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Physico-Chemical Characterization of Shark-Fins

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PHYSICO-CHEMICAL CHARACTERIZATION OF SHARK-FINS

BY

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ABSTRACT

Shark-fins are one of the most expensive fish products in the world that fetch high prices in the oriental market. The value of the fins depends on the species, size and quantity of fin needles. These factors are largely determined by the intrinsic chemical and physical characteristics of the shark-fins which this study addressed.

In order to formulate the relationship between body size and fin sizes of sharks, seven hundered and sixty-six shark specimens were measured and recorded from landing sites in Oman between July, 1991 to June 1992. The regression of body size in relation to the fin sizes revealed different R^2 within and among the different species of sharks. The best correlation was between the precaudal length and all four fins (dorsal, pectoral, tail and lower lobe of tail), especially in the spinner shark (R^2=0.97). This will aid shark-fin vendors and purchasers to estimate sizes of the identified species to predict their values in the market.

In the yield studies, the white fins gave a higher yield than the black fins. However, the lower lobe of tail from black varieties gave the heighest yield in fin needles, especially in the silky shark. Processing and

extraction of fin needles from pectoral fins of dogfish was more economical than from the tail as it required a about half the time of the tail processing.

The thickness of fin needles was directly proportional to the size of the fins. Due to swelling in preheated water at 60-70^{o}C, fin needles increased in thickness to an average of 79.8% of their original width and decreased in length to an average of 57% of their original length.

The proximate analysis of fin needles showed a very high nitrogen content, very low ash and no oil content. non-protein nitrogen was not detected. To the contrary, the fin's flesh had a higher content of non-protein nitrogen, ash and fat than the fin needles. The amino acid distribution of elastoidin is similar to that of collagen, except that the former contains cystine and a higher amount of tyrosine. The amino acid profiles indicate no signifcant difference between fin needles extracted from white varieties or black varieties of fins. The essential amino acids score of elastodin was less than half that of casein. Thus shark-fin is of low nutritional value. Elastoidins are very rich in sulfur which may explain the peculiar hydrothermal properties that distinguish them from other collagens.

Needles extracted from shark-fins are of high commercial value and are in high demand among the Chinese. This suggests that future studies could concentrate in

finding innovative methods to produce artificial needles or use the extrusion techniques to prepare protein fibers from shark-fins simulating the shark-fin needles.

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PREFACE

This thesis is prepared in the standard format according to the format specified by the graduate school at the University of Rhode Island.

Diagrammatic details on shark-fin's skeletal anatomy, measurement and cutting, processing, product forms and swelling in collagen fibrils are given in appendices 1-5; Details on raw data collected on the relation between shark body size and fin sizes and computer outputs are given in appendices 6-12.

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INTRODUCTION

Elasmobranchs which includes sharks, skates and rays are one of the most abundant apex predators in the sea. They are a strong and valuable component in marine fisheries which occupy the role of top predators within marine food webs.

From man's perspective, sharks have been considered both an unavoidable naisance, and an exploitable fishery resource. The commercial exploitation of sharks as a marine resource vary from meat and fin uses to leather industries. The meat is usually dried when it cannot be refrigerated while fins are usually dried for exportation to Asia (Applegate et al., 1993).

The demand for fins is high in the oriental countries where they are made into shark-fin soup. Fins which are highly regarded by the Chinese are considered the most valuable part of the shark and one of the most expensive food items in the world. With a Chinese population of over five million, Hong Kong is one of the most important market for shark-fins. According to trade statistics, as many as 64 countries supply shark-fins to Hong Kong. In 1982, 2,746 tons, valued at US $ 148.5 million, where imported (Ka-keong, 1983).

The market is highly quality conscious and the quality

and quantity of fin needles in the shark-fins is very important. These fin needles or rays with the cartilaginous radials serve to support the fins are also called elastoidin fibers or ceratotrichia (Alexander, 1975; Budker, 1971; Jollie, 1962). Best prices are obtained for a complete set of fins from a single fish rather than a mixture of all sorts of fins together (King et al, 1984). However, present day exports are mainly graded by the type, size and color (black or white fins) (Subasinghe, 1992).

This study investigated the relationship between body size to fin sizes for sharks valued for their fins which could be harvested off the Omani coast. Processing and yield studies of fin needles of the different shark species identified during the study in Oman. Further study involved the dogfish (Squalus acanthias), harvested off the Rhode Island coast. Physical and chemical characteristics were investigated in order to evaluate the chemical composition of fin needles.

LITERATURE REVIEW

1- SHARKS AND THEIR RELATIVES

A- EVOLUTIONARY BACKGROUND:

Sharks share the phylum Vertebrata; the superclass Pisces with all fish; the class chondrichthyes (cartilaginous fish) with skates, rays and chimaeras; the subclass Elasmobranchii with skates and rays; the order Selachii meanings sharks in Greek (Lineaweaver, 1970).

The fossil record of the cartilaginous fish consists mainly of teeth, spines and vertebrae since cartilage disintegrates shortly after death. These cartilaginous fish arose from the Placodermi (armored fishes) in the Devonian period. The placodermi mark a notable advance in vertebrae evolution in their possession of hinged jaws which revolutionized the feeding method and hence became more active and predaceous with paired fins development (Alexander, 1975; Castro, 1983; Keeton, 1967; Marshall, 1965).

To provide a framework for considering the mainstream of elasmobranch evolution, scientists divided the shark evolution into three periods or levels:- (Castro, 1983;

Gilbert, 1967; Maisy, 1987).

The Cladodont Level: The most ancient and primitive sharks, which started some 400 millions years ago and lasted for about 50 million years. Their name is derived from their multicuspid teeth (cladodont = branched tooth) and the best known of the cladodont shark is Cladoselache. As indicated by fossil records found in Ohio, Kentucky, and Tenessee, it was only about a meter long shark. The pectoral fins did not have narrow bases as in modern sharks, so their range of movement must have been limited. All the fins had undivided radials reaching close to the fin margins, instead of having most of the fin stiffened only by ceratotrichia.

The Hybodont Level: The hybodont shark form an intermediate level in shark evolution which started 345-280 millions years ago. Their name derived from their crushing teeth (hybodont = "humpback" tooth). A typical hybodont is Hybodus. These sharks had improved maneuverability and locomotion provided by their movable narrow-based fins. The radial of their pectoral fins were reduced and divided.

The Modern Elasmobranch Level: New sharks evolved with more progressive feeding and locomotion in about 135-65 million years ago. Such sharks had shortened protrusible jaws and calcified vertebrae. These early modern sharks, represented by Pleospinax, established the

evolutionary pattern for today's sharks and rays.

The sharks continued to evolve with cylindrical bodies and are divided into eight major orders, 30 families that contain 350 or more species.

The batoids or rays are different from sharks as they evolved as bottom dwellers with flattened bodies; these number about 430 species today. The tail is slender and the pectoral fin usually meet in front of the head. According to Marshall (1965) these enlarged wing-like pectoral fins of the rays, are built around long jointed rays of cartilage called radials that are attached to large basal cartilage.

Others, like the guitarfish, sawshark and sawfish are intermediate in shape between sharks and rays. They have long, shark-like caudal and dorsal fins supported only by cartilaginous radials and ceratotrichia.

B- General Remarks on sharks:

Sharks include a variety of usually cylindrical, elongated, or moderately depressed fish which differ from the closely related rays or batoids in having lateral gill openings and pectoral fins not fused to the sides of the head over the gill openings. Sharks have eyes on dorsal surface or sides of the head and spiracle through which water can enter and pass directly over the gills

(Ronsivalli, 1978). There are usually five pairs of gill opening located laterally, rarely six or seven. The mouth is usually ventral or subterminal on the head. The teeth on the jaws are set in numerous transverse rows and are constantly replaced from inside the mouth (Fischer and Bianchi, 1984).

Mature sharks vary in length from 15-19 cm to 12.1 m or more, and with weight varying from 10-20 gm to several metric tons. Most sharks are of small or moderate sizes; about 50% are of small sizes, 32% between 1 to 2 m; 14% between 2 to 4 m; and 4% over 4 m in total length (Fischer and Bianchi, 1984).

Most sharks are carnivorous, they feed on benthic invertebrates to pelagic cephalopods, small to large bony fish, and other sharks and rays. Ironically, the two largest species, whale sharks and basking shark feed on plankton by filtering water through their gill slits (Stevens, 1987).

According to Fischer and Bianchi (1984) the richest shark faunas occur in the Indo-west Pacific from South Africa and the Red Sea to Australia and Japan which includes the FAO fishing area 51. The Western Indian Ocean and Red Sea have an extremely diverse shark fauna, including 23 families, 62 genera, and at least 115 species. However, the Eastern waters of North America inhabited by only 62 species and most of these sharks are

oceanic (Seymour and Danberg, 1985).

C- Biological Characteristics of Sharks:

1- Biology of Sharks:

Marine teleosts maintain their blood concentration much lower than the surrounding sea water, thus must drink sea water to make up the osmotic water loss (and ion gain) across the permeable surfaces. However, in elasmobranchs tend to have blood osmolarity slightly more concentrated than the sea; thus they are able to prevent excessive gain or loss of water physiologically (Boylan, 1967; Moyle and Cech, 1988; Ronsivalli, 1978).

The high osmolality is achieved by combining a total blood electrolyte concentration about the same as, or a little greater than, that of the marine teleost fish, with the retention of urea and trimethylamine oxide (TMAO) in the blood. Consequently, water enters the body by osmosis as well as electrolytes tend to enter by diffusion, especially Na^+ and Cl^- as the salt concentration in the blood is less than in the sea water. The concentration of the various solutes, mostly sodium, chloride, urea, and TMAO, in the blood of elasmobranchs combine for an osmolality of about 1000-1100 milliosmole (mOsm)/kg while in the sea water is about 930-1030 mOsm/kg (Bond, 1979).

since elasmobranchs must excrete salts, they posses a unique physiological organ specialized in sodium excretion known as rectal gland. This gland supplement the kidney as a pathway for salt removal (Hickman Jr. and Trump, 1969; Bond, 1979; Oguri, 1990).

High urea concentration is maintained in elasmobranch by both the relative impermeability of urea by the kidney. This is unique. The kidney of most other vertebrates excrete urea instead of retaining it (Oguri, 1990). As much as 90-95% of urea, which is produced as end product of nitrogen metabolism in the liver and 95-98% of the filtered TMAO are reabsorbed by the tubules of the kidney of dogfish, Squalus acanthias (Hickman jr. and Trump, 1969; Perlman and Goldstein, 1988).

According to Perlman and Goldstein (1988) urea in elasmobranch may arise via three pathways: The Ornithine cycle, Purine pathway, and by the breakdown of dietary arginine. Many of the enzymes involved in these pathways have been shown to be present in the livers of a number of elasmobranchs. There is evidence for the presence of arginase, argininosuccinate synthetase and argininosuccinate lyase in the case of ornithine cycle and dietary arginine while enzymes such as urate oxidase, allantoinase, and allantoicase in the purine pathway in the livers of elasmobranchs (Goldstein, 1967).

