>95cm</td>
<td>DSLL</td>
<td>2</td>
</tr>
<tr>
<td>05</td>
<td>- DO -</td>
<td>Echinorhinidae</td>
<td><em>Echinorhinus brucus</em> (Bonnaterre, 1788)</td>
<td>Bramble shark</td>
<td>Erabadu mora, Annasi mora</td>
<td>2:1</td>
<td>154cm</td>
<td>LL</td>
<td>3</td>
</tr>
</tbody>
</table>

M/Fm = No. of male / No. of female
DSLL = Deep sea long line, LL = Long line
Identification of the Families, Genera and Species of the Order

Hexanchiformes

Only one specimen of Hexanchiformes shark was observed (Table.V). It possessed comb like teeth on lower jaw, and long cusped teeth on upper jaw (Fig. 3). These are the main characters of the Family Hexanchidae. The presence of 6 pairs of gill slits was observed in this shark and it is the main character of the Genus Hexanchus. This shark possessed 6 rows of comb like teeth on lower jaw and therefore, it was identified as the Species Hexanchus griseus (Fig. 3).

This is the first record of this species from Sri Lanka.
Fig. 3. The features used for the identification of Hexanchiformes shark
a. Arrangement of the teeth of left semi maxilla
b. Arrangement of the teeth of left semi mandible
Table. V. Identified species of the order Hexanchiformes, their names, gear vulnerability, sexratio, maximum length and number of specimens observed.

<table>
<thead>
<tr>
<th>No</th>
<th>Order</th>
<th>Family</th>
<th>Zoological name</th>
<th>English name</th>
<th>Local names</th>
<th>M/Fm</th>
<th>Max.L</th>
<th>Gear used</th>
<th>No. observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>06</td>
<td>Hexanchiformes</td>
<td>Hexanchidae</td>
<td><em>Hexanchus griseus</em></td>
<td>Cow shark, bluntnose six gill s, bulldog s, mud s.</td>
<td>no</td>
<td>1:0</td>
<td>400cm</td>
<td>LL</td>
<td>1</td>
</tr>
</tbody>
</table>

LL = Long line
Identification of the Families of the Order Orectolobiformes

Among the Orectolobiformes sharks [32 specimens] four distinct families, Rhiniodontidae, Stegostomatidae, Hemiscyllidae and Ginglymostomatidae were identified (Table. vi).

The features used for this identification are mentioned follow.

The family Rhiniodontidae is characterised by well demarcated ventral lobe of caudal fin and six prominent ridges on dorsal side of the body with lower most one expanding into a prominent keel on each side of the caudal peduncle (Table. vi).

In the other specimens of this order the ventral lobe of the caudal fin was inconspicuous and the dorsal ridges were absent.

Some specimens has the caudal fin about as long as rest of the body and this is the main character of the family Stegostomatidae. The mean value of the ratio of the total length to dorsal caudal margin length (TOT/CDM) of the members of this family was 2.09. That of all the other specimens of this order ranged from 3 – 3.8 (Table. vi).

Sharks with a lobe and groove present around outer edges of nostrils were identified as members of the Family Hemiscyllidae (Table. VI).

The balance of the Orectolobiformes specimens observed possessed relatively short caudal fins (the mean value of TOT/CDM was 3.00) and without a lobe and groove around outer edges of the nostrils (Table. vi). These sharks were identified as the members of the Family Ginglymostomatidae.
Identification of the genera and species of the Family Rhiniodontidae

All the individuals of the family Rhiniodontidae were identified as the species *Rhiniodon typus*. This is the only species of this family in the world (the characters of the family have been mentioned previously).

Identification of the genera and species of the Family Stegostomatidae

All the specimens of the family Stegostomatidae were identified as belonging to the species *Stegostoma fasciatum* (this is the only living species of this family in the world. Therefore, the same characters were used for the identification of the family, genus and the species).

Identification of the genera and species of the Family Hemiscyllidae

One genus, *Chiloscyllium* and two species *C. indicum* and *C. griseum* belonging to this family were identified.

All the specimens of this family possessed sub-terminal nostrils on snout (Table. VI), this is the main character of the Genus *Chiloscyllium*.

Presence of numerous small dark spots and streaks on dorso-lateral surface of the body were observed in four specimens of this genus. These colour markings were absent in the rest of the *Chiloscyllium* specimens. These two species were identified as *Chiloscyllium indicum* and *C. griseum* respectively (Table. VI).
Identification of the genera and species of the Family Ginglymostomatidae

One species of this family was identified. The specimens of this family possessed teeth with 11 - 13 cusplets (the middle one was the highest) on both jaws (Table. VII), this is the main character of the Species *Nebrius ferrugineus*.

*Nebrius ferrugineus*, *Chiloscyllium indicum* and *C. griseum* were by-catch of the bottom-set gill net and bottom-set longline fishery. These sharks were observed only at Beruwala fish landing centre.

*Rhiniodon typus* was a by catch of drift gillnet fishery. This species was observed both Pitipana and Beruwala fish landing centres.
Table VI. Characters used for the identification of Orectolobiformes shark.

<table>
<thead>
<tr>
<th>Species</th>
<th>TOT/CDM X(X1 - X2)</th>
<th>Ventral side of the snout</th>
<th>Shape of the caudal fin</th>
<th>2nd tooth of left/upper jaw</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Chiostylidium griseum</em></td>
<td>3.60 (3.52 - 3.63)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. indicum</em></td>
<td>3.00 (2.97 - 3.02)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Nebrius ferrugineus</em></td>
<td>3.00 (2.95 - 3.10)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Stegostoma fasciatum</em></td>
<td>2.09 (1.87 - 2.20)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Rhiniodon typus</em></td>
<td>3.80 (3.82 - 3.77)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Most prominent characters used in the identification of species
Table. VII. Identified species of the order Orectolobiformes (Carpet sharks), their names, gear vulnerability, sex ratios, maximum length and number observed.

<table>
<thead>
<tr>
<th>No.</th>
<th>Order</th>
<th>Family</th>
<th>Zoological name</th>
<th>English name</th>
<th>Local names</th>
<th>M/Fm</th>
<th>Max.L</th>
<th>Gear used</th>
<th>No. observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>07</td>
<td>Orectolobiformes</td>
<td>Hemiscylliidae (Gill,1862), (Bamboo sharks)</td>
<td><em>Chiloscyllum griseum</em> (Muller &amp; Henle,1838)</td>
<td>Grey bamboo</td>
<td>Thalagoi mora</td>
<td>1:1</td>
<td>70cm</td>
<td>BGN</td>
<td>12</td>
</tr>
<tr>
<td>08</td>
<td>- DO -</td>
<td>- DO -</td>
<td><em>C. indicum</em> (Gmelin,1789)</td>
<td>Slender bamboo</td>
<td>Hulang mora</td>
<td>3:1</td>
<td>58cm</td>
<td>BGN</td>
<td>4</td>
</tr>
<tr>
<td>09</td>
<td>- DO -</td>
<td>Ginglymostomatidae (Gill,1862), (Nurse sharks)</td>
<td><em>Nebrius ferrugineus</em> (Lesson,1830)</td>
<td>Tawny nurse shark</td>
<td>Kurakkan mora</td>
<td>1:1</td>
<td>212cm</td>
<td>BGN, BLL</td>
<td>8</td>
</tr>
<tr>
<td>10</td>
<td>- DO -</td>
<td>Stegostomatidae (Gill,1862) (Zebra sharks)</td>
<td><em>Stegostoma fasciatum</em> (hermann,1783)</td>
<td>Zebra shark</td>
<td>Iri mora</td>
<td>1:2</td>
<td>115cm</td>
<td>BGN</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>- DO -</td>
<td>Rhiniodontidae (Muller &amp; Henle,1839), (Whalesharks)</td>
<td><em>Rhiniodon typus</em> (Smith,1828)</td>
<td>Whale shark</td>
<td>Thimbiriya, Minimuthu mora,</td>
<td>2:1</td>
<td>465cm</td>
<td>DGN</td>
<td>5</td>
</tr>
</tbody>
</table>

BGN = bottom set gillnet, BLL = Bottom set gillnet, DGN = Drift gillnet
Identification of the Families of the Order Lamniformes

Four families, Odontaspididae, Pseudocarchariidae, Allopiidae and Lamnidae belonging to the Order Lamniformes were identified. The characters used for the identification are mentioned below.

The specimens with slender and pointed cusped teeth with lateral cusplets (Table. VIII) and a small intermediate teeth which separated anterior and lateral teeth in the upper jaw, were identified as the members of the Family Odontaspididae.

The specimens with very large eyes (the mean value of HDH/EYH was 2.66), long gill slits (the mean value of HDH/GS3 was 1.77) and long - cusped prominent teeth (Table. VIII), were identified as members of the Family Pseudocarchariidae.

Family Alopiidae has been identified as the largest family of the order Lamniformes in the monitored catches. This family was represented by 96% of the observed specimens of the order. The members of this order were characterised by a curved asymmetrical caudal fin, with dorsal lobe nearly or quite as long as rest of shark (the mean value of TOT/CDM was 2.00) (Table. IX).

The rest of the specimens of the order lamniformes possessed lunate caudal fins (Table. X). That is the main character of the Family Lamnidae.

The family Pseudocarchariidae is a new record from Sri Lanka.
Identification of the genera and species of the Family Odontaspididae

One genus, *Odontaspis* and two species *O. ferox* and *O. Noronhai* of this order were identified.

The Genus *Odontaspis* is characterised by the closer placement of the first dorsal fin to the pectoral bases than the pelvic bases. The mean value of the DPI/DPO < 1 (DPI= length from pelvic mid-point to first dorsal insertion; DPO= length from first dorsal mid point to pelvic origin).

Teeth of one of *Odontaspis* specimen possessed two to three cusplets on each side of cusp and it was identified as the Species *Odontaspis ferox* (Table. VIII).

Teeth of the other two species possessed only one cusplet on each side of cusp and they were identified as the Species *O. noronhai* (Table. VIII).

These two species are new records from Sri Lanka.

Identification of the genera and species of the Family Pseudocarchariidae

All the specimens of the family Pseudocarchariidae were identified as Species *Pseudocarcharias kamoharai* (this is the only species of this family) (Table. VIII).

This species is a new record from Sri Lanka.
Identification of the genera and species of the Family Alopiidae

Among the specimens of this family one genus *Alopias* and three species *A. superciliosus*, *A. vulpinus* and *A. pelagicus* were identified.

The family Alopiidae is comprised of one genus, *Alopias*. Therefore, the family characters (mentioned above) and generic characters are same.

The Species *Alopias superciliosus* is characterised by very large eyes with orbits expanded onto dorsal surface of head. Mean value of the HDH/EYH was 4.14 (height of the head / height of the eye ), The first dorsal fin base is closer to pelvic bases than pectoral bases (mean value of the DPI/DPO was 2.16), (Table.IX).

The eyes of the other two species of the genus *Alopias*, were relatively small (mean value of HDH/EYH>6) and orbit not expanded onto dorsal surface of the head. Their first dorsal fin base is about equidistant between pectoral and pelvic fin bases or closer to pectoral bases (mean value of the DPI/DPO < 1), (Table.IX).

While the pectoral fins of *A. vulpinus* were pointed, those of *A. pelagicus* were broad rather than pointed. The white colour of the abdomen extending over the pectoral base in *A. vulpinus* while the white colour of the abdomen was limited only into the ventral surface below the pectoral fin base in *A. pelagicus* (Table. IX).
Identification of the genera and species of the Family Lamnidae

Among the specimens of the family Lamnidae, one genus *Isurus* and two species *I. oxyrinchus* and *I. paucus* were identified.

Snout of the observed specimens of the family Lamnidae, were conical rather than dorso-ventrally flattened (the usual shape of snout of shark), Teeth thick, narrow, sharp edged and without lateral cusplets. Front teeth of both jaws were protruded. These are the characters of the Genus *Isurus* (Table. X).