The origin of TMAO in elasmobranch is not clear and

it is synthesized at a very low rate, to compensate the losses in the kidney and the gills (Goldstein and Funkhouser, 1972). According to Yancey and Somero (1979) marine elasmobranchs contain urea at concentration averaging 0.4M, which is high enough to significantly affect the structure of many proteins and the functions of many enzymes. Also present in the cells of these fish various methylamine substances such as trimethylamine oxide (TMAO), betain, sarcosine, and taurine in total concentration of 0.2M, or about half the urea concentration. These methylamine compounds and amino acids may be able to exert stabilizing influences on macromolecules and thus offset the destabilizing effect of urea. Maximum counteracting effects are attained when the methylamine compounds and urea present at elasmobranch physiological concentration or molar ratio of 1:2. Yancey and Somers (1979) have also shown this stabilizing effect of methylamines on certain mammalian enzymes that are not normally subjected to high urea concentrations. They tested the thermal stability of bovine ribonuclease and the reactivity of thiol groups of bovine glutamate dehydrogenase. Several other skeletal muscle enzymes such as creatine kinase, lactate dehydrogenase, and pyruvate kinase have been found at urea to methylamine ratio of 2:1, are effectively stabilized in elasmobranchs, holocephali, and more later in Latimeria (Bone and

Marshall, 1982). According to Stryer (1988) evidences indicate that urea act by disrupting non-covalent interactions in polypeptide in which, the reduced, randomly coiled polypeptide chain devoid of enzymatic activity. However, the presence of these compounds and amino acids will counteract urea action by stabilizing many inter- and intra-macromolecular interactions involving non-covalent bonds.

Cartilaginous fish have large fatty livers. As a result, their hepatosomatic index (HSI) which is expressed as a percentage ratio of liver weight to body weight is usually high (Oguri, 1990). The predominant component of lipids stored in the fatty liver is squalene (Heller et al., 1957; Corner et al., 1969). These unsaponifiable substances of shark liver oil also includes besides squalene, pristane, zamere, and to a lesser degree glycerol alcohol have very low specific gravity; therefore, may be used by as sources for buoyancy control, especially in deep water sharks (Summers and Wong, 1992; Kizevetter, 1973). In a study conducted by Bone and Roberts (1969) they have shown the significance of static lift provided by the liver of some species, but the density of most species was determined by the density of tissues as well the liver. In recent study conducted on blue sharks, Hazin et al. (1991) found out there was no significant correlation between body size and weight of

the liver in both the males and females of the blue sharks.

2- Body Temperature:

Some fish, such as the more advanced scombroids and some sharks are able to conserve the metabolic heat generated by the red muscle during cruising to maintain the myotomal muscle 7-10^{o}C above ambient water temperature. This remarkable discovery was reported by Carey and Teal (1969) as he measured the distribution of temperatures in mako and probeagle sharks. The pattern of isotherm was similar to that in a tuna with the warmest temperatures in the red muscle at the heaviest region of the body. These warm-bodied fish conserve heat through use of a set of countercurrent heat exchangers located in the circulation between the gills and the tissues. The heat exchanger form a thermal barrier which permits the flow of blood but blocks the flow of heat. These countercurrent heat exchangers are the rete mirabile (Carey and Teal, 1969; Bond, 1979; Bone and Marshall, 1982; Ronsivalli, 1978).

Black-tip sharks also have an elevated body temperature but they seem to lack the well-developed counter-current heat exchanger system. Carey et al. (1972) suggested that black-tip sharks are taking

advantage of the warm surface layer to raise their temperature, then manipulate their circulation to reduce heat loss. Ian Anderson (1987) who is probably the first scientist to drop a thermometer down the throat of a great white shark, have shown that the shark raises the temperature in its stomach by as much as 6.7^{o}C during meal time to help the digestion of meals.

3- Metal Accumulation:

Sharks accumulate mercury in their bodies, and the average level of mercury increases progressively with the age of the shark. Mercury residues differ between individuals of one species and between species. Younger individuals have usually a lower mercury level than older one (Kreuzer and Ahmed, 1978).

As top predators, sharks are considered as indicator of metals in the environment; therefore, obtained results reflect the bioavailability of the pollutants which also indicate the true state of pollution of the studied environment. In related studies by Marcovecchio et al. (1991) total mercury, cadmium and zinc accumulation was studied in muscle and liver from three species of sharks. The mercury concentrations were similar in both muscle and liver while the concentration of cadmium and zinc were higher in liver than in muscle. They also found that the

metal concentration increased proportionally to the total length of the sharks. In previous studies Lyle (1984) has also shown that mercury concentration was highly dependent on the shark size and increased more or less exponentially with length. Maximum observed concentrations exceeded 1.5 mg/kg in species of hammerhead sharks. This exceeded the tolerance levels established by law which is 0.5 mg/kg, set by the Australian National Health and Medical Research Council.

These studies concluded that metal accumulation is basically related to shark diets, longevity and slow growth rates which contributed significantly to the accumulation of such high concentration of metals especially, mercury.

4- Reproduction:

All sharks have internal fertilization and production of small numbers of large young, which hatch or born as active, fully developed miniature sharks after a long gestation period (Castro, 1983; Moyle and Cech, 1988). There are three mode of reproductions in sharks; Oviparity, ovoviviparity, and viviparity. Oviparity is the most primitive in sharks, in which sharks lay large eggs enclosed in leathery cases for protection. This mode of reproduction found in four families of shark which

includes the whale shark (Castro, 1983).

Some livebearing sharks, including most requiem sharks, hammerhead and all weasel sharks are placental viviparous in which the embryos are dependent on stored yolk. The ovoviviparity is also known as a placental viviparity is the most common where the embryos are nourished by yolk stored in a yolk sac (Fischer and Bianchi, 1984; Ronsivalli, 1978).

5- Growth Rate:

Unlike teleosts (bony fish), elasmobranchs are an extremely long-lived, slow-growing whose reproductive capacity is limited by late maturity, long gestation period, and low fecundity (Wood et al., 1979). Lower growth rates in sharks may be a consequence of their asynchronous and irregular feeding, slower digestion times, longer time of evacuation and elimination of a meal, thus new tissue production in sharks is slower compared with bony fish (Wetherbee et al., 1990).

As in most other fish, the rate of growth of a shark is determined in cm/yr which decreases continually as the shark ages. For example, Carcharhinus sorrah grows at a rate 20 cm/yr during the first five year after birth, then growth decline to 5 cm/yr or less while Carcharhinus tilstoni, grows at 17 cm/yr and by the time the shark are

5 years old, growth decline to 8-10 cm/yr (Davenport and Stevens, 1988). According to Stevens (1987) lemon sharks grow at about 15 cm/yr initially, but do not mature until around 240 cm which means they may take fifteen years to reach maturity. Age and growth of sharks show considerable variation between species and within species and the majority of sharks seems to have a maximum life span of 20 or 30 years (Hoenig and Gruber, 1990).

D- Shark Uses:

The outstanding feature of sharks is that all parts can be utilized. The fins, skin, meat, liver, teeth and carcass all have commercial value, though there are some difficulties in producing high quality skin and meat simultaneously under commercial conditions (Kreuzer and Ahmed, 1978).

1- The meat:

Sharks have been used as food since men were able to catch them. According to Horn and DeBoer (1986) the shark meat consumption has been recorded as early as the fourth century where the Persians and Cretans caught and sold shark in the Persian Gulf and the Mediterranean. Now, the principal consumers of shark products are Australia, USA,

Britain, Republic of Korea, Japan, USSR, India, Mexico, and most of the African countries.

In preparing fresh and frozen meat from shark, the fish must be bled as soon as possible to reduce the level of urea. For processing, the fish should be headed, gutted, washed and in some presentations, the shark is skinned. After processing, the shark meat needs to be washed to be frozen, dried, salted, and smoked. In case of freezing, shark meat frozen at -25°C (-13°F) and then can be cut while frozen into fillets as the case of large sharks or into trunks with the head, tail, guts and skin removed in small sharks (Kreuzer and Ahmed, 1978). The flavor and quality of meat and its products depend on effective bleeding, shark species, and sanitary handling practice (Ronsivalli, 1978).

Salting is probably the most common way of preserving shark meat. This involves two general methods; pickle salting and dry salting. In the former, 2 cm thick fillets are covered with salt and packed into a water-tight container with salt sprinkled between each layer. In dry salting, granular salt is used on 2 cm thick fillets and exposed to the sun. Salt should be free of microorganisms especially halophillic bacteria which cause a pink discoloration as a result of using solar salt. Mineral salt is preferable as it contains less impurities, such as calcium and magnesium salts, and

halophilic bacteria (Limpus, 1991). Meanwhile, iodized salt should also be avoided, as flesh turns black and shark will spoil during the drying process (Seymour and Danberg, 1980). In intial stages of drying, greater care should be taken to avoid flesh hardening due to rapid drying. For best results, shark fillets during night time are staked in piles and a heavy weight applied to facilitate drying and flatten the portions to hasten drying (Limpus, 1991).

Smoking can only add flavor but it does not preserve shark, thus smoked shark should be refrigerated to extend its shelflife. Properly handled sharks can be used for versatile seafood forms such as fish protein concentrate, shark dogs, shark cookies, shark-shrimp roll which can be fortified with minerals and vitamins (Morris and Stouffer, 1975).

2- The Skin:

The special feature of sharks is strong and rough skin with the placoid scales embedded in the skin which make it very hard to cut and stitch the leather. Such denticles protect microbes lodge among them (Ronsivalli, 1978). Shark skin is much more susceptible to damage of extremes of pH, heat, and microbial activity. However, properly skinned, fleshed and tanned skin makes the leather of

shark much stronger and more durable than most mammalian leathers (King et al., 1984).

Shark hides are graded according to species, size and defects on the skin. Hide from nurse shark is very valuable and skins from other species of sharks exceeding 1.5 m in length can generally be produced (Limpus, 1987).

3- The Liver:

The liver oils of many sharks have proved to be a valuable source of vitamin A. However, the subsequent development of a synthetic route for the commercial production of vitamin A contributed to the ultimate demise of shark liver oil industry (Kreuzer and Ahmed, 1978; Summers and Wong, 1992).

When liver lipids of bony fish are treated with alkali (saponification) a chemical soap and a free alcohol are formed and only traces of unsaponifiable matter remains. However, in lipids of shark, a high concentration of unsponifiable matter remains as residue containing long-chain saturated or unsaturated fatty acids and vitamin A (Olsen, 1987). In sharks the bulk of unsaponifiable substances is squalene as well as pristane, zamene, glycerol alcohols, and saturated and unsaturated fatty acids (Kizevetter, 1973).

According to Summers and Wong (1992) the world market

for cosmetic products from recovered liver oil is growing rapidly. Such oil should be first degummed (removal of metal oils), bleached and deodorized to produce moisturizing hand lotion and sunscreen lotion. Diacylglyceryl ethers from natural sources such as liver oil have bacteriostatic action and inhibit tumor growth, thus make them extremely beneficial along with other hydrocarbons for cosmetic formulation and production. Liver oil extract used also for preparation H to comfort hemorrhoid sufferers (Fussman, 1991).

4- Miscellaneous Uses:

Corneas from eyes of elasmobranch fish have been used as successful substituants of human corneas in the U.S. Unlike corneas of teleosts, corneas of elasmobranchs do not swell when placed in varying concentrations of salt solutions (Olsen, 1987).

Sharks have pharmaceutical value such as the heparin-like compounds in dogfish that tend to prevent blood clots; shark liver extract was also successful to treat cancer in mice, rats and chickens. Shark blood contains antibodies that fight disease causing in human (Ronsivalli, 1978). Scientists have discovered a potent chemical antibiotic in the stomach, liver, gallbladder, spleen and testes of dogfish which is called squalamine.

such chemical is reported to have strong antibacterial and antifungal properties which has potential for use in treating humans (Infofish International No. 1/94).

Shark teeth are used for jewelry as ear ornaments and used for making knives by the Eskimos. Mounted jaws of shark especially from great white shark are good conservation pieces that cost about $ 200.00 in Hawaii, and about $ 1000.00 for a large one in Australia (Olsen, 1987).

E- Shark Fisheries and Conservation:

The gear used for recreational purposes is usually limited to handlines and rod and reel. Commercially, longlines are the most popular method for catching large sharks (Castro, 1983). The gear used to catch sharks in the Western Indian ocean includes pelagic longlines, fixed and floating gillnets, bottom trawls, and purse seines. Sharks are caught by artisanal fisheries and by large fishing fleets. The most important families are the requiem sharks (Carcharhinidae),and threshers (Alopiidae) which are fished offshore while weasel sharks (Hemigaleidae), and hammerhead (Sphyrnidae) are commonly fished inshore (Fischer and Bianchi, 1984).