The two species of the genus could be identified using HDL/PIH ratio (head length / pectoral fin height), colouration of ventral side of the snout and the nature of the upper and lower teeth.

The mean values of HDL/PIH for *I. oxyrinchus* and *I. paucus* were 1.5 and 1.00 respectively. Dusky patches were observed on the ventral side of the snout region of the *I. paucus* while that region was white in *I. oxyrinchus* (Table.x).

Cusps of upper and lower anterior teeth curved lingually at bases and recurved labially at tips in *I. oxyrinchus* while those are rather straighter in *I. paucus*. The cusps of third teeth of both jaws were bend toward the fourth tooth at tips, in *I. oxyrinchus* while that of *I.paucus* were erected (Table.x).

The species *Isurus paucus* is a new record from Sri Lanka.
Table. VIII. Characters used for the identification of species of the families Odontaspidae and Pseudocarchariidae.

<table>
<thead>
<tr>
<th>Species identified</th>
<th>DPI / DPO X (X1 - X2)</th>
<th>HDH/EYH X (X1 - X2)</th>
<th>HDH/GS3 X (X1 - X2)</th>
<th>Shape of 1st &amp; 2nd teeth left/upper jaw</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Odontaspis ferox</em></td>
<td>0.60 (0.57 - 0.63)</td>
<td>10.20 (9.05 - 10.35)</td>
<td>2.51 (2.30 - 2.72)</td>
<td><img src="image1" alt="1st tooth" /> <img src="image2" alt="2nd tooth" /></td>
</tr>
<tr>
<td><em>O. noronhai</em></td>
<td>0.40 (one specimen)</td>
<td>7.60 (one specimen)</td>
<td>2.11 (one specimen)</td>
<td><img src="image3" alt="1st tooth" /> <img src="image4" alt="2nd tooth" /></td>
</tr>
<tr>
<td><em>Pseudocarcharias kamoharai</em></td>
<td>1.00 (1.18 - 0.95)</td>
<td><em>2.66 (2.33 - 2.81)</em></td>
<td><em>1.77 (1.50 - 1.81)</em></td>
<td><img src="image5" alt="1st tooth" /> <img src="image6" alt="2nd tooth" /></td>
</tr>
</tbody>
</table>

* Most prominent characters used in the identification of species
Table IX. Characters used for the identification of species of the family Alopidae.

<table>
<thead>
<tr>
<th>Species identified</th>
<th>TOT/CDM X (X1 - X2)</th>
<th>HDH/EYH X (X1 - X2)</th>
<th>DPI/DPO X (X1 - X2)</th>
<th>Shape of the pectoral fin and coloration of the ventral surface</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Alopias superciliosus</em></td>
<td>2.23 (2.00 - 2.34)</td>
<td>4.14 (4.21 - 3.44)</td>
<td>2.16 (2.00 - 2.45)</td>
<td><img src="image" alt="Alopias superciliosus" /></td>
</tr>
<tr>
<td><em>A. vulpinus</em></td>
<td>1.94 (1.90 - 1.98)</td>
<td>9.43 (9.33 - 9.51)</td>
<td>0.58 (0.50 - 0.61)</td>
<td><img src="image" alt="A. vulpinus" /></td>
</tr>
<tr>
<td><em>A. pelagicus</em></td>
<td>1.82 (1.80 - 1.86)</td>
<td>6.20 (5.50 - 6.80)</td>
<td>0.85 (0.80 - 0.88)</td>
<td><img src="image" alt="A. pelagicus" /></td>
</tr>
</tbody>
</table>

* Most prominent characters used in the identification of species
Table X. Characters used for the identification of species of the Family Lamnidae

<table>
<thead>
<tr>
<th>Name of the species</th>
<th><em>Isurus oxyrinchus</em></th>
<th><em>Isurus paucus</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>HDL / PIH ; X(X1-X2)</td>
<td>1.52 (1.50 - 1.55)</td>
<td>1.12 (1.00 - 1.14)</td>
</tr>
<tr>
<td>TOT / PIH ; X(X1-X2)</td>
<td>6.50 (6.66 - 5.26)</td>
<td>4.54 (4.22 - 4.76)</td>
</tr>
</tbody>
</table>

Shape of the caudal fin

Shape of the snout

Shape of the 1\textsuperscript{st}, 2\textsuperscript{nd} & 3\textsuperscript{rd} teeth of left half/upper jaw

Shape of the 1\textsuperscript{st}, 2\textsuperscript{nd} & 3\textsuperscript{rd} teeth of left half/lower jaw

* Most prominent characters used in the identification of species
Table. XI. Identified species of the order Lamniformes (Mackerel sharks), their names, gear vulnerability, sex ratios, maximum length and number observed.

<table>
<thead>
<tr>
<th>No</th>
<th>Order</th>
<th>Family</th>
<th>Zoological name</th>
<th>English name</th>
<th>Local names</th>
<th>M/F m</th>
<th>Max. L</th>
<th>Gear used</th>
<th>No. observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Lamniformes (Compagno, 1973)</td>
<td>Odontaspidae (Muller &amp; Henle) (Sandtiger sharks)</td>
<td><em>Odontaspis noronhai</em> (Maul, 1955)</td>
<td>Bigeye sandtiger</td>
<td>non</td>
<td>2:0</td>
<td>258 cm</td>
<td>LL</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td>- DO -</td>
<td>- DO -</td>
<td><em>O. ferox</em> (Riso, 1810)</td>
<td>Smalltooth sandtiger</td>
<td>non</td>
<td>1:0</td>
<td>225 cm</td>
<td>LL</td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td>- DO -</td>
<td>Pseudocarchariidae (Compagno, 1973) (Crocodile s.)</td>
<td><em>Pseudocarcharias kamoharai</em> (Matsubara, 1935)</td>
<td>Crocodile shark</td>
<td>non</td>
<td>7:5</td>
<td>66 cm</td>
<td>DGN</td>
<td>13</td>
</tr>
<tr>
<td>15</td>
<td>- DO -</td>
<td>Alopiidae (Bonoparte, 1838) (Thresher sharks)</td>
<td><em>Alopias pelagicus</em> (Nakamura, 1935)</td>
<td>Pelagic thresher</td>
<td>Kasaya</td>
<td>1:1</td>
<td>210 cm</td>
<td>DGN, LL</td>
<td>95</td>
</tr>
<tr>
<td>16</td>
<td>- DO -</td>
<td>- DO -</td>
<td><em>A. superciliosus</em> (Lowe, 1839)</td>
<td>Bigeye thresher</td>
<td>Kasaya</td>
<td>1:1</td>
<td>255 cm</td>
<td>DGN, LL</td>
<td>232</td>
</tr>
<tr>
<td>17</td>
<td>- DO -</td>
<td>- DO -</td>
<td><em>A. Vulpinus</em> (Bonnaturre, 1809)</td>
<td>Thresher shark</td>
<td>Kasaya</td>
<td>1:1</td>
<td>265 cm</td>
<td>DGN, LL</td>
<td>778</td>
</tr>
<tr>
<td>18</td>
<td>- DO -</td>
<td>Lamnidae (Muller &amp; Henle, 1838) (Mackerel sharks)</td>
<td><em>Isurus oxyrinchus</em> (Rafinesque, 1809)</td>
<td>Shortfin mako</td>
<td>Meeya, Yakka</td>
<td>9:7</td>
<td>392 cm</td>
<td>DGN, LL</td>
<td>155</td>
</tr>
</tbody>
</table>

DGN = Drift gillnet, LL = Long line
Identification of the Families of the Order Carcharhiniformes

Under this order 4 families Sphyrnidae, Triakidae, Hemigaleidae and Carcharhinidae, were identified.

Family Sphyrnidae is characterised by the heads with lateral blade like expansion (‘T’ shaped head) (Table. XII).

Family Triakidae possessed supraorbital crests on cranium (Tabl. XIII) and they did not possess precaudal pits which were present in all other carcharhiniformes sharks.

All the other specimens of sharks belonging to the Order Carcharhiniformes possessed conspicuous precaudal pits and their dorsal caudal margins were undulated (Table. XIII & XIV).

Among them, the sharks with spiral shaped intestinal valves were identified as belonging to Family Hemigaleidae and the sharks with scroll type intestinal valve were identified as the Family Carcharhinidae.

Identification of the genera and species of the Family Sphyrnidae

Among the sphyrnid sharks two genera, Eusphyra and Sphyrna, and four species E. blochii, S. mokarran, S. zygaena, and S. lewini were identified.

The genus Eusphyra is characterised by very narrow, wing like lateral blades of head. Their nostrils are greatly enlarged and their width was almost twice the width of mouth (mean value of NOW/MOW = 2.15), (Table. XII). The only species of this genus in the world is Eusphyra blochii.
Lateral blades of head of the other sphynids were not winglike and they were antero-posteriorly broad. They were identified as members of the Genus *Sphyrna*.

Presence of strongly serrated teeth and, nearly straight anterior and posterior margins of head are the main characters of the Species *Sphyrna mokkaran* (Table. XII).

The main character of the species *S. lewini* is the presence of prominent median indentation on anterior margin of the head. In *S. zygaena* there is no median indentation on the anterior margin of the head and this margin is well arched and smooth (Table. XII).
Table XII. Characters used for the identification of species of the Family Sphyridae

<table>
<thead>
<tr>
<th>Species Identified</th>
<th>NOW/MOW X(X1-X2)</th>
<th>Shape of the 1st tooth of left half/ upper jaw</th>
<th>Shape of the head</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Eusphyra blochi</em></td>
<td>2.15 (1.96 - 2.20)</td>
<td><img src="image1" alt="Image" /></td>
<td><img src="image2" alt="Image" /></td>
</tr>
<tr>
<td><em>Sphyra lewini</em></td>
<td>1.05 (1.00 - 1.22)</td>
<td><img src="image3" alt="Image" /></td>
<td><img src="image4" alt="Image" /></td>
</tr>
<tr>
<td><em>S. mokarran</em></td>
<td>0.60 (0.52 - 0.63)</td>
<td><img src="image5" alt="Image" /></td>
<td><img src="image6" alt="Image" /></td>
</tr>
<tr>
<td><em>S. zygaena</em></td>
<td>1.00 (0.9 - 1.13)</td>
<td><img src="image7" alt="Image" /></td>
<td><img src="image8" alt="Image" /></td>
</tr>
</tbody>
</table>

* Most prominent characters used in the identification of species
Identification of the genera and species of the Family Triakidae

Within the family Triakidae one genus, *Mustelus* and two species *M. manazo* and *M. mosis* were identified.

The genus *Mustelus* is characterised by the equal width of internarial space and nostril (INW/NOW = 1).

The entire palate and the floor of the mouth of *Mustelus manazo* are fully covered by compressed denticles while those of the *M. mosis* are partly covered by same kind of denticles. Numerous small white spots on dorsal surface of body were present in *M. manazo* and those were absent in *M. mosis* (Table. XIII).

Identification of the genera and species of the Family Hemigaleidae

The identified genus of this family was *Hemipristis*, it is characterized by the protruded teeth on the front lower jaw, a toothless space between teeth in mid line of both jaws (Table. XIII). The only species of this genus is *H. elongatus*. 
Table. XIII. Characters used for the identification of the species of the Families Triakidae and Hemigaleidae

<table>
<thead>
<tr>
<th>Species identified</th>
<th>Shape of the caudal region</th>
<th>Shape of the head</th>
<th>Shape of 1st tooth of left upper &amp; lower jaws</th>
<th>Shape &amp; arrangement of teeth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mustelus manazo</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
<tr>
<td>M. mosis</td>
<td><img src="image5.png" alt="Image" /></td>
<td><img src="image6.png" alt="Image" /></td>
<td><img src="image7.png" alt="Image" /></td>
<td><img src="image8.png" alt="Image" /></td>
</tr>
<tr>
<td>Hemipristis elongatus</td>
<td><img src="image9.png" alt="Image" /></td>
<td><img src="image10.png" alt="Image" /></td>
<td><img src="image11.png" alt="Image" /></td>
<td><img src="image12.png" alt="Image" /></td>
</tr>
</tbody>
</table>

* Most prominent characters used in the identification of species
Identification of the genera and species of the Family Carcharhinidae

Among the Carcharhинд sharks, 9 genera were identified, namely *Galeocerdo*, *Triaenodon*, *Negaprion*, *Lamiopsis*, *Scoliodon*, *Loxodon*, *Rhizoprionodon*, *Prionas* and *Carcharhinus*.