During the post war period from 1947-1985, shark catches have tripled for thirty families of sharks,

especially in third world countries, as the world catches have increased from 200,000 to 600,000 MT (Compagno, 1990). Yet, sharks were caught off the south-east coast of the U.S. had jumped up from 504 tons in 1980 to 7,850 tons by the end of the decade, an increase of more than 1,500 percent (Fussman, 1991). Recent stock assessments indicate that the shark stock of the Western North Atlantic is exploited at a rate twice the maximum sustainable yield for all species, sizes, and relative abundance (Musick, 1993).

According to Dayton (1991) the main threat to sharks is not only targeted fishing, but also incidental mortality as sharks are killed by accidents in drift nets and pelagic longliners. In 1988, Greenpeace Australia calculates that Taiwanese and Korean fleets killed over 2.25 million blue sharks in the north Pacific as they fished for squids. In another study, Russell (1993) observed a steady decline in shark landing and shark bycatch in the tuna longline fishery in the Northern Gulf of Mexico. As a result, most of the very large, full-time shark vessels were sold to be used in other fisheries.

Many elasombranchs have become a popular target of recreational fishermen for food and sport and as the interest in food products has increased as a global market has developed, conservation and management have not kept pace with shark utilization. Because of the life-history

pattern of elasmobranchs, makes these animals extremely susceptible to over-fishing. Factors such as bycatch, difficulty to measure the shark population dynamics, low priorities assigned to sharks due to low values of the landings, make it difficult to develop and implement effective management measures (Hoenig and Gruber, 1990).

Elasmobranchs can provide a vital contribution to the economies of many small-scale fishing communities. For example, in Australia, several measures have been taken to protect the depleted stocks of gummy shark and school shark which is a fishery industry valued as $ 15 million (Joll, 1993).

According to Dayton (1991) there are signs that governments are beginning to take the problem seriously as South Africa became the first country to ban the killing of great white shark; The United States is about to take measures to protect more than 30 species of shark. However, with sharks as a potential victims of overexploitation, shark populations are on a long-term collision course and as fisheries continue to expand, conservation of these fish are becoming even harder. Yet, conservation-minded researchers and international bodies that promote conservation may have to become more involved regardless of the difficulties.

2- Shark-Fins:-

A- General Form and Functions:

The evolution of jaws in fish have accompanied the development of a suitable pattern of fins for movement towards the prey. For the purpose of food capturing, swimming, buoyancy and control, sharks exhibit characteristics of hydrodynamic form; they are a torpedo-shaped, like the body of airplane. According to Budker (1971) the pectoral fins in sharks revealed close similarities with the profile found in the wings of certain airplanes. Thomson and Simanek (1977) found in sharks that they examined that paired and unpaired fins were strikingly uniform in their position of insertion on the body, whatever the shape of the caudal fins.

Pectoral fins work just like the wings of an aircraft, as they provide lift and drag by the downward inclination provided by the moveable, narrow bases of these fins as part of the evolutionary specialization of modern sharks. Caudal fins also exert a lift and a propulsive force during swimming, thus depressing the head. The lift due to the tail fin must be counterbalanced by that coming from the pectoral fins. These forces act as an upward force through the center gravity or point of balance (Harris, 1937).

Thomson and Simanek (1970) suggested that the first

dorsal fin lies close to the vertical plane containing the center of balance. The interplay of ventral head area and pectoral fin area can be noted in the two species of hammerhead - Sphyrna tiburo and Sphyrna zygaena. The former have a larger head area and smaller total pectoral fin area but the combined area will be equal for both species. Unlike the bony fish, sharks spread their pectoral fins to provide lift while bony fish spread their pectoral fins to brake (Breder, 1926).

There is a need for this lift since most selachians are without a swimbladder which make them denser than the water. Their density can be determined by weighing the shark in the air and then immersed in water by applying Archimedes' Principle. The difference in weight between shark density and water specific gravity must be balanced by upward hydrodynamic forces of the pectoral fins and tail (Alexander, 1965, 1975).

To keep afloat, most sharks use the liver which is rich in lipids as a buoyancy organ. Sharks possess high concentration of lipids in their liver, mainly squalene (Heller et al., 1957; Corner et al., 1969; Craik, 1978).

B- Anatomical Characteristics of Shark-Fins:

In vertebrate, cartilage and bones are the prominent structure of the skeleton which are specialized

derivatives of the connective tissues. Unlike bones, cartilage contains no canaliculi or haversian canal system. Therefore, blood vessels are absent (except in very large cartilage); the nutriment supplied to cells must be by diffusion (Romer, 1970; Webster et al., 1974).

In sharks, adult skeletons develop calcified cartilage especially in the vertebral column and the jaws, which produces a relatively hard and brittle endoskeleton. Calcified cartilage becomes infiltrated with calcium salts, thus resembles bone. Technically it is cartilage because it contains chondrocytes and chondroitin sulfate (Budker, 1971).

There are two types of fins, paired or unpaired. The median or unpaired include the dorsal, anal and caudal fin in sharks. The second type, the paired fins, represented by the pectoral and pelvic fins. Median fins develop by a fold of epidermis dorsally along the trunk to the tip of the tail. In case of dorsal fin, myotomes give off a muscle-buds which give rise to a muscle radials (Goodrich, 1930). In the process of concentration of dorsal fins, the body grows faster in length than the base of the fin. Thus a dorsal fin derived from fourteen segments comes to occupy only about six myotomes in adult. (Alexander, 1975). These segments of cartilage rods called the pterygiophores are connected end to end. The

larger one, which lies next to vertebral column called the basal, and the smaller one called the radial pterygiophore lie between the basal and sheets of packed ceratotrichia (Gilbert, 1973; Norman, 1936),(Appendix 1).

Modern sharks are characterized by aplesodic fins in which the radials are limited to the basal half and several layers of ceratotrichia overlap the radials and extend out to the fin margin. In primitive sharks such as the cladoselach, radials extend nearly to the margin of the fin which is known as the plesodic fin (Jollie, 1991).

In caudal fins, the major skeletal support is the neural and haemal arches with the vertebral column turning up into the dorsal part of the tail to form a heterocercal tail. Fin rays or ceratotrichia are present in both lobes of the tail-epicordal tail (dorsal side) and hypochordal tail (ventral side). In the lower lobe, these rays are more dense and well developed but modified and highly reduced in the upper lobe (Goodrich, 1930; Gilbert, 1973; Romer, 1970).

Pectoral fins are the anterior paired fins which are basically similar in structure to the dorsal fin. Its origin has been much debated but fin fold theory is more acceptable than modified gill structure theory as the origin of these fins (Goodrich, 1930; Romer, 1970).

Pectoral fins attached to the trunk by pectoral girdle

which articulate with three calcified cartilages called the basals. The central basal is termed the mesopterygium, which is the largest one. Metapterygium is the medial basal and propterygium is the lateral basal. Distally, a series of segmented radial which are the main support of the pectoral fin is followed by ceratotrichia (Gilbert, 1973; Applegate, 1967) (Appendix 1).

In sharks, ceratotrichia which is also called horny fin rays, dermal fin rays, and elastoidin fibers are unsegmented soft fin rays of epidermal origin (Jamieson, 1991; Goodrich, 1930; Romer, 1970; Howell, 1932; Applegate, 1967). During ontogeny ceratotrichia appears as a thickening of the basement membrane of the epidermis which are cut away by the movement of mesenchyme cells between the thickening and the membranes. With the first generation of ceratotrichium disposed into the dermis, a second one may form and dispose on both sides of the fin to which radial muscles become attached (Jollie, 1991).

In bony fish, fin rays differ from cartilagenous fins in that their rays are modified fin scales into elongated bony, jointed rays called lepidotrichia. The tip of the fins of bony fish may be additionally stiffened by tiny, unjointed, horny rods developed in the dermis of the skin which resembles ceratotrichia. These rods are called actinotrichia because of their fine structure (Goodrich, 1930; Jollie, 1991).

C- Biochemical Characteristics of Cartilaginous Materials:

Fibrous protein which includes collagen, elastin, alpha-keratin and silk are water insoluble. These contain a large percentage of non-polar, or hydrophobic amino acids, up to 93% in the case of elastin (Lehninger, 1970).

In their natural state, collagen fibers are inert, of high tensile strength, swell in acidic or alkaline media and exhibit a non-specific affinity for certain dyes, such as acid fuschin and anilin blue (White et al., 1959).

In order to determine the position of the atoms of a molecular or crystal structure in space such as fibrous protein, x-ray diffraction analysis is considered the ultimate experimental method. The spacing of regularly repeating atomic or molecular units in crystals can be determined by studying the angles and intensities at which x-rays of a given wavelength are scattered or diffracted by the electrons that surround each atom. Therefore, atoms having heavy metal, diffract x-rays the most and vice versa (Lehninger, 1970).

X-ray diffraction studies and the electron microscope, showed that collagen is a three-polypeptides chain twisted together to form a triple helix. The complete triple-helix unit is called tropocollagen. These units

are arranged in a staggered alignment with characteristic cross striation at 600 to 700 Angstron, depending on their source and degree of hydration (White, 1973; Lehninger, 1970; Bartley, 1968; Gustavson, 1964).

The triple helix structure is possible only because of the high incidence of glycine maintained by pairs of hydrogen bonds between the parallel peptide bonds, except for those involving proline or hydroxyproline. Increase in thermal stability of collagen has been attributed due to the increase in hydroxylated proline in collagen (Stryer, 1988; White, 1973). Thermal denaturation temperature is frequently sensitive to other forms of protein stabilization and destabilization treatment, such as ph, ionic strength, and the total number of imino acids residues (proline plus hydroxyproline) in collagen (Franks, 1988; Piez and Gross, 1960).

Heat denaturation of collagen yields a water-soluble protein, gelatin. Gelatin formation results from the separation or fragmentation of the three strands of the triple-stranded helix of collagen into a varying amount of smaller molecular species. This seems to involve only a physical change, since there is no chemical evidence of hydrolysis. Gelatin contains no tryptophan and small amount of tyrosine and cystine (Harper, 1987; harper, 1969).

A distinctive amino acid in collage is hydroxylysine

which has two main functions: to participate in the formation of cross-links and to act as sites for the attachment of sugar groups (McGilvery, 1979).

Links within tropocollagen molecules and between different molecules are formed by lysine and hydroxylysine residues. Such cross links are called aldol cross-link which stabilize and strengthen the collagen fibers (Stryer, 1988; Lehninger, 1975).

Connective tissues consist of units of polysaccharide and protein called the proteoglycans, the ground substance of connective tissues. Glycosaminoglycans are the polysaccharides chains in proteoglycans which are made of disaccharide repeating units containing either a glucosamine or galactosamine. Such compounds are also named the acid mucopolysaccharides when they contain negatively charged carboxylate or sulfate groups. The sulfate-free uronic acid is the hyaluronic acid and heparin (Gottschalk, 1972 A; Stryer, 1988).

In 1887, C. S. W. Krukenberg isolated and identified chondroitin sulfate. Then in 1955, Eugene A. Davidson and Karl Meyer of the University of Columbia showed that chondroitin sulfate is a repeating disaccharide which consist of glucuronic acid and sulfated N-acetylgalactosamine in alteration (Caplan, 1984). Blumenfeld et al (1963), concluded that glucose and galactose are attached to the protein through a glycosidic

bond in ichthyocol, and that the hydroxyl groups at positions 2, 3 and 4 of both hexoses are unsubstituted. In galactose, the hydroxyl at position 6 is also unsubstituted. The hexosaminidic linkages are all (1 --> 4) and the glucuronidic (1 --> 3). In earlier studies Hoffman and Meyer (1962) showed that the hexosaminidic linkage was based mainly on the action of bacterial enzymes which acted by an elimination process with the appearance of alpha, beta -unsaturated acid.