Among the identified 22 species of this order, 14 species belonged to the genus *Carcharhinus* while others (8) were non-*Carcharhinus* species.

The genus *Galeocerdo* which comprised only one species *G. cuvier* was the main non-*carcharhinus* genus of the family Carcharhinidae present in the catches. This species was characterised by very long upper labial furrows extending in front of the eyes, spiracles and prominent lateral keels on caudal peduncle, and vertical black or dusky bars on their dorsal surface (Table. xiv).

The Genus *Triaenodon* is characterised by the teeth of both jaws, which possessed two cusplets in each side of the cusps and tubuler anterior nasal flaps (Table. xiv). Conspicuous white tips appeared on first dorsal and upper lobe of caudal fins. The Species *Triaenodon obesus* is the only species of this genus.

The genera *Negaprion* and *Lamiopsis* were characterised by the second dorsal fin which nearly as large as the first dorsal (mean value of D1H/D2H = 1.2). Upper and the lower teeth of the genus *Negaprion* were with unserrated cusps, while the cusps of the upper teeth of the genus *Lamiopsis* were strongly serrated and lowers with smooth cusps (Table xiv). *Lamiopsis temmincki* is the only living species of the Genus *Lamiopsis*.
There are two species of Negaprion in the world, *N. brevirostris* and *N. acudens*. These two species could be identified by the nature of the base of the upper teeth. In the former species those are serrated while those of the latter one are not serrated. Base on this character, the species present in the monitored catches were identify as the Species *Negaprion acutidens*.

The origin of second dorsal fin was well behind to that of the anal fin (mean value of PD2/PAL> 1) in the Genera *Scoliodon, Loxodon and Rhizoprionodon* (that was well anterior or near to the anal origin in others) (Table. xv).

The genus *Scoliodon* which comprised only one species *Scoliodon laticaudus* is characterised by very long, flat laterally expanded, spadelike snout and teeth with smooth edged oblique cusps(Table. xiv).

Presence of conspicuous notch on the posterior corner of the eyes is the main character of the genus *Loxodon*, the Species *Loxodon macrorhinus* is the only living species of this genus.

The genus *Rhizoprionodon*, is characterised by the presence of well conspicuous labial furrows (Table. xiv). There are seven living species of this genus. Specimens observed in this genus were with strongly serrated cusps of the teeth on the both jaws. The Species *Rhizoprionodon acutus* is the only species of this genes with the serrated cusps.

The genus *Prionace* is characterised by the presence of papillose gill rakers on gill arches and weak lateral keels on caudal peduncle. The Species *Prionace glauca* is the only living species of this genus.
Table. xiv. Characters used for the identification of seven “non Carcharhinus" species of the Family Charcharhinidae.

<table>
<thead>
<tr>
<th>Species identified</th>
<th>Shape of the snout</th>
<th>Shape of the caudal region</th>
<th>1&quot; tooth left/upper &amp; lower</th>
<th>Presence of gill rakers</th>
<th>PD2/PAL X(X1-X2)</th>
<th>HDL/POR X(X1-X2)</th>
<th>D1H/D2H X(X1-X2)</th>
<th>DPI/DPO X(X1-X2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galeocerdo cuvier</td>
<td></td>
<td></td>
<td></td>
<td>No</td>
<td>0.96(0.87-0.98)</td>
<td>5.50(5.44-5.70)</td>
<td>3.25(3.20-3.30)</td>
<td>0.56(0.51-0.57)</td>
</tr>
<tr>
<td>Triacodon obesus</td>
<td></td>
<td></td>
<td></td>
<td>No</td>
<td>0.97(0.90-0.99)</td>
<td>6.44(6.37-6.50)</td>
<td>1.43(1.39-1.46)</td>
<td>1.92(1.89-1.96)</td>
</tr>
<tr>
<td>Negaprion brevirostris</td>
<td></td>
<td></td>
<td></td>
<td>No</td>
<td>0.98(0.95-1.00)</td>
<td>3.70(3.50-3.85)</td>
<td>*</td>
<td>1.22(1.20-1.28)</td>
</tr>
<tr>
<td>Lamiopsis temminckii</td>
<td></td>
<td></td>
<td></td>
<td>No</td>
<td>0.98</td>
<td>3.7 (one specimen)</td>
<td>*</td>
<td>1.25</td>
</tr>
<tr>
<td>Scoliodon laticaudus</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>1.12(1.00-1.16)</td>
<td>2.69(2.61-2.73)</td>
<td>3.66(3.57-3.73)</td>
<td>1.87(1.81-1.90)</td>
</tr>
<tr>
<td>Loxodon macrorhinus</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>1.17(1.07-1.22)</td>
<td>2.20(2.14-2.30)</td>
<td>5.20(5.00-5.30)</td>
<td>1.15(1.00-1.18)</td>
</tr>
<tr>
<td>Rhizoprionodon acutus</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>1.10(1.05-1.15)</td>
<td>3.00(2.85-3.13)</td>
<td>4.81(4.78-4.85)</td>
<td>0.80(0.78-0.82)</td>
</tr>
<tr>
<td>Prionace glauca</td>
<td></td>
<td></td>
<td></td>
<td>* papillose gill rakers present</td>
<td>0.94(0.88-1.00)</td>
<td>2.60(2.50-2.72)</td>
<td>3.00(2.91-3.17)</td>
<td>1.53(1.50-1.58)</td>
</tr>
</tbody>
</table>

* Most prominent characters used in the identification of species
<table>
<thead>
<tr>
<th>Species identified</th>
<th>Shape, markings and relative arrangement of fins</th>
<th>First tooth of left upper and lower jaws</th>
<th>DPI/DPO X(X1-X2)</th>
<th>MOW/POR X(X1-X2)</th>
<th>HDH/EYH X(X1-X2)</th>
<th>PD2/PAL X(X1-X2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Carcharhinus</em> longimanus</td>
<td><img src="#" alt="Diagram" /></td>
<td><img src="#" alt="Diagram" /></td>
<td>0.94(0.91-0.97)</td>
<td>1.75(1.28-1.98)</td>
<td>8.50(8.00-8.75)</td>
<td>0.95(0.91-0.97)</td>
</tr>
<tr>
<td><em>C. albimarginatus</em></td>
<td><img src="#" alt="Diagram" /></td>
<td><img src="#" alt="Diagram" /></td>
<td>0.98(0.90-1.00)</td>
<td>1.13(1.00-1.20)</td>
<td>6.66(6.12-6.78)</td>
<td>1.01(1.00-1.20)</td>
</tr>
<tr>
<td><em>C. wheeleri</em></td>
<td><img src="#" alt="Diagram" /></td>
<td><img src="#" alt="Diagram" /></td>
<td>0.63(0.63-0.63)</td>
<td>1.66(1.64-1.68)</td>
<td>9.00(8.97-9.03)</td>
<td>1.00(1.00-1.00)</td>
</tr>
<tr>
<td><em>C. amblyrhnchos</em></td>
<td><img src="#" alt="Diagram" /></td>
<td><img src="#" alt="Diagram" /></td>
<td>0.72(0.68-0.80)</td>
<td>1.15(1.00-1.28)</td>
<td>7.20(6.95-7.41)</td>
<td>0.97(0.93-1.00)</td>
</tr>
</tbody>
</table>

* Most prominent characters used in the identification of species
### Table

<table>
<thead>
<tr>
<th>Species</th>
<th>Length (mm)</th>
<th>Width (mm)</th>
<th>Height (mm)</th>
<th>Width/Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>C. sorrah</td>
<td>0.65(0.57-0.77)</td>
<td>1.09(0.98-1.12)</td>
<td>10.5(9.85-11.1)</td>
<td>1.03(1.00-1.20)</td>
</tr>
<tr>
<td>C. hemiodon</td>
<td>0.98(0.96-1.00)</td>
<td>1.18(1.10-1.26)</td>
<td>6.78(6.58-6.98)</td>
<td>1.03(1.01-1.05)</td>
</tr>
<tr>
<td>C. falciformis</td>
<td>0.75(0.68-0.80)</td>
<td>0.95(0.92-0.10)</td>
<td>6.40(5.98-6.72)</td>
<td>0.98(0.88-1.00)</td>
</tr>
<tr>
<td>C. altimus</td>
<td>0.35(0.28-0.4)</td>
<td>1.19(1.02-1.24)</td>
<td>8.50(7.95-9.00)</td>
<td>1.00(0.98-1.12)</td>
</tr>
<tr>
<td>C. plumbeus</td>
<td>0.31 (one specimen)</td>
<td>0.53 (one specimen)</td>
<td>11.05 (one specimen)</td>
<td>1.00 (one specimen)</td>
</tr>
</tbody>
</table>

* Most prominent characters used in the identification of species
<table>
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<tr>
<th>Species</th>
<th>Image</th>
<th>Length</th>
<th>Width</th>
<th>Height</th>
<th>Identification</th>
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<tr>
<td>C. melanopterus</td>
<td>![Image]</td>
<td>0.88(0.75-0.92)</td>
<td>1.64(1.23-1.73)</td>
<td>9.00(8.87-9.35)</td>
<td>1.09(1.00-1.20)</td>
</tr>
<tr>
<td>C. macloti</td>
<td>![Image]</td>
<td>0.61(0.50-0.71)</td>
<td>0.85(0.80-0.90)</td>
<td>7.20(6.85-7.50)</td>
<td>1.04(0.98-1.10)</td>
</tr>
<tr>
<td>C. amboinensis</td>
<td>![Image]</td>
<td>0.45 (one specimen)</td>
<td>1.66 (one specimen)</td>
<td>* (one specimen)</td>
<td>0.96 (one specimen)</td>
</tr>
<tr>
<td>C. brevipinna</td>
<td>![Image]</td>
<td>0.50(0.43-0.57)</td>
<td>1.17(1.00-1.30)</td>
<td>10.6(10.0-10.9)</td>
<td>0.97(1.26)</td>
</tr>
<tr>
<td>C. limbatus</td>
<td>![Image]</td>
<td>0.28(0.20-0.34)</td>
<td>1.28(1.00-1.41)</td>
<td>7.60(7.00-8.00)</td>
<td>0.98(0.90-1.01)</td>
</tr>
</tbody>
</table>

* Most prominent characters used in the identification of species
Table. xvi. Identified species of the order Carcharhiniformes (Ground sharks) their names, gear vulnerability, sex ratios, maximum length and number observed.