In the molecular structure of proteoglycan, a central strand of hyaluronic acid is the organizing molecule. From the central strand projects the core protein where numerous polysaccharides attach to it. Three regions of attachment at the core protein include: oligosaccharide is attached via a glycosylamine linkage between N-acetyl-D-glucosamine to the amide nitrogen of asparagine residue as in the case of ovalbumin. The second attachment as in submaxillary mucoprotein, involves glycosidic bond between N-acetyl-D-galactosamine to the hydroxyl group of serine or threonine residue. The third attachment represented by collagen involves with the hydroxyl group of hydroxylysine residue (Caplan, 1984; Lehninger, 1975).

According to Michelacci and Horton (1988), proteoglycans isolated from shark cartilage differed from mammalian cartilage as they failed to form complexes with

hyaluronate. Thus they were unable to show the presence of hyaluronic acid in shark-fin cartilage nor in the other cartilage of shark. Furthermore, the molecular weights of the chondroitin sulfate and keratan sulfate extracted from shark-fin cartilage were higher than those obtained from mammalian cartilage. A ratio of four chondroitin sulfate chains per keratan sulfate chain in shark cartilage were estimated, while a ratio of two chondroitin sulfate chains per keratan sulfate chain were estimated for the proteoglycans of human articular cartilage.

In elasmobranchs, the cartilage contains a 6-sulfate compound whereas that of the notochord contains the 4-sulfate or chondroitin sulfate A (Harper, 1987).

Suzuki (1960) has isolated and identified a novel disaccharide bearing two sulfates which he named chondroitin sulfate D. One of the sulfate is substituted at the 6- position of the acetylgalactosamine residue, and a novel sulfate residue is substituted at the 2- or 3- position of the uronic acid. A similar disulfate has also been isolated from a preparation of chondroitin sulfate B which was distinct from chondroitin sulfate D by its infrared spectrum, low Morgan-Elson reaction, and which gave a purple color with aniline hydrogen phathalate.

In extractability or solubility of cartilage, different solvents have different effects on different types of cartilage. For example, mature collagen is

insoluble in water while prolonged extractions in weak organic acids or alkalines and cold neutral salts can dissolve young collagens (White, 73; Gustavson, 1964).

Proteoglycans were extracted from bovine cartilage using different concentrations of chaotropic solvent such as 4M guanidinum chloride (Heinegard et al, 1981; Hardingham and Mur, 1973); 5M guanidinum chloride (Paulsson and Heingard, 1981). In proteoglycan extraction from shark cartilage, Michellacci and Horton (1988) used different solvents at different concentrations as follow: 1M, 2M, 3M, and 4M of guanidinum chloride (GuHcl), 8M urea, 2% SDS, and 3M guandinum chloride plus 2mM 2-mercaptoethanol. Only 8.6%, 12%, 36%, and 84% extracted by 2% SDS, 8M urea, 4M GuHcl, and 3M GuHcl, respectively. However, Vynios et al. (1985), have extracted 85% of the uronic acid using 2% SDS from squid cranial cartilage.

In another study by Mathews (1971), trypsin and chymotrypsin were used to cleave the chondroitin sulfate-protein from the cartilage and notochord of some vertebrate and invertebrate species.

The mechanism of action of most of these regents such as urea, Beta-mercaptoethanol and guanidine hydrochloride is not fully understood, but it is evident that they act by disrupting nearly all non-covalent interaction in the polypeptides of native protein (Stryer, 1988).

In conjunction with collagen and polysaccharides,

elastin is found in most of the connective tissues. Unlike collagen, elastin can not be converted into gelatin by boiling and its amino acid composition is different from that of collagen (Tables 1 and 2). The unique characteristics of elastin are its high content of glycine, alanine, proline and valine (Neuman, 1949). About 93% of the side chains of the protein are non-polar or hydrophobic amino acids (Lehninger, 1970; Bartley,1968). However, hydroxylysine and glycosylated hydroxylysine are not present in elastin (Murray et al., 1990).

Elastin disclosed a faint collagen-type diffraction based on small-angle diffraction pattern in beef ligament which would resulted from impurities in elastin. Furthermore, results from electron optical studies concluded that elastin should be excluded from the collagen family (Bear, 1952).

Spiro (1972 B) outlined the criteria to be a member of the collagen family. These include, the occurrence of hydroxylysine and hydroxyproline, the presence of approximately one-third of the amino acid (glycine), the observation of 640 Angstron periodicity under the electron microscope, infrared absorption spectrum, and the wide-angle x-ray diffraction pattern.

According to Bear (1952), x-ray investigations of collagen-containing tissues or derivatives involved in

wide-angle diffraction exhibit essentially indentical patterns even with the degradation product of collagen, gelatin, yields, upon stretching, the same oriented diagram as tendon.

D- Biochemical Characteristics of Fin Rays (Elastoidin):

Elastoidin, an insoluble fibrous protein found in the shark-fins which is also known as ceratotrichia, was first isolated from Mustelus laevis by C.S.W. Krukenberg as early as 1885 (Damodaran el al., 1956). In his remarks, Krukenberg noted its similarity to collagen but differed from the latter in not yielding gelatin on boiling with water. Yet, elastoidin classified in the collagen family on the basis of its wide-angle x-ray diffraction, and the presence of a 600-800 Angstron periodicity (Bear, 1952). Finally, Damodaran et al (1956) showed the elastoidin amino acid composition which resembles the amino acid composition.

Table 2 compares the chemical composition of elastoidin from shark-fin, bovine collagen and elastin. The similarity of elastoidin to collagen can be summarized as follows: A high glycine content that amounts to 32%, the presence of hydroxyproline and proline that amounts to about 17% of the total residue, presence of hydroxylysine, threonine and serine in amounts usually found in mammalian

collagen, and the residues of non-polar amino acids up to 60%, just about equal to the amount found in bovine collagen.

Elastoidin deviates from collagen in having a high tyrosine content and the presence of cystine which would contribute to the elastoidin distinctive hydrothermal properties.

It appears that elastoidin consists of a tightly bound mixture of a collagen-like substance which yields a water-soluble gelatin, rich in hydroxyproline, and a water-insoluble residue containing a remarkable a mount of tyrosine, 18-25%, and relatively little hydroxyproline upon autoclaving at 15 pound pressure for 16 hours (Gross and Dumsha, 1958). However, Ramachandran and Sastry (1964) and Ramachandran (1962) showed that elastoidin, yielded three fractions or residues upon treatment with formic acid. These three components are characterized by the presence of a high tyrosine content in fraction A, a high content of tryptophan in fraction B and the absence of either tyrosine or tryptophan in fraction C.

Fraction C exhibits the collagen characteristics in having a high hydroxyproline and proline content. The carbohydrate content of fraction C is the same order as that for vertebrate collagens. The neutral sugar components were glucose and galactose present in 2:5 ratio; basic sugar as glucosamine was also present

(Ramachandran and Sastry, 1964).

Previous studies by Gross et al.(1958) showed that shark elastoidin gelatin contains a higher amount of glycine, hydroxyproline, proline and a considerable amount of aminopolysaccharides. Such studies have also revealed the presence of glucose, galactose, glucosamine and galactosamine chromatographically. It also has indicated the absence of fucose and mannose in elastoidin.

Gross et al. (1958) have also studied the effect of enzymes on native elastoidin which includes, collagenase, trypsin, chemotrypsin, pepsin, hyaluronidase and 0.1N NaOH and 0.1N HCl. These agents failed to separate the fibers into its fractions but they dissolved the collagen in the following order: 5%, 12%, 20%, 70%, 0.0%, 0.0%, and 0.0%, respectively.

In similar studies by Damodaran et al. (1956), native or intact elastoidin fibers resisted the action of crude trypsin, slightly acted on by papain and was completely dissolved by crude pepsin. However, the shrunk fibers were completely digested by all three enzymes.

Bear (1952) suggested that intact or native elastoidin has an ordered structure or configuration (state I), while the shrunk fiber is not normally stable as it is transformed to the amorphous state (II).

At state (I), elastoidin shows many of the collagen characteristics such as: usual wide-angle diffraction and

small-angle characteristics, positive uniaxial double refraction, resistance to tryptic hydrolysis, and thermoelastic behavior like that of normal solids with negative temperature coefficient.

At state (II), elastoidin has quite new properties such as: Fiber shrinks to 27% of its original length with contractile and rubbery characteristics; losses of the ordered structure during shortening yielding a single wide-angle diffraction as double refraction diminishes; the resistance to trypsin is markedly diminished; and thermoelastic coefficient is large and positive which is attesting to its rubberlike nature.

Upon cooling, elastoidin at state (II) shows signs of reversion to state (I), in which it regains spontaneously over half of the initial length at 20°C. The positive double refraction and normal wide angle diffraction return, and there is even some regaining of resistance to trypsin.

Domadaran et al. (1956) have also reported such properties in elastoidin in which it contracted to about 30% of its original length at 63-64°C in water. However, applying longitudinal tension and cooling the shrunk fiber to 20°C, it regained about 85% of its initial length.

Bear (1952) shades light on formalin stabilization or formalin-treated specimens. Such specimens partially regain spontaneous length and the collagen wide-angle

pattern while untreated specimens remain shortened and lose their normal wide-angle diffraction as the case with avian tendons. This indicates that formalin stabilizes the protofibril links of each fibril so that they do not become hopelessly disarranged during the shortening phase. In the case of protofibril at the normal state (I), the fibril yields the collagen wide-angle diffraction pattern as protofibrils possess the normal specific configuration.

E- Processing of Shark-Fins and Preparation of fin needles:

The processing of shark-fins requires skilled professional chefs, where a series of precise, week long procedures are used to make a bowl of soup from raw fin. Recipes handed down from the time of the Southern Song Dynasty, 800 years ago call for the raw fin to be scraped clean of meat, then boiled for two hours. The stock is then thrown away and the fin boiled again for two hours with fresh water. This is repeated for five days. Finally, the fin is skinned and what little remains is transparent threads of gelatinous matter. To make a tastyand tempting dish of shark-fin soup, a rich and thick stock of chicken, mushroom, ham, ginger, scallions, soy sauce, sweet yellow rice wine, vinger, salt and sugar is mixed with the thread-like noodles (Sinclair, 1989).

For commercial purposes, shark-fins may be marketed in several forms; fresh, chilled, frozen, dried raw fins or processed (skin-off). Processed product forms include dried prepared fins and wet and dried fin nets (Appendix 4). Traditionally, the grading of shark-fin depends on the shark species or the natural color of the skin, size, thickness, form of presentation, and content of fin needles. However, present day exports are mainly graded by the type, size and color (black or white) (Subasinghe, 1992; Ka-keong, 1983) and (Table 4).

According to Limpus (1991) to insure the utmost quality of raw materials, the following processing steps should be followed:

1) Cutting: Fins should be cut from the shark as soon as the fish is caught. Cutting and trimming of shark-fins need extreme care, otherwise their value is reduced. The dorsal fin has more meat at its base and should be cut with a broadly-curved, concave cut to eliminate the meat, but preserving as much of the fin as possible. This highly preferred cut by traders is called "half-moon cut" which can be applied to the pectoral fins as well (Figure 6,8 and 13). Cutting meat from dried fins is not recommended as fins get harder and cause incorrect cutting. Trimming excess meat makes drying process much easier and fins will not become smelly as the case with

irregular (crude) cuts where meat is left at the base of the fin. The residual meat often imparts a bad odour and color during processing with a deterioration of product quality. The lower part of the tail is cut off with a straight cut right under the thick cartilage that runs through the tail, keeping clear of the meaty part (Appendix 2).