<table>
<thead>
<tr>
<th>No</th>
<th>Order</th>
<th>Family (References)</th>
<th>Zoological name</th>
<th>English name</th>
<th>Local names</th>
<th>M/Fm</th>
<th>Max. L</th>
<th>Gear used</th>
<th>No. observed</th>
</tr>
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<tr>
<td>20</td>
<td>Carcharhiniformes</td>
<td>Triakidae (Gray, 1851) (Houndsharks)</td>
<td><em>Mustelus manazo</em> (Bleeker, 1854)</td>
<td>Star spotted smooth hound shark</td>
<td>Weli mora</td>
<td>5/2</td>
<td>78cm</td>
<td>BGN</td>
<td>5</td>
</tr>
<tr>
<td>21</td>
<td>- DO -</td>
<td>- DO -</td>
<td><em>M. mosis</em> (Hemprich &amp; Ehrenberg, 1899)</td>
<td>Arabian smooth hound</td>
<td>Weli mora</td>
<td>1/2</td>
<td>85cm</td>
<td>BGN</td>
<td>3</td>
</tr>
<tr>
<td>22</td>
<td>- DO -</td>
<td>Hemigaleidae (Hasse, 1879) (Weasel sharks)</td>
<td><em>Hemipristis elongatus</em> (Kunzinger, 1871)</td>
<td>Snaggletooth shark</td>
<td>Beheth mora</td>
<td>2/1</td>
<td>130cm</td>
<td>FLL</td>
<td>3</td>
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<tr>
<td>23</td>
<td>- DO -</td>
<td>Carcharhinidae (Jordan &amp; Evermann, 1896) (Requiem s.)</td>
<td><em>Carcharhinus albimarginatus</em> (Ruppell, 1837)</td>
<td>Silvertip shark</td>
<td>Ba-suduwa</td>
<td>3/2</td>
<td>202cm</td>
<td>FLL, DGN</td>
<td>25</td>
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<td>24</td>
<td>- DO -</td>
<td>- DO -</td>
<td><em>C. altimus</em> (Springer, 1950)</td>
<td>Bignose shark</td>
<td>Gaslabba</td>
<td>1/1</td>
<td>210cm</td>
<td>FLL, DGN</td>
<td>122</td>
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<tr>
<td>25</td>
<td>- DO -</td>
<td>- DO -</td>
<td><em>C. amblyrhynchos</em> (Bleeker, 1856)</td>
<td>Grey reef shark</td>
<td>--</td>
<td>1/2</td>
<td>155cm</td>
<td>FLL, DGN</td>
<td>3</td>
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<tr>
<td>26</td>
<td>- DO -</td>
<td>- DO -</td>
<td><em>C. ambloinensis</em> (Muller &amp; Henle, 1839)</td>
<td>Pigeye shark</td>
<td>Perunthalaya</td>
<td>1/0</td>
<td>225cm</td>
<td>FLL</td>
<td>1</td>
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<tr>
<td>27</td>
<td>- DO -</td>
<td>- DO -</td>
<td><em>C. brevipinna</em> (Muller &amp; Henle, 1839)</td>
<td>Spinner shark</td>
<td>Gal kunda</td>
<td>2/1</td>
<td>185cm</td>
<td>FLL, DGN</td>
<td>3</td>
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<tr>
<td>28</td>
<td>- DO -</td>
<td>- DO -</td>
<td><em>C. falciformis</em> (Bibron, 1839)</td>
<td>Silky shark</td>
<td>Honda, Lambura, Bala, Ahin. mora</td>
<td>1/1</td>
<td>284cm</td>
<td>FLL, DGN</td>
<td>15837</td>
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<tr>
<td>29</td>
<td>- DO -</td>
<td>- DO -</td>
<td><em>C. hemiodon</em> (Valenciennes, 1839)</td>
<td>Pondicherry shark</td>
<td>--</td>
<td>2/0</td>
<td>128cm</td>
<td>FLL</td>
<td>2</td>
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<tr>
<td>30</td>
<td>- DO -</td>
<td>- DO -</td>
<td><em>C. limbus</em> (Valenciennes, 1839)</td>
<td>Blacktip shark</td>
<td>Gal kunda Ba-kaluwa</td>
<td>1/1</td>
<td>198cm</td>
<td>FLL, DGN</td>
<td>4</td>
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<td>31</td>
<td>- DO -</td>
<td>- DO -</td>
<td><em>C. longimamus</em> (Poey, 1861)</td>
<td>Oceanic whitetip shark</td>
<td>Polkolaya</td>
<td>1/1</td>
<td>256cm</td>
<td>FLL, DGN</td>
<td>1054</td>
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<td>S</td>
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<td>DO</td>
<td>C. macloti (Muller &amp; Henle, 1839)</td>
<td>Hardnose shark</td>
<td>Beheth mora</td>
<td>1/1</td>
<td>78cm</td>
<td>DGN, PLL</td>
<td>124</td>
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<tr>
<td>33</td>
<td>DO</td>
<td>DO</td>
<td>C. melanopterus (Quoy &amp; Gaimard, 1824)</td>
<td>Blacktip reef shark</td>
<td>Gal kunda, Lagga mora, Ba kaluwa</td>
<td>1/1</td>
<td>120cm</td>
<td>DGN, BLL</td>
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<td>34</td>
<td>DO</td>
<td>DO</td>
<td>C. Plumeus (Nardo, 1827)</td>
<td>Sandbar shark</td>
<td>-</td>
<td>1/0</td>
<td>165cm</td>
<td>FLL</td>
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<tr>
<td>35</td>
<td>DO</td>
<td>DO</td>
<td>C. Sorrah (Valenciennes, 1830)</td>
<td>Spot-tail shark</td>
<td>Gal kunda, Lagga mora, Ba kaluwa</td>
<td>1/1</td>
<td>135cm</td>
<td>DGN, FLL, BLL</td>
<td>285</td>
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<tr>
<td>36</td>
<td>DO</td>
<td>DO</td>
<td>C. Wheeleri (Garrick, 1982)</td>
<td>Blacktail reef shark</td>
<td>Gal kunda</td>
<td>2/0</td>
<td>124cm</td>
<td>DGN</td>
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<tr>
<td>37</td>
<td>DO</td>
<td>DO</td>
<td>Galeocerdo cuvier (Peron &amp; Lesueur, 1822)</td>
<td>Tiger shark</td>
<td>Koti mora, Maylakkandiya</td>
<td>1/1</td>
<td>325cm</td>
<td>DGN, FLL</td>
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<td>38</td>
<td>DO</td>
<td>DO</td>
<td>Lamiopsis temminki (Muller &amp; Henle, 1839)</td>
<td>Broadfin shark</td>
<td>-</td>
<td>0/1</td>
<td>123cm</td>
<td>DGN</td>
<td>1</td>
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<tr>
<td>39</td>
<td>DO</td>
<td>DO</td>
<td>Loxodon macrorhinos (Muller &amp; Henle, 1839)</td>
<td>Sliteye shark</td>
<td>Neliya</td>
<td>1/1</td>
<td>78cm</td>
<td>DGN</td>
<td>824</td>
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<tr>
<td>40</td>
<td>DO</td>
<td>DO</td>
<td>Negaprion acutidens (Ruppell, 1837)</td>
<td>Sicklefin lemon shark</td>
<td>Gal kunda</td>
<td>4/3</td>
<td>233cm</td>
<td>DGN, FLL</td>
<td>7</td>
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<tr>
<td>41</td>
<td>DO</td>
<td>DO</td>
<td>Prionace glauca (Linnaeus, 1758)</td>
<td>Blue shark</td>
<td>Huja mora, Nil mora</td>
<td>1/0</td>
<td>286cm</td>
<td>DGN, FLL</td>
<td>321</td>
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<td>42</td>
<td>DO</td>
<td>DO</td>
<td>Rhizoprionodon acutus (Ruppell, 1837)</td>
<td>Milk shark</td>
<td>Weli mora</td>
<td>0/2</td>
<td>126cm</td>
<td>BLL</td>
<td>2</td>
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<tr>
<td>43</td>
<td>DO</td>
<td>DO</td>
<td>Scyllaena laticeps (Muller &amp; Henle, 1838)</td>
<td>Spadenoise shark</td>
<td>-</td>
<td>3/2</td>
<td>65cm</td>
<td>DGN</td>
<td>5</td>
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<tr>
<td>44</td>
<td>DO</td>
<td>DO</td>
<td>Triakisurus obesus (Ruppell, 1837)</td>
<td>Whitetip reef shark</td>
<td>Gal mora</td>
<td>1/1</td>
<td>150cm</td>
<td>BGN, DGN, BLL</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>- DO -</td>
<td>Sphymidae (Gill, 1872) Hammerhead shark</td>
<td><em>Eusphyra blochii</em> (Cuvier, 1817)</td>
<td>Winghead shark</td>
<td>Udalu mora</td>
<td>1/1</td>
<td>88cm</td>
<td>DGN</td>
<td>10</td>
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<tr>
<td>45</td>
<td>- DO -</td>
<td>- DO -</td>
<td><em>Sphyra lewini</em> (Griffith &amp; Smith, 1834)</td>
<td>Scalloped hammerhead</td>
<td>Udalu mora</td>
<td>1/1</td>
<td>285cm</td>
<td>DGN</td>
<td>652</td>
</tr>
<tr>
<td>46</td>
<td>- DO -</td>
<td>- DO -</td>
<td><em>S. mokarran</em> (Ruppel, 1837)</td>
<td>Great hammerhead</td>
<td>Udalu mora</td>
<td>1/1</td>
<td>310cm</td>
<td>DGN</td>
<td>59</td>
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<tr>
<td>47</td>
<td>- DO -</td>
<td>- DO -</td>
<td><em>S. zygaena</em> (Linnaeus, 1757)</td>
<td>Smooth hammerhead</td>
<td>Udalu mora</td>
<td>1/1</td>
<td>265cm</td>
<td>DGN</td>
<td>120</td>
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</tbody>
</table>

BGN = bottom set gillnet, BLL = Bottom set longlines, DGN = Drift gillnet, FLL = Floting longlines
2. A key for the identification of sharks present in the catches landed at Negombo - Pitipana fish landing centre.

1. a. Anal fin absent .......................................................... 2
   b. Anal fin present .......................................................... 7

2. a. Prominent large thorn like dermal denticles scattered
   over body and fins....................................................... Echinorhinus brucus
   b. Dermal denticles not prominent and not thorn like .................. 3

3. a. No spines on first or second dorsal fins .................. Dalatias licha
   b. Spines present on dorsal fins ........................................ 4

4. a. Rear tip of pectoral greatly elongated ......................... 5
   b. Rear tip of pectoral not elongate .................................. 6

5. a. Second dorsal is half height of first dorsal or less .......... Centrophorus moluccensis
   b. Second dorsal is over half height of first dorsal fin .............. C. uyato

6. a. Spines of first and second dorsal fins
   about as heigh as respective fins .................................. Centroscyllium ornatum
   b. Height of first and second dorsal fins greater than their spines .............................................. Centrophorus spp.

7. a. Mouth well in front of the eyes ..................................... 8
   b. Corners of the mouth extend back beyond the eyes ............. 12

8. a. Nearly terminal mouth, transverse and huge Caudal fin without terminal lobe,
   Prominent three pairs of lateral ridges on dorso-lateral surface
   Keels on caudal peduncle ............................................... Rhinodon typus
   b. Small sub terminal mouth, Caudal fin with terminal lobe, No keels on caudal peduncle .......... 9
b. Caudal fin much shorter than the rest of shark ......................................................... 10

10. a. Anal fin separated from caudal fin and prominent,
    Origin of first dorsal fin directly above the origin of pelvic fin............. *Nebrius ferrugineus*

   b. Anal fin low long based and just anterior to caudal fin,
      Anal fin joined with of caudal fin,
      Origin of first dorsal fin directly above lower insertion of pelvic fin ..................... 11

11. a. All the five gill openings situated above the base of the pectoral fin,
    No markings on the body surface ................................................................. *Chiloscyllium griseum*

   b. First gill opening well in front of the base of pectoral fin,
      Numerous dark spots and dashes on body surface ........................................ *C. indicum*

12. a. Six pairs of gill openings ................................................................. *Hexanchus griseus*

   b. Five pairs of gill openings .............................................................................. 13

13. a. Head laterally expanded ............................................................................. 14

   b. Head not laterally expanded ............................................................................. 16

14. a. Lateral blades of head very narrow and wing like. Nostrils greatly enlarged,
    Their widths nearly twice the mouth width.............................................. *Eusphyra blochii*

   b. Lateral blades of head anteroposteriorly broad, Not wing like,
      Nostril short and less than half of mouth width ................................................ 15

15. a. Anterior margin of head nearly straight,
    Posterior margin of head not arching ...................................................... *Sphyra mokarran*

   b. Anterior margin of head sloping backward rather than straight,
      Posterior margin of head arching postero laterally ........................................ 16

61
16. a. No median indentation on anterior margin of head .............................................. \textit{S. zygäena}
b. Median indentation on anterior margin of head ....................................................... \textit{S. lewini}