2) Washing and Sorting of Fins: Freshly cut fins have to be cleaned thoroughly by scrubbing away any dirt or adhering extraneous matter and washing them well in sea water. As restated by Table 3, bad handling and delay in cutting causes such defects as blemishes due to decay.

3) Chilling: If fins are to be sold or processed within a few days, they must be packed and stored at $0^{\circ}C$.

4) Freezing: To keep fins for long periods at optimum quality, immediate freezing of fins after washing them is required.

5) Drying: The cleaned fresh fins may be sun dried on mats, trays or racks, or hung from a line. Fins can be either dried directly, or slightly salted before drying by dusting them with salt in a ratio of 1:10, salt to fin. Meanwhile, the cut portion should be liberally sprinkled

with salt. A little lime may also be used at the cut portion and the fins are set aside for 24 hours. The fins are then dried after rinsing in clean sea water to remove excess lime and solid salt.

Fins should be turned over periodically while drying them to facilitate drying and to prevent scorching and curling. Prolonged exposure to the sun causes burns in the skin of shark and fins. At night, fins should be taken indoor to protect them from dew deposition, insect and vermin (Table 3). Throughout the drying process, fins should be kept away from rain, sands and other extraneous matter that could contaminate the fins. The fins may be dried in the sun so that the moisture content is 10-15% level (MPEDA 1989; ISI, 1969) or to 7-8% moisture content (Clucas, 1982).

The properly dried fins make a characteristic sound when tapped against each other. Mechanical drying may be used when sun-drying is not possible. However, traders prefer sun-dried fins to oven dried fins (Ka-keong, 1983).

In planning the processing facilities for fin processing line, Kreuzer and Ahmed (1978) recommended a plant designed for shark utilization that includes the following for fin processing: a working table 1 x 1 meter, a brine tank with 100 liter capacity, a working table 1.5 x 1 meter for trimming, a salting room with

salting tanks, a drying yard at least 10 x 5 meter and a fin store 3 x 4 meter. Fins that are collected at the filleting and skinning line of the shark's pilot processing unit will be carried to the fin processing line. Fins will be handled at the working table, washed in the basin with 3% brine, then all traces of skin and meat are carefully removed at the trimming table. Finally fins are dried and stored.

In order to meet the market demand, many processing methods have been developed to extract fin rays and the most popular method is described by Ka-keong (1983). In this method, fins are descaled and skinned in pre-heated water (80-90^{o}C) to remove the skin (Appendix 3). Sometime 3% hydrogen peroxide is used for bleaching and removal of blood stains. The final product is processed fin with the skin off but, otherwise, retaining its shape. Some processors remove the very hard and non-edible cartilage base of the dorsal fins and the cartilaginous platelets between the two layers of fin needles in the pectoral and dorsal fins to obtain a better price (Appendix 4).

The final stage is preparation of the fin to extractthe fin needles by soaking and boiling the processed fin. Boiling will dissolve the membrane and expose the fin rays; then extraction of the fin rays by hand. The final product is wet or dried fin needles with

moisture content of 5-8%, just about ready for shark-fin soup (Figure 11).

In other modified processing methods, Nair and Madhavan (1974) and Ramachandran and Sankar (1989) used a simple process for extraction of fin rays from sharkfins by soaking the fins in 10% acetic acid for 24 hours to hydrolyze the collagen in the skin to gelatin. Therefore, skinning becomes easier. To soften the skin or muscles further, fins may be treated with acetic acid at 50-60^{o}C to allow fin ray extraction. However, in this method fin rays tend to swell due to acetic acid and shorten to about 30% of their original length.

In an improved chemical method for extraction of fin rays, Jayawardena (1980) used 1% HCl solution for quicker and easier extraction of different types of fins. Rays obtained with the use of dilute HCl were softer; however, dried fin rays' final product from white caudal fins using 1% HCl was of very poor quality, very thin, short and shrunk.

Jayawardena (1980) also tested the extraction of fin rays by using 0.1 NaOH and 10% acetic acid on other fins. The products obtained by the former had soapy characteristics while the product from the latter had a reduction in length and increase in diameter. However, different method of extraction had no influence in the yield.

F- The Shark-Fin Market:

Shark-fins used mainly in making shark-fin soup have a traditional and virtually exclusive market among established Chinese ethnic groups in different parts of the world, but little marketability elsewhere. Thus, Hong Kong is considered the largest market for shark-fin, with a Chinese population of over five million, while Singapore is considered the second most important buyer of shark-fins.

The commercial value of the fins depends on their types, size, thickness, form of presentation, and color (black or white). The most valuable genera in shark-fin trading are Sphyrna spp. (Hammerhead), Isurus spp. (Mako shark), and Prionace spp. (Blue shark). Other species of commercial importance includes; Alopias spp. (Thresher shark), Carcharhinus spp. (White- and Black-tipped shark), Carcharodon spp. (White shark), Galeocerdo spp. (Tiger shark) and Rhincobatus spp. (Shovel-nose guitarfish). However, the pectoral fins of the Sawshark (Pristiophorus spp.), and the upper lobe of the tail of all sharks areconsidered to have no commercial value (Subasinghe, 1992; Ka-keong, 1983).

1) Grading: Consumers and buyers are very conscious of the quality, processing method, and final presentation.

In general, traders prefer sun-dried fins to be a fin set of four fins from the same fish which will include 25% dorsal, 50% pectoral and 25% tail. Black fins generally fetch a lower price than white fins (Trachet et al. 1990). The most expensive of white varieties is Boon leong sit (in Chinese) while the most expensive of the black varieties is Tua sit (in Chinese), and in both cases they represent the largest sizes of fins (Tressler and Mewlemon, 1951; Domantay, 1958). Two methods of measurement are commonly used in fin grading: length along the curve of the largest side of the fin (anterior corner) in accordance with the Indian Standard (1969) and length measured from the center of the base to the tip of the fin which is in accordance with the World-Wide Standard for shark-fins set by the FAO/WHO (1986) (Appendix 2).

Depending on the size, fins are graded as extra large (40 cm and above), large (30-40 cm), medium (20-30 cm), small (10-20 cm), very small (4-10 cm) and mixed or assorted which includes the extremely small fins (Subasinghe, 1992) and (Table 4). According to Ka-keong (1983) various product forms are handled in the shark-fin market which include:

a- Raw unprocessed fins wet or dried,

b- Processed fins (skins removed but otherwise fins retain their shape. Sometimes the cartilaginous platelet

is removed from the pectoral fin which is probably the most expensive form of presentation),

c- Prepared fins - fin nets,

d- Wet or dried fin needles ,

e- Frozen fins,

f- Canned shark-fin soup.

2) Pricing: The wholesale and retail prices of raw dried fins are subject to frequent fluctuations, but those processed and prepared are more stable (Ka-keong, 1983). According to Walford (1931), the wholesale price paid in 1931 was from 15 cents to $ 1.50 per pound. Prices nearly quadrupled from 1973 to 1977 which indicates a very strong demand for shark-fins (Kreuzer and Ahmed, 1978); However, the market for shark-fins has been depressed in various occasions. For example, in October 1983 prices suffered a major set back due to the devaluation of the Hong Kong dollar (Infofish Trade News. 22/83); also in the 1990 political unrest in China (Infofish Trade News. 6/90).

For import and export trades, traders have to assess a sample before agreeing on a price. The trader examines the samples carefully upon arrival and issues a letter of credit as soon as he accepts the samples. Sellers are generally obliged to accept the buyer evaluations and prices set by the buyers. Since sellers have little

choices as outlets are limited in numbers, they must either agree to the price offered by the buyers, or else carry their stocks until more rewarding returns are available. The busy season for importers and wholesalers is usually around the Chinese New Year (7th-10th of February) while business is slack in July and August, as these two months are considered to be inauspicious by the Chinese (Kruezer and Ahmed, 1978).

3) Distribution Channels: Shark-fins are a unique commodity in the sense that their market is both a seller's and a buyer's market. The buyer is usually a processor who imports dried unprocessed fins, then sells to a wholesaler or a retailer and finally to an end-user. Over 80% of imported shark-fins sold in Hong Kong ended in restaurants (Ka-keong, 1983; Infofish correspondence, 1991). However, according to Ka-keong (1983) these channels of distribution are loosely structured and some large operators adopt the vertical integration approach in which they import, process, retail, export and re-export. A few large seafood restaurants also import dried fins directly from abroad for their own use.

4) World-Wide Market for Shark-fins: A market survey was conducted by Kruezer and Ahmed (1978) to provide an overall assessment of the world supply of sharks and the

current demand trends for shark products. The following are some of the countries that indicate promising potential for shark products and specifically shark-fins:

a) United States:

The volumes or quantities involved in the trade of shark-fins in the United States is not considerable and these are only sought after by the Chinese population on the East and West Coasts. Some importers are buying shark-fins from South America but the quality is poor; therefore, the highest prices paid do not exceed US $ 4.00 per pound for unprepared mixed fins. However, supermarkets handling oriental foods imported from Hong Kong sell skin-off tail at the retail price of US $ 35.50 per pound.

In addition, canned shark-fin soup has been exported to the United States by a firm in Hong Kong. The consumers are mostly restaurants and individual households. According to statistical data from Infofish Trades News (1990) Hong Kong imported 75 MT in 1985 and 229 MT in 1989 from the U.S., which indicates a growing activity in shark-fin trading in the United States.

b) Japan:

There is little market for shark-fins in Japan as Japanese do not favor shark-fin soup. However, Japan is an exporter of shark-fins which are almost entirely from home production (Table 5). Hong Kong and Singapore are

the major buyers of Japan's shark-fin production.

c) Hong kong:

The largest market for shark-fins is Hong Kong (Table 5). It continues to be very strong as rising incomes and improved living standards maintains Hong Kong as the biggest buyer of shark-fins. In comparing the total imports with re-exports, Hong Kong has re-exported only 15%, 19%, 20% of shark-fins between the year of 1985-1987, which indicates the size of the market and local consumption of shark-fins in Hong Kong (Infofish Trade News, 1987).

Since 1976, Japan was the major supplier of shark-fins to Hong Kong which accounted for 33%, Singapore 13%, and Mexico 3% in quantity (Kreuzer and Ahmed, 1978). However, these figures declined between 1985-1989 due to competition from other shark-fin exporters such as China, the United States, and various countries in South America (Infofish Trade News, 1990). Imports come from all over the world to Hong Kong and quality, size, and cut vary considerably; therefore, prices vary as well. Importers in Hong Kong require only unprocessed or unprepared dried fin because they prefer to carry processing by themselves. Unlike other markets, importers in Hong Kong are ready to buy unlimited quantities of high-quality shark-fins.

d) Singapore:

Singapore is considered the second major market, being

strong in import and re-export (Table 5). Its own production of shark-fins is poor. Shark-fin trading in Singapore is sub-divided into unprocessed dried fins and processed or prepared fins. The principal suppliers of dried shark-fins were Japan, India, and Sri Lanka in 1976. However, in 1988-1989, India was the major supplier to Singapore as imports jumped up from 266 MT in 1988 to 2348 MT in 1989 (Infofish Trade News, 1990).

Singapore, also re-exported dried shark-fins and prepared fins to Hong Kong, Japan, and West Malaysia. The ratio of exports to total imports have been rising steadily since 1974 and 1976 (Kreuzer and Ahmed, 1978). Table 4 shows that this trend of decline in domestic consumption has continued between 1988-1990. Export of shark-fins in 1988 was 871 MT, which accounts for 46% of the total imports, but in 1990 exports jumped to 80% which leaves only 20% of the total imports for local consumption. According to Kreuzer and Ahmed (1978) this trend of decline in import and increase in export is probably due to a gradual change in the life style of the people, as less and less shark-fin is served on ceremonial occasions.

e) Malaysia:

Malaysia is a small market for shark-fins with a consumption of about US $ 0.5 million a year. The import and export of shark-fins consists of salted, dried or

in-brine and prepared shark-fins. The suppliers are mainly Japan, Taiwan and India. Shark-fin export to Malaysia suffered a major setback in 1983 due to increase in import taxes from 20% to 50% (Infofish Trade News, 1983).