17. a. Caudal fin lunar shaped & nearly symmetric
   Keels on caudal peduncle ......................................................................................... 18
   b. Caudal fin not lunate and prominently asymmetric
   No keels on caudal peduncle ..................................................................................... 19

18. a. Head longer than the pectoral fin ..................................................................... \textit{I. oxyrinchus}
b. Head about as long as pectoral fin ......................................................................... \textit{I. paucus}

19. a. Upper lobe of the caudal fin about as long as rest of the body ......................... 20
   b. Upper lobe of the caudal fin not as long as the rest of the body ......................... 22

20. a. Very large eyes, Extended onto dorsal surface of head. Upper lobe of caudal fin not firmly tapering, Terminal lobe of caudal fin clearly distinguished.
   Ventral surface of body not whitish ........................................................................ \textit{Alopias superciliosus}
b. Relatively small eyes, not extended onto dorsal surface of head.
   Upper lobe of caudal fin firmly tapering.
   Terminal lobe of caudal fin minute Ventral surface of body whitish......................... 21

21. a. Labial furrows present, Side above pectoral bases whitish ............................... \textit{A. vulpinus}
b. Labial furrows absent, Side above pectoral bases dark .......................................... \textit{A. pelagicus}

22. a. Nictitating membrane absent ............................................................................. 23
   b. Nictitating membrane present ............................................................................... 25

23. a. Teeth without cusplets, Keels on caudal pedancele ......................................... \textit{Pseudocarcharias kamoharai}
b. Teeth with cusplets, No keels on caudal pedanele.................................................... 24
31. a. Unserrated teeth in both jaws
   Pre oral length much shorter than mouth width ........................................... *Egaprion brevirostris*
   b. Serrated teeth in upper jaw
   Pre oral length about equal to mouth width ........................................... *Lamiopsis temmincki*

32. a. Eyes with posterior notch
   Conspicuous White patch on the tip of first dorsal
   Strong black line on the posterior margins of first dorsal and caudal fins .
   Small white marking on the posterior edge of first dorsal inside black line ....................... *Loxodon macrorhinus*
   b. No posterior notches with eyes ........................................................................ 33

33. a. Second dorsal origin well behind anal origin
   Labial furrows conspicuous .................................................. *Rhizoprionodon acutus*
   b. Second dorsal origin well anterior to mid base of anal ............................................. 34

34. a. Papillose gillrakers
   Weak lateral keels present on caudal peduncle
   Dorsal and dorso-lateral colouration brilliant blue ........................................... *Prionace glauca*
   b. No papillose gillrakers
   No keels on caudal peduncle .................................................................................... 35

35. a. A conspicuous white marking on first dorsal fin .............................................. 36
   b. No white marking on first dorsal fin ...................................................................... 38

36. a. No white markings on other fins except the first dorsal
   Second dorsal and anal fins with dusky patches
   Broad black band on the posterior margin of the caudal fin ....................... *Carcharhinus wheeleri*
   b. White markings present on more than one fin ..................................................... 37

37. a. All fins with white posterior margin ................................................................. *C. albimarginatus*
   b. White tipped first dorsal and pectoral fins with broad blunt and rounded apex
   Conspicuous black patches on second dorsal, pelvic and anal fins
   Apex of the lower lobe of the caudal fin broad and round with white markings. *C. longimanus*

38. a. No colour markings on the fins or on the body surface ........................................ 39
   b. Conspicuous black markings on one or more fins ................................................ 41
39. a. Hyper calcified pointed rostrum (can easily be felt by pinching its snout)
   Teeth on both jaws are not serrated ................................................................. C. maclotii

   b. Rostrum not hyper calcified ...................................................................................... 40

40. a. Very long, flat, laterally expanded, spade like snout
   Rear tip of first dorsal about over the pelvic mid base
   Second dorsal origin well behind the anal origin ...................................................... Scoliodon laticaudus

   b. Extremely tall triangular first dorsal fin
   Origin of first dorsal over or anterior to the pectoral insertion.............................. C. plumbius

41. a. A well marked black spot present only on the second dorsal fin........................................ 42

   b. Black markings can be seen on other fins ................................................................. 43

42. a. Posterior margin of the first dorsal fin rather straight
   Cusps of the lower teeth rather straight ............................................................. C. dussumieri

   b. Posterior margin of the first dorsal fin concave
   Cusps of the lower teeth oblique ............................................................................... C. seaiei

43. a. Under side of the pectoral fin tips with black or dusky patches without defined border........ 4

   b. No black markings on pectoral tips or with defined bordered black patches ................. 47

44. a. Lower teeth with serration ......................................................................................... 45

   b. Lower teeth without serration ..................................................................................... 46

45. a. External (commissural) edge of lower teeth (toward the corner of mouth) serrated

   Extremely tall triangular first dorsal fin

   Very small eyes

   First dorsal originates over or anterior to the pectoral insertion .................................. C. plumbius
b. Both side of lower teeth serrated
Margins of caudal and pelvic fins pitch dark
First dorsal origin just opposite to pectoral insertion ........................................... C. alimtus

46. a. Black markings present on second dorsal, dorsal and ventral caudal lobes
Upper teeth weakly serrated, oblique, high cusps and with strong distal cusplets. C. Hemiodon
b. No black markings on other fins except pectorals
Upper teeth strongly serrated, slightly oblique, and without cusplets ................... C. falciformis

47. a. No black markings on pectoral tips
Black band on the posterior margin of the caudal fin ........................................... C. amblyrhynchos
b. Pectoral fin tips with strong, defined bordered black spots
Ventral caudal lobe with a strong black spot .............................................................. 48

48. a. Unserrated lower teeth Long pointed snout
All fins except pelvic possess black tips
Prominent and fairly long upper labial furrows ..................................................... C. brevipinna
b. Lower and upper teeth are serrated ................................................................. 49

49. a. Oblique cusped serrated teeth in both jaws, No black tips on pelvic and anal fins
Conspicuous black spots on pectoral second dorsal and ventral pelvic lob
First dorsal only with black edge or relatively small black patch........................... C sorrah
b. Straight cusped serrated teeth in both jaws
Conspicuous black spots on second dorsals and ventral caudal lobe
First dorsal with a prominent black blotch ......................................................... 50

50. a. Upper teeth with cusplets
Short, bluntly rounded snout
Nasal flaps elongated as nipple- shaped lobes ..................................................... C. Melanopterus
b. Upper teeth with out cusplets
Pointed snout ...................................................................................................... 51
51. a. A conspicuous white band present on flank  
   Wedge shaped pointed snout ................................................................. \textit{C. amblyrhnchoiides}

b. No white band on flank Long pointed snout ................................................... \textit{C. limbatus}

(Synonymy of the identified species are given in Appendix - 1)
3. Species abundance

The dominant species of the observed shark catches was the Silky shark *C. falciformis*. Out of a total of 21483 specimens, 15837 belonged to this species and it represent 75% of the total shark specimens observed. The second dominant one was Oceanic whitetip shark *C. longimanus*, but the number of individuals encountered were 1054 or 5% of the total specimens observed. However, the contribution of it to the total catch was well below compared to that of Silky shark.

Out of the 48 species identified, there were only 14 species which had been represented by more than 100 individuals or 0.47% (Table. XVII.).

*Alopias pelagicus* was the least dominant of the 15 species and formed 0.45% of the total.

Except *Loxodon macrorhinus* (Sliteye shark) and *C. macloti* (Hardnose) the others in the Table. xvii. were common components of the catches. The Sliteye and the Hardnose were highly seasonal in their occurrence, about 84% of Sliteye sharks and about 40 % of Hardnose sharks were recorded in September and August 1993 respectively.

The occurrence of the silky shark *C. falciformis* showed peaks in July and December 1993, but these two peaks were not present in 1994. However, a peak was noted in January and February of 1995. During these peak months, a little over 1000 Silky sharks were observed (Fig. 4).

All the major species of sharks caught fell into four major groups, namely the Mackeral sharks, Hammerheads, Threshers and Requim sharks and, the Hammerheads, Threshers and the mackerel sharks were more abundant in the catches from June to September 1993. This trend was repeated also in 1994 but the number of individuals caught in each group was less than that in 1993 (Fig. 5).
The peak for the Requim sharks observed in August 1993 (Fig. 5) was due to the seasonal catch of the Sliteye sharks in this month. From January to March 1995, there was an increasing trend of the Requim sharks catches (Fig. 5).
Table. XVII. Major species of shark present in the catches

<table>
<thead>
<tr>
<th>No.</th>
<th>Species name</th>
<th>Number of individuals</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Carcharhinus</em> falciformis</td>
<td>15837</td>
<td>75.07</td>
</tr>
<tr>
<td>2</td>
<td><em>C. longimanus</em></td>
<td>1054</td>
<td>5.00</td>
</tr>
<tr>
<td>3</td>
<td><em>Loxodon macrochirus</em></td>
<td>824</td>
<td>3.91</td>
</tr>
<tr>
<td>4</td>
<td><em>Alopias vulpinus</em></td>
<td>778</td>
<td>3.69</td>
</tr>
<tr>
<td>5</td>
<td><em>Sphyrna lewini</em></td>
<td>652</td>
<td>3.37</td>
</tr>
<tr>
<td>6</td>
<td><em>Prionace glauca</em></td>
<td>321</td>
<td>1.52</td>
</tr>
<tr>
<td>7</td>
<td><em>C. sorrah</em></td>
<td>285</td>
<td>1.35</td>
</tr>
<tr>
<td>8</td>
<td><em>A. superciliosus</em></td>
<td>232</td>
<td>1.10</td>
</tr>
<tr>
<td>9</td>
<td><em>Isurus paucus</em></td>
<td>158</td>
<td>0.75</td>
</tr>
<tr>
<td>10</td>
<td><em>I. oxyrinchus</em></td>
<td>155</td>
<td>0.73</td>
</tr>
<tr>
<td>11</td>
<td><em>C. macloti</em></td>
<td>124</td>
<td>0.59</td>
</tr>
<tr>
<td>12</td>
<td><em>C. altimus</em></td>
<td>122</td>
<td>0.58</td>
</tr>
<tr>
<td>13</td>
<td><em>S. zygaena</em></td>
<td>120</td>
<td>0.57</td>
</tr>
<tr>
<td>14</td>
<td><em>Galeocerdo cuvier</em></td>
<td>100</td>
<td>0.47</td>
</tr>
<tr>
<td>15</td>
<td><em>A. pelagicus</em></td>
<td>95</td>
<td>0.45</td>
</tr>
</tbody>
</table>
Fig. 4. Monthly variations of number of sharks observed

(SKY = silky shark, OTH = other sharks)
(MAK = Mackerel sharks, HAM = Hammerhead sharks, THR = Thresher sharks, CAR = Requiem sharks except Silky sharks)

Fig 5. Monthly variations of number of individuals recorded in major groups of sharks.
4. Shark fishery

A. Crafts and gears

In the west coast of Sri Lanka, shark fishery is entirely carried out by multiday fishing vessels. There were two kinds of fishing fleets (Abu Dhabi type and 32 footers) both in same size and capacity. Both these types of crafts operated drift gillnet cum long line gear combination. The specifications of craft and gears are given in Table. XIII.

The number of units of nets and hooks used on board different type of craft were not significantly different (Table. XVIII). Each unit of net (one piece) consisted of 1,000 meshes by 80 - 120 meshes with mesh sizes ranging from 14 cm and 15 cm. The nets were hung on to a polypropylene head rope of about 10 -12 mm in diameter.

Each basket of long line consisted of 5 hooks. The distance between adjacent branch lines was about 5m. The number of baskets taken to sea varied from 30 to 150 and the average number of baskets used in one operation was 50. The main line is usually a No. 250-400 monofilament. Tarred Kuralon ropes of 4-6 mm diameter were also used as the main line. The length of a branch lines varied from 8 - 50 meter with No. 200 -300 monofilament. Usually the branch lines were not uniform in length, even within a same basket. Chunked small cetaceans, Skipjacks, Kawakawa, Bullet tuna, Frigate tuna, and Squids were usually used as baits.