The prices in the Malaysian market are generally lower than in Singapore and Hong Kong as importers buy a greater proportion of low quality fins. Locally prepared and packed fins are offered in wholesale at about US $4.00-5.50 per kg.

G- Future Prospects for the Shark-Fin Market:

The demand for shark-fins seems unabated by the principal markets in South East Asia. The market is highly quality conscious and producers have to exercise the greatest care in turning out the right product.

Recently, the issue of finning sharks has taken a new turn as more governments have started to restrict the practice. Conservationists have argued the need to put limits on such practices since the shark population is declining. There is news that Singapore has banned finning and shark-fin imports, promoting artificial needles instead, as a way to discourage finning sharks and preserve the shark population. Moreover, in 1993, the Omani government banned all fishermen and fishing vessels

from finning sharks in an effort to reduce sea and seashore pollution with shark carcases (personal communication, 1993). The real threat to shark populations is probably from the new and largely unregulated activities of large-scale finning. For example, in the Cocos Island off Florida, fishermen began finning hammerhead sharks (Sphyrnidae spp.) seven years ago. The population of hammerhead sharks dropped so rapidly that a sanctuary was created. Now, though, there are reports that some fishermen bribe guards to allow them to continue the practice (Dayton, 1991).

According to Compagno (1990) the oriental shark-fin fishing seems all-pervasive and may be affecting large oceanic sharks worldwide. Longliners, purse seiners, and pelagic gillnetters can harvest shark-fins with relatively little effort and storage problems as sharks are discarded after removal of their fins. The high value gourmet product could cause problems for those species valued for their fins, similar to those afforded elephants and rhinoceros by the persistent ivory trade. In such a case, for species figuring in the shark-fin trade, the value of fins will continue to rise in the vast oriental market as they become more scarce.

MATERIALS AND METHODS

The shark specimens examined in this study were caught by artisanal fishermen using bottom lines and fixed gill nets off the coast of Oman, FAO fishing area 51, from July 1991 to June 1992. All traditional fishing operations were performed within the 20 mile coastal fishing area zone using fiberglass skiffs or boats.

The major landing site for these boats is Muttrah Souq which is located in the capital area.

1- Morphometric Studies:

A- Identification of Shark Species:

For this purpose, regular visits to main fish landing sites (Muttrah Souq) was conducted to identify sharks valued for their fins.

For Identification purpose, fresh shark was brought from landing sites to the Seafood Technology Section Laboratory at the Marine Science and Fisheries Center were fish weight and length were recorded. Immediately, the fish was studied for identification using the FAO Species Identification Sheets for Fishery Purposes, Western Indian Ocean, Fishing Area 51, volume 5. After identifying the

fish, fins were cut from the shark to be either processed immediately or put in plastic bags and kept in the freezer at -20^{o}C for further processing.

B- Morphometric and Statistical Description:

Regular visits were conducted to shark landing spots in the capital area to measure sharks harvested off the Omani Coast valued for their fins. In this study, Standard length (SL) or Precaudal length (PL) was adopted as the standard measurement. It was more practical and easier for this kind of study than Total length (TL) and Fork length (FL) because shark can be measured even if the caudal fin and other fins are removed. In Standard/Precaudal length, the shark was measured from the tip of the head or snout to the beginning part of the caudal fin base. A caliper or an accurate measuring device was used. The fins were measured according to the world-wide standard for shark-fins set by FAO/WHO (1987). By these standards, the fins are measured by from the tip of the fin to a point in the middle part of the body where the cut is made as shown in Appendix 2.

Data collected in a one-year period, entered and stored in the computer to be analyzed for length frequency, species average length, seasonal variation, abundance, and percentage of ratio of fin length to shark length.

C- Morphometric Equations:

In order to formulate the relationship between the body size (Standard/Precaudal length) and fin sizes (dorsal, pectoral and caudal fins) of each species, the linear regression formula $Y = a + b x$ was adopted.

Data collected from sampling site was recorded and stored in the computer. A spreadsheet program (Lotus 123 or Quattro Pro 4.0) was used to analyze and compute the coefficient values and constant for a formula that ties one or more ranges of independent variables to a range of dependent variable, which also indicate the statistical precision of the actual or observed values during data collection.

In case of one independent variable, regression analysis allows the prediction of a value of a dependent variable based on other value of one independent variable:

$Y = a + b x$

Where Y is the dependent variable, ie. dorsal fin,

a is the constant or the Y intercept

b is the slope or x coefficient

x is the independent variable

In case of more than one independent variable, regression analysis allows the prediction of a value of dependent variable on other values of more than one independent variables. In other words, multiple regression, which actually determines the possible

relationship between shark size to fins sizes (dorsal, pectoral and caudal fins):

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4$$

The analysis was based on a one-year data collection which would provide morphometric equations based on each of the sampled species valued for its fins.

2- Physical Studies of Shark-Fins:

A- Yield Studies:

In order to study the yield of different types and grades of shark-fins on dry basis, fins were cut and collected according to the procedures described by Ka-keong (1983) and processed by a modified method described by Nair and Madhavan (1974), and the Marine Products Export Development Authority (1989) (Figure 1)

Fresh shark weight and precaudal length was recorded, then fins were measured by the standard measurements described previously (Appendix 2). Fin cutting involved the half-moon cut (Figures 6,8 and 13). The fins, sun-dried to determine the weight on dry basis. For processing, dried fins were soaked in water 24-48 hours. The water was changed every 12 hours to soften the muscles. Then fins were placed in a container with 7% acetic acid solution for at least 24 hours to hydrolyze the skin to gelatine. The hydrolyzed skin was scraped off

by a brush in running cold water. The fin was then dried under the sun for another 48 hours and the weight was recorded (Figures 1,7,9 and 14).

Fin needle preparation involved soaking of the dried processed fin for 48 hours, then placed in boiling water to hydrolyze the membrane and gelatinous materials around the fin needles. Boiling the processed fin left the edible fin needles to be extracted by hand in chilled water and the non-edible cartilage platelet between two layers of fin needles (Figure 10). The dried weight of fin needles and cartilage was determined. To calculate the yield percentage of fin needles on dry basis, the weight of dry needles divided by the weight of dry raw fin, was multiplied by 100.

Fins from dogfish were collected from "Seafresh U.S.A." in Narragansett, Rhode Island. The same processing steps mentioned above were performed for the yield studies of dogfish (Figures 12-15). However, yield studies were performed on wet and dry basis. Fins of dogfish was dried mechanically by vacuum dryer at 110^{o}F.

The moisture content of fresh fins from dogfish was determined for the pectoral fins in the straight and half-moon cut forms and for the caudal fin (tail) at 100^{o}C.

B- Time and Effort Studies on Fins of Dogfish:

Thirty pectoral and thirty caudal fins were collected in the fresh form, washed, weighed, and the length was measured. The time was monitored in each step of the fin processing. Then, the excess meat of the pectoral fins was cut and trimmed. The weight was recorded before and after the cutting and trimming.

Fresh pectoral fins were soaked in 7% acetic acid for 24 hours while the tails soaked for an additional 24 hours to soften the skin and the meat of the tails. The skin was scraped off with a knife and the weight and the deskinning time was recorded.

For fin needle extraction, the processed fins were placed in boiling water and then needles extracted in chilled water. The extraction time was monitored and finally the wet fin needles were weighed and mechanically dried in an oven at 45^{o}C for 5 hours. The dried needle weight was recorded and the percentage of yield was calculated as mentioned earlier.

C- Thickness and Hydrothermal Studies of Fin Needles:

Thickness studies was performed in Oman on fresh, native fin needles (elastoidin) using a modified method described by Ramachandran and Sanker (1989). For this purpose, fin needles extracted from fresh pectoral fins of different grades of black fins and fresh dorsal fins of

different grades of white fins in their natural form. In this case, fresh fins were soaked in water for 24 hours, and then in 7% acetic acid for 1-2 hours only, just to soften the skin so the fin can be split into two halves. The fin needles were extracted by hand in random and washed in fresh water. The color and appearance was determined visually. The length was measured by a ruler or a scale. Thickness was determined by measuring the maximum width of native fin needle using a standarized micrometer fixed in the eyepiece of a microscope.

Hydrothermal studies were conducted after the length and thickness of native elastoidin was determined. In this part of the study, native elastoidin was placed in pre-heated water between 60-70^{o}C to determine the shrinkage properties. Color and appearance was also observed, and length and thickness was determined as described above. Finally the percentage increase in width or thickness, and decrease in length after the heat treatment was calculated as follow:

$$\text{Percentage increase in needle width} = \frac{\text{Original thickness - Shrinkage thickness}}{\text{Original thickness}} \times 100$$

and

Percentage decrease in needle length

$$= \frac{\text{Original length - Shrinkage length}}{\text{Original length}} \times 100$$

3- Chemical Studies:

A- Proximate Analysis:

1- Moisture, Ash and Total crude nitrogen (Kjeldahl nitrogen determination) were determined according to the AOAC (1980) methods.

2- Crude fat content was determined by modified AOAC (1980) acid hydrolysis method for determination of crude fat.

One gram of well-mixed dried fin needles or 2 grams of wet fin flesh placed in 50 ml screw cap centrifuge tubes. Ten ml of (25 parts HCl: 11 parts of H_2O) added and mixed with the sample. The mixture was heated on steam bath for 90 minutes with occasional mixing. Then, 5 ml ethanol, mixed; 15 ml ether, shaked; 15 ml petroleum ether and shaked. Centrifugation for 10 minutes at 1200 RPM, and the ether-fat layer was extracted into a predried and preweighed flask. This was repeated for a total of 3 extractions with 15 ml of each ether.

The extract was allowed to evaporate under the hood overnight, then placed in oven at 100^{o}C for about 20 minutes. The flask was then weighed and the percentage of fat content was calculated as:

$$\frac{\text{Weight of flask with extracted fat - Empty flask}}{\text{Sample weight}} \times 100$$

B- Acid Insoluble Ash (AIA) was determined in fin needles according to the method described by Van Keulen and Young (1977).

C- Non-Protein Nitrogen of fin needles and fin flesh was determined according to Omanian standard (1986) methods.

One gram of well-mixed sample of fin needle (crushed or ground) or fin flesh mixed with 150 ml distilled water, 2 ml of 10% sulfuric acid and 12% sodium tungstate. Suspension was made up to 200 ml, allowed to stand overnight and then filtered on Whatman no. 4. Clear filterate was evaporated to dryness in Kjeldahl flask. Nitrogen was determined of the dried filterate by the general method for nitrogen determination described by AOAC (1980).

D- Amino Acid analyses of fin needles were determined according to the AOAC (1990) methods performed by the Southern Testing and Research Laboratories, Inc. 3809 Airport Dr., Wilson, NC 27896

E- Protein Efficiency Ratios of fin needles were determined according to the AOAC (1990) methods performed

by the Southern Testing and Research Laboratories, Inc.

F- Metals/Minerals Analyses were determined according to the AOAC (1993) methods performed by the Southern Testing and Research Laboratories, Inc.

RESULTS AND DISCUSSION

1- Morphometric Studies:

A- Identification of Shark Species:

Ten shark species were identified as having valuable fins during data collections from the shark landing sites at Muttrah Souq between July, 1991 and June, 1992. As indicated by Table 6, eight of these species belong to the Carcharhinidae family (Requiem sharks) and are classified as black fins (greyish black) due to their natural color. Although the lower side of the pectoral fin is white in color, the color of the upper or outer side was taken into consideration. In such classifications, the dorsal fin, pectoral fin, and caudal fin (whole tail) are used for export by local traders.