As their lengths, average numbers of gear units, crew on board and average number of fishing days were almost same for the two type of fishing vessels which are usually called 32 footers and “Abu-Dhabi” type (fitted with 56 - 75 hp inboard engines) (Table. XVIII), both these categories were considered as one type of fishing craft. [The reason to use the term “Abu Dhabi” type was the source of funding was from Abu Dhabi trust fund which was utilized to construct these type of vessels during 1983 - 87 (MFMP, 1995)].
Highest number of baskets were operated, from March to May 1993 and from January to March 1994. During the months of June and October in 1993 and May to December in 1994 the long line operations declined markedly (Fig. 6.). These periods roughly coincided with the south-west monsoon seasons. In-between these periods the number of baskets operated increased from 26 to 65 (Fig. 6).

Number of net pieces operated during the period of study fluctuated from 25 to 49. From April to September 1993 and from April to October 1994 the number of net pieces operated have not varied significantly (Fig. 6). This is roughly the South – west monsoon period when peak catches are landed by gillnets.
Table. XVIII. Specification of fishing crafts engaged in shark fishery

<table>
<thead>
<tr>
<th>Fishing craft</th>
<th>Length of the craft</th>
<th>Average number of net pieces</th>
<th>Average number of baskets of hooks</th>
<th>Average number of people on board</th>
<th>Average number of fishing days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abu Dhabi type fishing vessel</td>
<td>10.7m</td>
<td>32</td>
<td>52</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Common 32 footers</td>
<td>10-11m</td>
<td>30</td>
<td>48</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>
Fig. 6. Monthly variation of number of units of gears operated per vessel
B. Catch and effort

The average number of fishing vessels that operated per month was 416 during the period of study and it fluctuated from 275 to 665. The average number of fishing operations per boat per day was 1 and the average number of fishing days per trip was 6. Therefore, the average number of fishing operation per month (fishing effort) was 2496. Therefore, the monthly fishing effort varied from 1650 to 3990 (Fig. 7).

The fishing effort seems to be declining from November 93 to April 94 (Fig. 7). The average effort for this six months period was 1920 and it was a 25% deduction from the average monthly effort over the whole year. This period roughly coincided with the inter-monsoon period.

The average CPUE for all species of large pelagics was 266kg per operation and the monthly CPUE varied from 144kg to 441kg during the period of study. However, it did not show prominent peaks. A declining trend of the CPUE was shown from January to April 1994 and this period roughly coincided with the inter-monsoon period. The effort too has declined around the same period (Fig. 7).

There was an increasing trend of CPUE with the fishing effort increasing up to 2550 fishing operations per month and the maximum CPUE (144kg per operation) was reported at that level of effort. When the fishing effort was increasing above the 2550 limit, the CPUE has started to decline (Fig. 8).

The dominant species in the “large pelagic” catches were Skipjack tuna *Katsuwonus pelamis*, Silky shark *C. falciformis*, and Yellowfin tuna *Thunnus albacares*. The catch rate of Skipjack, was 71kg per operation and it varied from 8.5kg to 157kg, that of the Silky shark...
and Yellowfin were 67kg and 60 kg per operation, and they varied from 15.7kg to 280kg and 13kg to 150 kg respectively (Fig. 9).

The lowest catch rates for Silky shark were recorded in October of both 1993 and 1994. In March, April and May of 1993, February, April and May of1994 and January and February of 1995, the catch rate of Silky shark were higher than that of the Skipjack and Yellowfin tuna. From September to December of both 1993 and 1994 the catch rate of the Silky shark were comparatively lower than the other two species of the large pelagics. During the same period the catch rate of Yellowfin tuna was considerably high compared to the Silky shark. In December 1994 catch rates of these three species were the same. Since then the catch rate of Yellowfin tuna has declined and that of Silky shark has increased up to February 1995 (Fig.9).

A clear inverse relationship of the catch rates of the Silky shark and that of the Yellowfin tuna was noted. From March to July1993, from February to June 1994 and from January to February 1995 the catch rates of the Silky shark were higher than that of Yellowfin tuna. During the periods in between, the catch rates of Yellowfin tuna were higher than that of the Silky shark (Fig.9).

At the beginning (March to May 1993), at the middle (Feb. to May 1994) and at the end (Dec. 1994 to Feb. 1995) of the study the silky shark was the dominant species of the catch (Fig. 10). It dominated in 11 months of the period of study while the Skipjack and the Yellowfin dominated in 6 and 7 months respectively.

From June to November in both years, the monthly production of silky shark was low (Fig. 10). Two peaks of the catches of silky sharks were observed in April 1993 and May 1994.
From November 1994 up to February 1995 the monthly production of Silky shark have shown an increase (Fig.10).

The contributions of the Skipjack, Silky shark and the Yellowfin to the mean annual production were 2200mt, 2010mt and 1800mt respectively (Fig.11). Their estimated percentage contributions in weight, to the total catch were 28.88, 25.28, and 22.34 respectively. Over 76% of the total catch was represented by these three species.

The contribution of the Oceanic whitetip *C. longimanus* which was the second dominant shark species of the catch was 0.75% while the other shark species (except the Silky shark) contributed 7% to the total catch. It that shows the relative contribution of the Oceanic whitetip shark was very low compared to the others (Fig.11). However, 33% of the total large pelagic catch was made by the shark species.
Fig. 7. Monthly variation of the fishing effort and the CPUE of the large pelagic fishery
Fig. 8. Variation pattern of CPUE with the fishing effort
SIS- Silky shark, SKJ- Skipjack tuna, TFT- Yellowfin Tuna, TOTAL- CPUE for the total catch

Fig. 9. Monthly variation of CPUE of the large pelagic catch and the three major species.
SIS - Silky shark, SKJ - Skipjack tuna, YFT - Yellowfin tuna

Fig. 10. Monthly variation in the total production of the three major varieties of "large pelagic fishery"
Fig. 11. Total production of major varieties of fish present in large pelagic catches
Fig. 12. Number of Silky sharks *C. falciformis* caught by different gears according to the length classes.

GN - No. of fish caught by gill net fishery,  LL - No. of fish caught by long line fishery
A total of 2231 silky observed sharks were caught in gillnets and 3035 were caught in longlines. Therefore, the percentage contributions were 43% and 57% respectively.

Size of the fish caught by gill nets ranged from 65cm to 255cm and that of the long line from 75cm to 285cm.

The mean length and standard deviation for the gill net catch were 125.15cm and 33.8 while those for the long line catch were 160cm and 97.6.

The mode of the gill net curve is 125 cm and that of the long line curve is 165cm.

Percentage of individuals below 125 cm (the minimum reported length at maturity for either sex of the Silky shark), caught by gill nets (71%) was higher than that of the long line (29%) (Fig. 12).
5. Fishing areas

The multi-day boats targeting sharks, tuna and other large pelagics are operated from Negombo - Pitipana landing center. These vessels fished mostly in the west and north-western waters of Sri Lanka and the area lies apparently between 81 and 70°E longitudes and 5 and 15°N latitudes. However, about 10-15% of the boats fished even beyond the 70°E and 15°N (Fig. 13.a,b,c,d,e,f,g,h).

Seasonally there was a marked difference in the area fished. From March to May, fishing extended toward the north-western direction beyond the 73°E and 6°N, where as from June to August over 95% of the fishing operations have shifted toward south-eastern direction beyond the 73°E and 6°N.

From September to November, over 85% of the fishing operations still remained as in the previous period. An extension of fishing operation, again toward the north-western direction has been initiated during the last month (November) of this period. From December to February the pattern was almost similar to the March – May period.

However, during the entire study period, over 35% of the total fishing operation were concentrated in a small area, between 75.0 and 77.5°E longitudes and 7.0 and 8.0°N latitudes.

These results shows that the shifting of fishing areas (from the north-west and west direction to the south-west and south direction) roughly coincided with the occurrence of the south-west monsoon period (from May to October). During the south-west monsoon months, most of the fishing operations occurred relatively closer to the island, while during the other months, there was a tendency to extend the fishing operations more toward the north-western direction, even beyond the Laccadive islands.
Fig. 13.a. Areas of fishing during March - May 1993

- Fishing area
- Concentrated fishing

Fig. 13.b. Areas of fishing during June - August 1993

- Fishing area
- Concentrated fishing
Fig. 13.c. Areas of fishing during Dec. – Feb. 1993

Fig. 13.d. Areas of fishing during March - May 1994
Fig. 13.c. Areas of fishing during June – Aug. 1994

Fig. 13.f. Areas of fishing during Sep. – Nov. 1994
Fig. 13.g. Areas of fishing during Sep. – Nov. 1993

Fig. 13.h. Areas of fishing during Dec. – Feb. 1993
Table. XIX. Variation of fishing ground during the period of study

<table>
<thead>
<tr>
<th>Periods</th>
<th>Area of fishing</th>
<th>Area of concentrated fishing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. March - May 1993</td>
<td>68.0°E-79.5°E and 6.0°N-13.5°N</td>
<td>75.0°E-77.5°E and 6.5°N-8.0°N</td>
</tr>
<tr>
<td>2. June - Aug. 1993</td>
<td>74.5°E-82.0°E and 4.0°N-8.5°N</td>
<td>77.0°E-78.5°E and 7.0°N-8.0°N</td>
</tr>
</tbody>
</table>
| 3. Sep. - Nov. 1993 | 74.5°E-79.5°E and 5.5°N-10.0°N | 75.0°E-77.5°E and 7.0°N-8.0°N  
|                   |                                  | 78.5°E-79.5°E and 8.0°N-9.0°N |
| 4. Dec. 1993-Feb. 1994 | 71.0°E-80.0°E and 7.0°N-12.5°N | 75.5°E-79.0°E and 7.0°N-8.0°N |
| 5. March - May 1994 | 70.0°E-81.5°E and 3.5°N-12.5°N | 75.5°E-77.5°E and 6.5°N-7.5°N |
| 6. June - Aug. 1994 | 72.5°E-80.0°E and 4.0°N-10.0°N | 75.0°E-78.5°E and 6.5°N-8.0°N |
| 7. Sep. - Nov. 1994 | 73.0°E-79.5°E and 7.0°N-11.0°N | 75.5°E-78.5°E and 7.0°N-8.0°N |
| 8. Dec. 1994-Feb. 1995 | 70.0°E-82.0°E and 5.0°N-13.0°N | 75.5°E-77.0°E and 7.0°N-7.5°N  
|                   |                                  | 78.5°E-80.0°E and 8.0°N-9.0°N |
6. Population parameters

The length frequency distribution of *Carcharhinus falciformis* for the two years studied is shown in Fig. 14. The best growth curves estimated by the complete ELEFAN computer programme (Gayanilo et al 1988) is also shown in this figure. The values for asymptotic length \((L_{\infty})\) and growth coefficient \((K)\) estimated for the stock of Silky shark were 325cm and 0.3 year\(^{-1}\) respectively.

The length converted catch curve of *Carcharhinus falciformis* is shown in Fig. 15. The estimated mortality rates and exploitation rate were as follows.

- Instantaneous total mortality coefficient \((Z)\) = 1.68
- Natural mortality coefficient \((M)\) = 0.42
- Fishing mortality coefficient \((F)\) = 1.26
- Exploitation rate \((E)\) = 0.75

The estimated fishing mortality coefficient for the gillnet and long line combination of gear was 1.68. The mean annual effort was 29898 operations per year. Therefore, the estimated catchability coefficient was \(5.6 \times 10^{-5}\).

The probabilities of capture of *C. falciformis* is shown in Fig. 16. The estimated sizes of *C. falciformis* at 25%, 50%, and 75% probabilities of capture were 123.35, 130.72 and 149.47 respectively. Results of the analysis of the recruitment pattern of *C. falciformis* during the study period are shown in Fig. 17. This shows one peak around late July - early August.
Species name: C. falciformis (Silky shark)

Loo 325.00
K 0.300
C 0.000
WP 0.000
SS 2
SL 135.00
Rn 0.092

Fig. 14. Monthly length frequency distribution of Carcharhinus falciformis during the study period with the estimated growth curves
Fig. 15. Length converted catch curve of *Carcharhinus falciformis*
PARAMETERS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>File</td>
<td>SILKY</td>
</tr>
<tr>
<td>L_5</td>
<td>325.00 cm</td>
</tr>
<tr>
<td>K</td>
<td>0.300</td>
</tr>
<tr>
<td>C</td>
<td>0.000</td>
</tr>
<tr>
<td>WP</td>
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<td>tx</td>
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</tbody>
</table>

Estimates

<table>
<thead>
<tr>
<th>Length Class</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>L_{25}</td>
<td>123.35 cm</td>
</tr>
<tr>
<td>L_{50}</td>
<td>138.72 cm</td>
</tr>
<tr>
<td>L_{75}</td>
<td>149.47 cm</td>
</tr>
</tbody>
</table>

PROBABILITY OF CAPTURE ANALYSIS

INSTRUCTIONS

Species name: C. falciformis
Other identifiers: Silky shark

Fig. 16. Probability of capture analysis of *Carcharhinus falciformis*
Fig. 17. Recruitment pattern of *Carcharhinus falciformis*
Discussion

Species identification

Sharks and their allies, rays skates, rat fishes and chimaeras, are classified under sub-class Elasmobranchii of the class Chondrichthyes, all of which are cartilaginous fishes (Jordan, 1925).

Sharks, rays and skates have a unique sort of blood, because their kidneys actively reabsorb urea (the end product of protein metabolism) so that it is retained in blood for ionic and water regulation (Nielsen, 1994) and have upper jaws slung from their skulls not fixed as with chimaeras and ratfishes, so they are placed in a sub-class Plagiostomi (the odlique mouth).

Sharks differ from rays and skates because their pectoral fins are separate form the side of their heads; they have free upper eye lids, and gill openings on their heads (in rays they are located below the pectoral fins). Based on these characters most writers (Jordan, 1925, Young, 1981, Compagno, 1984 and Smith, 1986) have contended themselves with placing the sharks in one super-order Selachimorpha.

This super order comprises eight orders of sharks. Hexanchiformes- the frilled and cow sharks, Squaliformes- the dogfish sharks, Orectolobiformes- the carpet sharks, Lamniformes- the mackerel sharks, Carcharhiniformes- the ground sharks, Pristiophoriformes, the saw sharks, Squatiniformes the angel sharks and Heterodontiformes- the bullhead sharks (Compagno, 1984 and Smith, 1986).

The present study revealed the occurrence five of the above mentioned orders of sharks, in the catches landed at Pitipana fish landing centre. The species belonging to the latter three
Though the presence of the Great White Shark, *Carcharodon carcharias* (Linnaeus, 1758) was recorded by De Silva in 1984 as an observation made by him in Galle harbour in 1965, no records have been made thereafter about this shark. According to Compagno 1984, no evidence is available about the occurrence of this shark from the Sri Lankan waters.

De Silva (1985), has reported the presence of forty-four species belonging to five orders and fourteen families in the Sri Lankan waters. However, ten of them, *Notorynchus cepedianus* (Peron, 1807), *Chiloscyllium plagiosum* (Bennett, 1830), *Eugomphodus taurus* (Rafinesque, 1818), *Chaenogaleus macrostoma* (Bleeker, 1852), *Hemigaleus microstoma* (Bleeker, 1852), *Carcharodon carcharias* (Linnaeus, 1758), *Carcharhinus amblyrhynchos* (Whitley, 1934), *C. dussumieri* (Valenciennes, 1839) *C. sealei* (Pietschmann, 1916) and *Rhizoprionodon oligolinx* (Springer, 1964), were not recorded during the present study. Compagno, (1984), has already mentioned the occurrence of these species in the waters around Sri Lanka.

Due to lack of details about the study areas and the methodologies used in De Silva’s identifications, the information in De Silva (1984) is of very little assistance for a comparative analysis with the findings of the present study.

Four sphyrid sharks (Hammerhead sharks) recorded by Goonawardene, (1971) and Jinadasa, (1995) and thirteen species belonging to three Orders and six Families recorded by Amarasekara and Joseph (1987), were repeatedly recorded during this study.

De Bruin (1994), has recorded 4 orders, 14 families, 24 genera and 41 species from the Sri Lankan waters. However, two families (Scyliorhinidae and Proscylliidae of the Order Carcharhiniformes) and ten species [*Eridacnis radcliffei* (Smith, 1913), *Eugomphodus*...
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99
*tricuspedatus* (Day, 1878), *Chiloscyllium plagiosum* (Bennett, 1830), *Atelomycterus marmoratus* (Bennett, 1830), *Halaelurus hispidus* (Bleeker, 1852), *hemigaleus microstoma* (Bleeker, 1852), *Carcharhinus amblyrhynchodes* (Whitley, 1934), *C. dussumieri* (Vaenciennes, 1839), *C. sealei* (Pietschmann, 1916) and *Rhizoprionodon oligolinx* (Springer, 1964) recorded by him were not found during the present study.

Sivasubramaniam (1969), recorded the presence of 11 predatory pelagic sharks in the coastal waters of Sri Lanka and, except one species *Sphyrna tudes* (Valenciennes, 1822) (Small-eye hammerhead), others were repeatedly recorded during this study.

The only study in the past on the taxonomy of sharks landed in the commercial catches was carried out by Amarasekara and Joseph (1987). Except this study, the main aim of the others was to list the shark species present in the territorial waters of the country.

Almost all the shark catches landed at Negombo - Pitipana fish landing centre were brought by the multiday fishing vessels. Over 90% of them carried out their fishing operations beyond the continental shelf of the island and targeted the oceanic or offshore pelagic sharks. That could be the reason for the absence of some coastal pelagic and demersal species and the presence of some new pelagic species in the findings of the present study.

The results of the present study revealed the occurrence of 48 species of sharks belonging to 5 orders, fifteen families and 26 genera within the areas where the fishing operations were carried out.
Two families, **Pseudocarchariidae** and **Squalidae** and nine of the species identified, **Centrophorus moluccensis**, **C. uyato**, **Centroschyllium ornatum**, **H. griseus**, **O. noronhai**, **O. ferx**, **P. kamoharai**, **I. paucus**, and **C. plumius** were found to be hither to unrecorded taxa from Sri Lanka.

Identified species of shark are ranked according to the number of individuals in each species recorded in the catches within the study period (Table. XX).
Table. XX. Ranking of the species present in the shark catches landed.

<table>
<thead>
<tr>
<th>Ranking No.</th>
<th>Number of individuals presented</th>
<th>Percentage</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>1500 or more</td>
<td>75%</td>
<td><em>Carcharhinus falciformis</em></td>
</tr>
<tr>
<td>02</td>
<td>500 – 1499</td>
<td>3-5%</td>
<td><em>C. longimanus</em>, <em>A. vulpinus</em>, <em>S. lewini</em>, <em>L. macrorhinus</em></td>
</tr>
<tr>
<td>03</td>
<td>100 – 499</td>
<td>0.5-1.5%</td>
<td><em>P. glauca</em>, <em>C. sorrah</em>, <em>A. superciliosus</em>, <em>I.paucus</em>, <em>I. Oxyrinchus</em>, <em>C. macloti</em>, <em>C.altimus</em> <em>S.zygaena</em>, <em>G.Cuvier</em>, <em>Centrophorus moluccensis</em></td>
</tr>
<tr>
<td>04</td>
<td>10 – 99</td>
<td>0.05-0.45%</td>
<td><em>A. pelagicus</em>, <em>Chiloscyllium griseum</em>, <em>P.kamoharai</em>, <em>A.pelagicus C. albimarginatus</em>, <em>C. melanopterus</em>, <em>T. Obesus</em>, <em>E. blochii</em>, <em>Centrophorus uyato</em></td>
</tr>
<tr>
<td>05</td>
<td>Less than 10</td>
<td>&lt;0.05%</td>
<td><em>H.griseus</em>, <em>O.ferox</em>, <em>C.ambioinensis</em>, <em>C.plumbus</em>, <em>L. temminki</em>, <em>C. ornatum</em>, <em>D. licha</em>, <em>E. brucus</em>, <em>C.indicum</em>, <em>N. Ferrugineus</em>, <em>S.fasciatum</em>, <em>R.tupus</em>, <em>O.noronhai</em>, <em>M.manazo</em>, <em>M.mosis</em>, <em>H.elongatus</em>, <em>C.amblyrhychnos</em>, <em>C.brevipinna</em>, <em>C.hemiodon</em>, <em>C.limbatus</em> <em>C.wheeleri</em>, <em>N.Acutidens</em>, <em>R.acutus</em>, <em>S.laticaudus</em>.</td>
</tr>
</tbody>
</table>
Carcharhiniformes is the most diverse order of the sharks in the world. It comprises 193 living species belonging to 8 families and 48 genera (Compagno, 1984). Even in the present study this order was the most diverse one and it was represented by 29 species belonging to 4 families and 13 genera.

There are 73 living species of sharks in 18 genera belonging to 3 families of the order Squaliformes (Compagno, 1984) and this is the second most diverse order in the world. But in the catches monitored this order was represented by only 5 species belonging to 2 families and 4 genera.

The order Lamniformes comprises 16 living species of the world belonging to 7 families and 10 genera (Compagno, 1984). During the study period 8 species of this order belonging to 4 families and 4 genera were recorded.

The order Orectolobiformes comprises 31 living species in the world belonging to 7 families and 13 genera (Compagno, 1984). This order was represented by 4 families, 4 genera and 5 species in the monitored catches.

The order Hexanchiformes is the second least diverse order of the sharks in the world and it comprises five species belonging to 4 genera and 2 families (the world’s least diverse order is Pristiophoriformes, it comprises one family, 2 genera and 5 species) (Compagno, 1984). This order was represented in the monitored catches by only one species.
Therefore, it can be concluded that the most diverse order of sharks in the present study was Carcharhiniformes, followed by the Orders Lamniformis, Orectolobiformes Squaliformes and Hexanchiformes. The last one was the least diverse among the orders present in the catches.

Out of the 29 species identified within the order Carcharhiniformes, 14 belonged to the genus *Carcharinus*. This is the largest genus of shark in the world and it comprises 29 living species of sharks (Compagno, 1984). Other than these 29 species, a new species of this genus, *Carcharinus tilstoni* has been identified from Australian waters by Lavery and Shaklee, 1991, using genetic evidence.

De Bruin (1995), has recorded the occurrence of 14 species of sharks belonging to this genera from the Sri Lankan waters. Out of these 14 species, three (*C. amblyrhyynchoides*, *C. dussumieri* and *C. sealei*) were not recorded in the present study.

One species identified in this genus, *C. plumbius*, is a new record from Sri Lanka.

One family, *Pseudocarcharididae* and four species *Pseudocarcharias kamoharai*, *Odontaspis noronhai*, *O. ferox* and *Isurus paucus* of the order Lamniformes were found to be hither to unrecorded taxa from Sri Lanka.

Although the number of individuals caught were well below compared to the Carcharhiniformis sharks, some Lamniformis sharks were common components of the shark catches.
Among them, two *Isurus* species have been recorded throughout the study period. There are two species of Lamnid sharks *Isurus oxyrinchus* and *I. paucus* in the world (Compagno, 1984), and both species were present in the catches observed. Moreno and Moron (1992), recorded the presence of a new variety of Genus *Isurus* from Spanish waters called 'Marrajo criollo' although its taxonomic status is not still cleared.