Most of the Carcharhinus species were distinguished by black colorations on their fins. However, some species lack such coloration which made their identification more

difficult. Hammerhead sharks having fins which are also in the same classification have one of the extreme body form which can be distinguished easily.

Only one species which belongs to the Rhinchobatidae was identified as having white fins (Figure 8). These rays, or batoids, are close relatives of the sharks but differ from the latter in having their pectoral fin expanded forward and fused to the sides of their heads over the gill openings (Compagno, 1987). Thus, only their dorsal fins and caudal fins (whole tail) are cut and collected for export as white fins. These rays are also known as guitarfish. They are the main source of white fins which fetch a better price than black fins during export by shark-fin traders in India (Nair and Madhavan, 1974; MPEDA, 1989).

In the grading system of shark-fins, fins are classified according to species and then by size within a species. Fins from Hammerhead sharks are graded as top grade while fins from the Black-tipped shark and guitarfish are considered as grade one fins (Subasinghe, 1992; King et al, 1984; Ka-keong, 1983).

B- Morphometric and Statistical Description:

Among the ten species observed at the landing site which have a potential value in the shark-fin market, only seven species were considered for statistical analysis.

The remaining three species, sicklefin lemon shark, Negaporion acutidens, blacktip reef shark, Carcharhinus melanopterus, and guitarfish, Rhynchobatus djiddensis were rarely observed and were usually caught or landed in relatively small sizes. According to Nair and Madhavan (1974), fins from sharks over 1.25 m in total length (approximately one meter in precaudal length) are considered of commercial value. Therefore, the three remaining species were not considered in the statistical analysis due to size and scarcity.

During data collection, less than ten lemon sharks were recorded and only two attained the recommended size. The blacktip reef shark was also are uncommon species with sizes recorded less than 1 m (PL). According to Last and Stevens (1994) the blacktip reef shark is a small-sized shark that can grow to a total length of 140 cm only. Finally, the white spotted shovelnose ray or guitarfish was less common and just about a dozen rays were recorded. Only one guitarfish was landed that attained a size of more than 2 m (PL).

Such small sizes of sharks harvested off the coast of Oman suggests that sharks are caught as a bycatch using fishing gear for large pelagics. Figure 2 indicates that the majority of the shark landed are of small to medium size ranging from 1-1.5 m (PL). However, according to Fischer and Bianchi (1984), most of the sharks are of

small to medium size; 50% are small, between 15 cm and 1 m (TL); and 32% are between 1 or 2 m (TL).

Among the seven species which is commonly observed during the study, the black-tip shark, Carcharhinus limbatus, and the pigeye shark, Carcharhinus amboinensis, attained the largest sizes (Table 7). The maximum reported size for these sharks is 250 cm and 280 cm (TL), respectively (Fischer and Bianchi, 1984). During data collection, the black-tip shark ranged from 121 cm to 202 cm (PL), (Appendix 9), while the pigeye sharks ranged from 134 cm to 178.7 cm (PL) (Appendix 12). These are heavy-bodied sharks with relatively large fins compared to body size (Table 8). These morphometric characteristics of having a large dorsal and pectoral fins are also shared by the sandbar shark . As indicated by Tables 7 and 8, the Scalloped hammerhead shark is an exception to the remaining species in that the average length or percentage fin length of pectoral fins is less than the average length or percentage fin length of the dorsal fin. This is probably a trade off in hammerhead sharks since they have a larger ventral head area and a smaller total pectoral fin area (Thomson and Simanek, 1970).

The smallest recorded body size of the seven species of sharks was observed in the spottail shark, Carcharhinus sorrah. The average precaudal length was less than a meter with relatively small fin sizes (Table 7).

According to Davenport and Stevens (1988) only a few spottail sharks attained a size above 130 cm (TL) in females and above 112 cm (TL) in males caught by Taiwanese gill-net fishermen in Northern Australia.

The silky shark, Carcharhinus falciformis, and the spinner shark, Carcharhinus brevipinna, are the most common species which attained body sizes larger than 1 meter in average precaudal length. However, these two species share similar morphometric characteristics of having lower values of percentage fin lengths to the body size (Table 8).

Since the value of shark-fins depends on their natural color, form of presentation, content of fin needles and size of fins (Ka-keong, 1983) (Table 4); the pigeye, the black-tip, the sandbar and the hammerhead sharks attained the best sizes of fins compared to their body sizes (Tables 7 and 8).

The best ratio of fin length to shark length in term of dorsal fin ratio is attained in hammerhead and sandbar sharks, in pectoral fin ratio the black-tip and sandbar sharks, while in tail ratio to body size in hammerhead and pigeye sharks. Thus, these four species are of superior quality out of the seven species studied for their morphometric characteristics.

During sampling, silky sharks were the most abundant and constituted about 33.6% of the total sampled shark

species (Figure 3). These results along with the findings from Anderson and Waheed (1990) who indicated that 68% of the catch of the shark species were silky sharks in the Maldives, suggests that the silky sharks are the dominant species in the Western Indian ocean (Fishing Area 51). Spinner sharks were in second place in terms of abundance which constituted 28% of the shark species sampled during the study. Among the four species which possess superior fin sizes, hammerhead was more abundant than the pigeye and blacktip sharks, which were equally abundant at 5.4%.

Silky sharks which start moving into the Gulf of Oman in April when the summer water temperature increases and stay there until September (Figure 4). According to Last and Stevens (1994) silky sharks are found in water temperatures above 23^{o}C. During the winter and spring,spinner sharks are more common, sometimes even in the summer. Other species, though less abundant, do stay in local waters year-round.

C- Morphometric and Regression Equations:

Seven hundered and sixty-six of the different shark species were measured and recorded from the landing site at Muttrah Souq between July, 1991 to June 1992. The precaudal length of shark regression (to predict values of one variable in term of the other) in relation to the dorsal, pectoral, tail and lower lobe of tail lengths

revealed different R^2 within and among each species (Table 16).

In the silky shark, regression formulas indicate that the best correlation is between precaudal length and all four fins (dorsal, pectoral, tail and lower lobe of tail) since the coefficient determination was the highest (R^2=0.92) (Table 9). This set contained two hundred and forty-nine silky sharks ranging in size from 44 cm (PL) to 185 cm (PL) (Appendix 6).

A silky shark's precaudal length (PL) can be converted to its total length (TL) using the regression: (TL) = 3.4378 + 1.3358 (PL), R^2= 0.997, N= 283 (Bonfil et al., 1993). Furthermore, Anderson and Waheed (1990) derived a length-weight relationship for silky sharks: $(W) = 8.174 \times 10^{-6} L^{2.914}$, R^2= 0.98, N= 208. However, it was found that size and weight vary greatly, not only among species and families, but also from one specimen to another (Kizevetter, 1973). With such formulas, shark-fin vendors and purchasers can predict the length of fins of silky sharks; thus they can grade the fins and predict its value in the market according to the size and type of fins of the silky shark (Table 4).

In hammerhead and spinner sharks, precaudal regression on the various fins revealed that fin length was the best predictor of shark size. However, fin lengths (dorsal, pectoral, tail and lower lobe of tail) can be predicted

with good accuracy as the R^2 values were above 0.90 in both species (Tables 10 and 11) (Table 16). Since hammerhead sharks were less abundant, regression analysis was performed on a set of 62 sharks (Appendix 7), while for the spinner shark, regression was derived from 231 sharks (Appendix 8).

From the linear regression analysis of black-tip and sandbar sharks, the best relationship was also with precuadal length regression on all four fins R^2= 0.94 and 0.91, respectively (Tables 13 and 12). Estimation of fin length of sandbar and black-tip sharks was also possible since the R^2 values were in the range of 0.80-0.91 in both species. Regression was performed on a set of 46 blacktip sharks ranged from 121 cm to 202 cm (PL) (Appendix 9), and a set of 38 sandbar ranged from 83 cm to 147 cm (PL) (Appendix 10).

As previously mentioned, during the study, spottail sharks attained small to medium body sizes. The range of the shark body sizes sampled were between 59 cm to 155 cm (PL); however, the majority were less than a meter in precaudal length (Appendix 11) and (Table 7).

A precaudal length-to-fin length relationship for spottail sharks was based on a set of 97 measurements but three measurements were excluded from the analysis as outliers, leaving a total of 94 measurements (Appendix 11) and (Table 14).

Regressing tail length on body size revealed a good correlation among the four fins in the spottail shark; however, using all four fin regressed on body size was better correlated (Table 14, Table 16).

The worst correlation was revealed in pigeye sharks, especially with the regression of body size on dorsal fin or pectoral fin length (Table 15). As a large, slow-growing, and heavy bodied species (Randall, 1986), the pigeye shark can be expected to have an overlapping body size to fin sizes which caused bias in the results. A reliable correlation was revealed in body size regresssion on all fins as well as with predicting the tail and the tail's lower lobe of the pigeye.

The use of multiple regression analysis by taking the fin sizes (dorsal, pectoral, tail, and lower lobe of tail) as a function of body size (precaudal length) revealed a stronger correlation than using the body size as the independant variable to predict the sizes of different fins (Table 16). Yet, by measuring the precaudal length with absolute precision, fin sizes can be determined or predicted to indicate the fin size or grade. Therefore, the value of such fin can be predicted in the market by knowing the size of the shark species that I have studied.

2- Physical Studies of Shark-Fins:

A- Yield Studies:

Yield studies were performed on different fin types and sizes of different shark species in Oman. The average size of black and white dorsal fins was 14.7±3.6 cm (small sizes), 54.8%±3.7 moisture content; pectoral fins was 19.8±3.1 cm (small to medium sizes), 51.9%±3.5 moisture content; and caudal fins was 35.76±8.87 cm (large to extra large sizes), and 59.2%±5.3 moisture content. Fin needles or rays were dried on the sun to a moisture content of 10%±2.0.

The content of fin rays or fin needles varied among the different fin types within the same species and among different species with the caudal fin (whole tail) of black varieties containing the lowest yield. Nair and Madhavan (1974) have found that the yield from the black varieties was only half of the white variety based on the straight cut. As indicated by Table 17-b, the black fins had a lower yield than the white fins; especially the black tails were only about a third that of the white tails. However, the lower lobe of tails is very massive in fin rays which gave the highest yield ranging from 28.0%±0.0-44.0%±3.0, and contained very little cartilage which make it easier for the importer to process (Table 18). In the lower lobe, these fin rays (ceratotrichia) are more dense and well developed but modified and highly reduced in the upper lobe (Goodrich, 1930; Romer, 1970).

Thus, in the black tails, needles are only available from the lower lobe. the rest of the tail (upper lobe) is discarded (Infofish International 2/91). Among the black fins, the dorsal fins of the silky shark, the pectoral fins of the sandbar shark, and the tail or lower lobe of tail of the silky shark gave the highest yield of fin needles. This indicates that among black fins the difference in yield is due to differences in fin types as well as species difference.

Black fins from black varieties contain a considerable quantity of cartilaginous platelets interspaced between two layers of massive fin rays. Whereas, in white fins and the lower lobe of black tails the structure is constituted by rays and the gelatinous material with low cartilage content. Table 18 indicates that the white fin contains less than a half of the average content of cartilage of the black fins (Figure 10). Since the pectoral and dorsal fins from black varieties contain large quantities of the cartilage platelets, many processors split the processed fins into two portions to remove the platelet. According to Ka-keong (1983) such products increase the price of dorsal and pectoral fins, just like the processed tails, as it becomes packed only with individual strands of rays and gelatinous substances.

The yield of processed fins (skin off) from dried fins was higher in white fin than black fins which indicate

that black fins possess a thicker skin than the white variety, though the skin hydrolysis was not faster or easier with the white fins. Among and within different fins of different shark species there were different yield in the percentage of processed fins (Table 19).