The only notable recent approach made into the taxonomy of shark in the northern Indian ocean region (FAO fishing area No. 51) is “The Shark Fisheries In the Maldives” (Anderson and Ahmed, 1993). This study identified 26 species from Maldives. Four species (three *Centrophorus* and one Proscylliid) have been collected but their identity not confirmed. Four more species are believed, on circumstantial and anecdotal evidence, to exit in Maldavian waters. Thus, a total of 34 shark species are currently thought to be found in Maldives. However, the investigators of the above study have included two species, in their check list, *Rhina ancylostoma* (Bowmouth Guiter fish) and *Rhynchobatus dijiddensis* (Giant Guitarfish) which can not be considered as sharks. According to the taxonomic-principles followed in the present study these two species are basically skates.

A total of 72 shark species were recorded from the trawl catches of southern Indonesia and northwestern Australia. This portion of the Indian ocean is included in the FAO fishing area No. 57. These catches comprised of 3 Hexanchids, 8 Hqualids, one Squatinid, one Heterodontid, 10 Hemiscylids, one Stegostomatid, one Ginglymostomatid, one Rhiniodontid, 2 Odontaspidis, one Pseudocarcharhinid, 3 Alopiids, one Lamnid, one Scyliorhinid, one Triakid, 3 Hemigaleids, 29 Carcharhinids and 4 Sphyrnids (Tarp and Kailola, 1984). Forty one of them were present in the observed catches of the present study.
Species abundance

The results of this study revealed that 90% of the sharks identified from the off-shore gillnet and longline fisheries belonged to the order Carcharhinidae with *Carcharhinus falciformis* (75%) being the most dominant species. Amarasekara and Joseph (1987), estimated the contribution of the Carcharhinid sharks to the catch as 82% and of which 73% of the catch was represented by *Carcharhinus falciformis* alone.

Joseph (1997), has reported that the Blue shark *Prionace glauca* and the Oceanic Whitetip shark *C. longimanus* were the second and third dominant species of the large pelagic catch and their contribution were 12.3% and 6.3% respectively. According to the present study the Oceanic whitetip shark was the second dominant species while the Blue shark was the third. Their contributions to the catch were 5% and 3% by weight respectively.

As far as the number of fish caught was concerned the position of the Blue shark has come further down in the list to sixth position (Table. XVII). The reason for this could be the seasonal catch of large school of juvenile Sliteye sharks in August 1993 and high representation of the Thresher sharks and Scallop hammerheads in the catches during the South-west monsoon periods (Fig.3 and 4).

Other than the requim sharks (the sharks belong to the family carcharhindae), the mako, hammerheads and the threshers were the major groups of sharks in the large pelagic catches.
Sivasubramanium (1969) had reported that in the tuna fishing ground of the Indian Ocean, the mako sharks (genus *Isurus*) show a relatively higher percentage composition of the species hooked on the longline, for areas north of the equator than for those south of the equator. During the period of this study, the longline operations were carried out entirely in the areas north of the equator. About 10% of the hooked sharks were belonged to the genus *Isurus* and it was the second dominant genus of the longline catch of sharks.

There were two South-west monsoon periods during the study period (from May to September of 1993 and 1994). Within these periods, relatively high catches of hammerhead sharks (*Family Sphyrnidae*) and the thresher sharks (*Family Alopiidae*) were reported. The reasons behind this seasonal occurrence could be the shifting of the fishing areas during the South-west monsoon period (from North-west to South-west and South directions and from the distant fishing grounds to closer ones), declining of the longline operation during the monsoon period (average number of basket of hooks used during the monsoon period were reduced by about half fold), migratory behaviour (horizontal or and vertical) of these groups of shark during the monsoon period (however, literature is not available in this regard) and the development of the northern Somali Current during the Southwest monsoon in the northern Indian ocean (Tomczak and Godfrey, 1994).

Due to heavy rains, strong winds and rough sea condition during the monsoon periods, most of the fishermen limit their operations to the areas closer to the coast and fishermen tend to limit the long line operations (there is a high possibility of breaking the main line and the branch lines and entangling of the adjacent branch lines). Therefore, a relatively high catch of the species inhabiting the coastal waters with a tendency to gill or entangle in gill nets could be expected.
According to Compagno (1984), the hammerheads and threshers identified are either coastal, pelagic or semi-oceanic sharks (except the pelagic thresher *A. pelagicus*). The depth of occurrence of the hammerhead species, *S. lewini*, *S. mokarran*, and *S. zygaena* are surface to 275m, 80m, and 20m respectively and that of *A. superciliosus* and *A. vulpinus* range from the surface to at least 500m and 350m and prefer to live in deeper zone of coastal waters, over the continental shelves. Therefore, the high contribution made by them during the respective monsoon periods can be accepted. *A. pelagicus* is primarily an oceanic, epipelagic species and the depth of occurrence range from surface to 152m, their contribution (4%) to the total catch of hammerheads and threshers was insignificant.

**Silky shark fishery**

The drift gill net cum longline combination was the only gear used in the 'large pelagic fishery' during the study period. However, a declining trend of long line operations were noticed during the south-west monsoon period (May to September) while the gill net operations were continuing throughout the year.

Catch and effort statistics of the present study shows an increasing trend of CPUE with the effort up to 3200 operations per month and a declining trend of CPUE above that level of effort. Therefore, the introducing of more multiday fishing vessels will lead further declining of CPUE. Identifying of new fishing grounds and introducing of new fishing methods (eg. Deep sea longlining for Bigeye tuna) are required for a better CPUE in large pelagic fishery.

Results of the present study revealed that the Silky shark was the dominant species in the shark catches. According to Sivasubramaniam (1992), the Silky shark, much of it immature, contributes to more than 50% of the Sri Lankan shark catch. Joseph (1997)
estimated that the contribution of this species to the total shark catch was 60.9% by weight. The result of the present study reveal that about 3/4 (74.5%) of the estimated total shark catch consist of the Silky shark.

North of the equator Silky shark has a density of distribution equal to or even higher than that of Oceanic whitetip. In the central part of the north-equatorial region Silky shark has the highest density of distribution for any shark species in the tuna grounds of the Indian Ocean (Sivasubramaniam, 1969). During the study period the distribution of the fishing grounds were located totally in the region north of equator. That could be the reason for the high catch of the Silky shark. This could be attributed to that, their distribution in association with north-equatorial region.

The reason behind the declining of Silky shark catches from June to October of both years could be the shifting of fishing areas and the reduction of long line operations due to the monsoon weather conditions. However, as the study was confined to just two years, these findings are very preliminary.

A fishing ground close to Chagos archipelagos and Diego Garcia islands, within British Indian Ocean Territory (BIOT) have been located by local fishermen in 1995. Since then fishermen starting fishing there. As a result the shark catches (especially the silky shark) have been significantly increased from Nov. 1994 to Feb. 1995.

Several arrests of Sri Lankan fishermen by BIOT fisheries patrol have been reported by Anderson et al. (1996), since Oct. 1995 and proves that the shark catches are also brought in from BIOT.
The size (total length) of the silky sharks caught by longline is relatively larger than that of the gill net catch, the respective mean lengths were 160cm and 125cm. The contribution made by the longline catch to the total Silky shark catch was 14% higher than that of the gillnet catch. Therefore, it can be concluded that the longline is more efficient than the gillnet in the silky shark fishery. However, both these gears caught a large number of juvenile sharks and their contribution to the total catch was well above 50% (as mentioned below). Therefore, the continuation of this fishery at the present rate could badly affect the survival of the silky shark populations in the wild.

**Biological parameters of Silky shark *C. falciformis***

The Silky shark, *C. falciformis*, is a large, pantropical species attaining 330cm total length (Garrick *et al.*, 1964) and inhabits both coastal and oceanic waters. Fisheries for this species probably exist world-wide although population dynamics and structure of this species were poorly known (Compagno, 1984). World-wide there have been very few studies concerning silky shark biology. This has hindered studies of its potential for exploitation (Bonfil *et al.*, 1993). In Sri Lanka, silky shark is one of the most important species of the large pelagic fishery.

Bass *et al.* (1973), estimated the length at maturity of silky shark in the western Indian Ocean to be 240 and 248-260cm for males and females respectively.

However, the study conducted by Bonfil *et al.*, (1993) on silky shark in Campeche Bank, Mexico, revealed the males become mature at 10 years of age and at 225cm of total length while females become mature at 12 years of age and at 232-245cm of total length. According to Compagn (1984), males mature at about 187 to 217cm and females mature at 213 to 230cm.
As revealed during the present study the length frequency of the silky sharks ranged from about 70cm to 285cm. Though several attempts were made to obtained the length frequency range of this species from the regional countries, no response were met. As far as the Sri Lankan catches were concerned, the majority of the individuals caught were below 187cm (total length), which is about the lowest value recorded for the length at maturity for any sex. In the gillnet catch the percentage composition of the individuals below 185cm was around 97% while that for the longline catch was around 84%. It is noteworthy the fact that almost 89% of the total individuals caught by both gears were below 185cm. Therefore, it is safer to say that large number of immature individuals from the populations of silky shark are exploited by the gear presently employed in the large pelagic fishery of Sri Lanka. However, it is impossible to assess the impacts of the existing fishery on the silky shark populations inhabiting the Indian Ocean since the stock status is poorly understood.

The estimated values for the growth parameters (k and \( L_\infty \)) of this species obtained during the present study were 0.3 and 325cm respectively. However, these estimated growth parameters do not agree with some of the values reported so far.

The values for k and \( L_\infty \) of \textit{C. faiiciformis} estimated by Hoenig (1979) in the seas off Rhode island were 0.048 and 468cm respectively. In the North-western Gulf of Mexico the estimated values for the respective growth parameters of Silky shark were 0.153 and 291cm (Branstetter, 1987). Bonifil et al., (1993), revealed the values for k and \( L_\infty \) of the Silky shark in the Campeche Bank of Mexico to be 0.101 and 311cm respectively.

The estimated value for the growth constant of \textit{C. faiiciformis} during the present study is relatively high compared to the values reported in the above mentioned studies. This could
have been partially due to the significant high contribution by relatively smaller individuals to the catch on account of the selectivity of the gear employed in the fishery. In addition there may be stock specific reasons, sample bias (sampled only in a limited area), analytical errors or a combinations of these.

However, this is the first attempt that ELEFAN programme is used in analysis of population parameters of a Chondrichthyes species.

The estimated value for \( L_{\infty} \) during the present study was very much closer to the proposed value for the maximum total length of this species (330cm) as recorded by Compagno (1984) and Garrick et al., (1964).

The estimated value for the exploitation rate \( (E) \) of \( C. faiiformis \) during the present investigation was 0.75. However, according to Gulland (1975) the optimum fishing mortality of an exploited stock should be approximately equal to natural mortality or \( E \) optimum should be equal to 0.5. As the present level of exploitation seems to be an over exploitation, immediate introduction of management measures are highly required.

Due to insufficient information such as the range of distribution, migratory behaviour etc. about the Silky shark stocks within the fishing areas concerned, the data collected were not used in a Virtual Population Analysis. Therefore, no predictions were made for resource management purposes.
References


## Appendix - 1

### Synonymy of the Identified shark species

<table>
<thead>
<tr>
<th>No</th>
<th>Species</th>
<th>Synonymy</th>
</tr>
</thead>
<tbody>
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<td>1</td>
<td>Centrophorus moluccensis</td>
<td>C. sculpratus, Atractophorus armatus</td>
</tr>
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<td>2</td>
<td>C. uyato</td>
<td>Squalus infernus, Acanthias nigrescens, C. armatus barbatus</td>
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<tr>
<td>3</td>
<td>Centrosylium ornatum</td>
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<td>Dalatias licha</td>
<td>Squalus americanus, Dalatias soralophagus, S. nicaensis, S. scymnus, Scymnus vulgaris, S. aquitanensis, Scymnornis philippisi, Pseudocymnus boshuenensis, Scymnornis brevipinna, D. tachiensis</td>
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<td>5</td>
<td>Echinorhinus brucus</td>
<td>Squalus spinosus, E. obesus, E. maccroi, Rubusqualus maccroi</td>
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<td>Hexanchus griseus</td>
<td>Squalus vacea, Notidampus monge, N. vulgaris, H. Corinus, H. griseus australis</td>
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(Compagno, 1984)