During processing, dried fins required more soaking in water and acetic acid than the fresh ones to hydrolyze the skin, especially ones that had been dried and stored for a long period. Fins dried and stored for more than a year may need extended soaking in water and then treatment with hot acetic acid (MPEDA, 1989; Nair and Madhavan, 1974).

Fresh shark-fins usually give transparent fin needles of light color or golden yellow color when dried. However, when the fin is dried and stored for a period of more than one year, a brown or reddish brown color was obtained. Prepared dried fin needles with 12%+2.0 moisture content have a brittle and hard texture. Soaking or boiling dried fin needles will cause hydration and swelling of fin needles due to water intakes. According to Bear (1952) dry elastoidin, unusually develops distortion at small angle diffraction, and unusually low axial periodicity of 600 Angstron as the long charged side chain at bands normally distort the vertical main chain helices from a straight course. Hydration in neutral water, causes the relaxation of attachment between protofibrils; therefore, more room becomes available for

the charged side chains at bands which now permit straightening of the main chains and do not distort the main chain coil (Appendix 5).

Fin needle extraction was much easier with large fins than small fins. The latter contained tiny and thin needles that are extremly hard to extract and usually float in water during washing process. Thus they were easily lost during draining.

In the case of dogfish, the fins were in the range of very small to small fins because the size ranged between 5-10.9 cm in dorsal and pectoral fins while the tails ranged from 16-20 cm (Figure 12). Fin needle extraction was very tedious as they contained many tiny needles especially in the dorsal and the tail. The fin needles of dogfish have similar characteristics to those of white fins in that they do not curl when boiled in water. Also the tail shares similar structural features as the tails of white fins in that the lower and upper lobes are utilized (Appendix 1). Also the cartilage content was very low in the dorsal and pectoral fins (Tables 17-b and 18). The moisture content in the fresh raw fin of dogfish was 75.77%, 75.35% and 73.5% in the tail, pectoral fin (straight cut), and pectoral fin (half-moon cut). More than 99% of the moisture was lost during the first 24 hours in the oven at 100^{o}C (Figure 5).

The average percentage yield of dried fin needles

(12%+2.0 moisture) to the shark body weight was as follow: 0.25%, 0.195%, 0.185%, 0.183%, 0.17%, 0.137%, 0.117% for the sandbar shark, silky shark, hammerhead shark, blacktip reef shark, guitarfish, spottail shark and spinner shark, respectively (Table 17-a)

B- Time and Effort Studies on Fins of Dogfish:

A total of thirty washed pectoral fins (straight cut) weighed 604.7 grams which yielded 372 grams after cutting and trimming (half-moon cut). All fins were graded as small fins since they were in the range of 10-20 cm. The processing and extraction of fin needles was easier and less laborious than the tails of dogfish (Tables 20-a and 20-b). This is because the pectoral fins contained no meat at the base of the fin. Therefore, fin needles can be extracted more easily than tail needles. Moreover, the tails contained more of the tiny needles which are embedded in a thick and sticky membrane. Thus, the time of extraction and washing of extracted needles required about double the time of the pectoral fin (Table 20-b).

The actual effort to extract fin needles from the thirty pectoral fins was 223 minutes to get 131.55 grams of wet needles or an average of 7.43 minutes to get 4.385 grams from a single fin. In tails it required 396 minutes to get 110.06 grams of wet fin needles or an average of 13.2 minutes to get 3.668 grams from a single tail. The

moisture loss was 77.53% and 72.9% for the pectoral and caudal fin at 45°C for 5 hours.

C- Thickness and Hydrothermal Studies of Fin Needles:

Thickness of fin needles was directly proportional to the size of fins within species, but slightly varied among different species (Table 21). Among fin sizes of 20 cm and above, the white fin and blacktip reef shark contained thicker needles than in the other species. Fin needles from fins of 15 cm and below, contained thinner needles that usually dried up once exposed to the light of the microscope.

Prepared fin needles in the natural form (native elastoidin) have a physical characteristics of transparent light-yellow color, morphologically homogeneous with a hard but flexible texture. These needles shrunk immediately in the pre-heated water at 60-70°C. As seen from Table 22, decrease in length or contraction at an average of 57% was associated with increase in thickness or swelling at an average of 79.8%. The transparency of the shrunk needles or elastoidins was reduced to a creamy yellow color with a softer and rubber like texture. Bear (1952) attributed such textural changes to changes in the thermoelastic properties from negative temperature coefficient in native elastoidin to the positive thermoelastic coefficient in the shrunk ones. In thermal

contraction, collagen fibrils are capable of undergoing considerable shortening, with the axial periods as low as 400 Angstron.

In this study, the elastoidin fibers of different species contracted to an average of 57% of their intial length. Fin needles extracted from black varieties on their natural form curled during thermal contraction. However, needles from the white fins never curled and stayed with its original rod shape. Collagen fibrils, including the elastoidin are manifested to a sharp contraction to about one third of their original length due to abrupt loss of molecular structure (Balian and Bowes, 1977; Damodaran et al., 1956).

Fin needles soaked in 10% cold acetic acid solution for 24 hours became thicker at an average of 1 mm in diameter with an appealing glassy appearance (Table 22). This is due to osmotic swelling in acid or alkaline solution largerly at bands of collagen fibers between positive and negative charge on the protein. The ionic groups at bands are discharged by means of hydrogen ions of acids at the negative side chains. Meanwhile, the equal number of free negative ions required to remain at the bands produce local osmotic swelling, which contract the structure axially. Axial periods are shortened to 540 Angstron in acid-swollen fibrils based on electron microscope evidence (Bear, 1952; Balian and Bowes, 1977)

(Appendix 5).

3- Chemical Studies:

A- Proximate Analysis:

Fin needles extracted from different fin types or different shark species showed a very high content in total nitrogen content. As indicated in Table 23, the total nitrogen content of fin needles on the dry basis, ranged from 17.4%±0.3 in the hammerhead shark to 15.99%±0.2 in the dogfish. As perviously mentioned, elastoidin fibers are considered in the collagen family; therefore, the protein content is calculated by multiplying the nitrogen content by the conversion factor 5.55. The factor 6.25, which often employed to calculate protein content in food stuffs, is generally misleading and gives an overestimated protein content in collagen (Leach and Eastoe, 1977)

Jayawardena (1980) reported a total nitrogen content of 16.44% (dry basis) in fin needles extracted from black and white varieties and the balance may be carbohydrate. Other studies revealed the content of little carbohydrate in elastoidin fiber such as glucose, galactose, glucoseamine and galactoseamine (Gross et al., 1958; Gross and Dumsha, 1958). The ratio of carbohydrate to nitrogen was extremely low at 0.061 in the elastodin fiber

of tiger shark. Sastry and Ramachandran (1965) reported nitrogen content of 15.99% (dry basis) in fin needles extracted from tiger shark while Ramachandran and Sankar (1989) reported an average of 15.69% total nitrogen in the fin needles extracted from whale shark.

As seen from Table 23, the ash content is very low while the fat is absent in fin needles. Jayawardena (1980) reported a very low ash content (0.25) and a negligible oil content in fin needles. Others reported a 0.12% ash content in fin rays on dry basis (Personal correspondence, 1993). Moreover, fin rays do not contain any blood vessels since cartilage lack the havarsian canal system (Romer, 1970).

In contrast, the fin's flesh has a higher content of ash and fat than the fin needles (Table 24). According to Gordievskaya (1973), the flesh of almost all the shark species is lean except for the greenland and sevengill sharks. The protein content of shark meat is calculated by substracting the non-protein nitrogen from the total nitrogen content and the difference is multiplied by the conversion factor 6.25.

Bykov (1972) reported a 23.6% protein, 0.4% fat, and 1.3% ash in the flesh of the black-tip reef shark. Kizevetter (1973) indicated that requiem sharks, hammerhead sharks and guitarfish contains 3.3-4.6% nitrogen and 0.8-1.7% ash on wet basis.

B- Acid Insoluble Ash:

Fin needles prepared from fins of different shark species contained no acid insoluble ash (Table 23). Impurities such as silica, sand and other extraneous materials could contaminate the fin and fin needles during drying or processing them. Thus such test is mainly to detect impurities in dried products that has not been prepared under hygienic conditions.

C- Non-Protein Nitrogen:

The component non-protein nitrogen in fin needles was not detected (Table 23). This is in contrast to fin flesh, which contained a considerable amount of non-protein nitrogen (Table 24). According to Kizevetter (1973), the specific taste of shark meat is due to the peculiar composition of nitrogenous substances in it. These include the urea, TMAO, and nitrogen of volatile bases. Gordievskaya (1973) indicated that urea accounts for most of the non-protein nitrogen which scarcely depends on the size and weight of the shark. Furthermore, Yancy and Somero (1979) showed that the elasmobranchs contain a family of methylamine compounds, largely TMAO which is maintained at 1:2 molar concentration to urea. At such concentration these methylamine compounds offset the destabilizing effects of urea, thus stabilize the protein structure in the elasmobranchs.

D- Amino Acid Analyses:

As indicated in Table 25, the amino acids profile of elastoidin extracted from different shark species reveals no significant difference in chemical compositions of their protein. The distribution of amino acids of elastoidin follow the general pattern of typical collagen. The glycine content is high and the percentage of non-polar amino acids is in the same range of the collagen. The hydroxy amino acid (hydroxyproline) is lower in elastoidin which offset by a higher serine and threonine.

Elastoidin differed from bovine collagen in having a higher content of tyrosine and cystine which probably explain the peculiar hydrothermal properties of elastoidin. According to Bear (1952) the swelling behavior of normal collagen, elastoidin and ovokeratin, progressively richer in sulfur also show increasing resemblance to keratin, whose resistance to swelling is attributed to stabilization of fibrillar structure probably by disulfide bridges between polypeptide chains.

E- Calculated Protein Efficiency Ratio:

As indicated in Table 26, the calculated essential amino acid score for elastoidins of hammerhead, guitarfish and dogfish were 45.1, 45.4, and 45.6, respectively as percent of essential amino acid score of casein. This

indicate that the protein's nutritional value of elastoidin is less than half of the casein since it contians very little of the essential amino acids. Moreover, they are an insoluble fibrous protein which make them hard to react with digestive enzymes.

Table 25 compare the content of elastoidin's essential amino acids with casein and the percentage deficiency.

F- Metals/Minerals Analyses:

Table (27) indicates that elastoidin is very rich in sulfur which may attribute to elastoidin distinctive hydrothermal properties and resistance to gelatinization. Sources of sulfur may be the methionine, cystine and sulfur carbohydrate.

Elastoidin extracted from fins of guitarfish (white fins) have a higher content of calcium, magnesium, and zinc but a lower phosphorus content than the fins of hammerhead (black fins) and dogfish. The mercury and lead content is low since the unit of measurement is part per billion. The tolerance level for mercury in the United States and Canada in fish is 0.5 ppm (Kreuzer and Ahmed, 1978).

CONCLUSIONS

1- Ten shark species were identified as having valuable fins during data collections. Eight species belong to the Carcharhinidae family, and one to the Sphyrnidae. All are classified as having black fins. Only one species was identified as having white fin which belongs to Rhinchobatidae family.

2- Among the ten species, only seven where considered for statistical analysis in which all were classified as having black fins.

3- Among the seven species, the pigeye, the black-tip, the sandbar, and the hammerhead sharks attained the best ratio of fin sizes to body size.

4- Silky sharks were the most abundant species, followed by the spinner shark during data collection.

5- The regression of body size (precaudal length) to fin sizes revealed different correlation within and among each species.

6- In the seven species, the best correlation was between precaudal length and all four fins (dorsal, pectoral, tail and lower lobe of tail) as the R^2 was the heighest.

7- The content of fin needles varied among the different fin types within the same species and among the different shark species. The white fins gave a higher yield than

the black fins.

8- Among the black fins, the dorsal fins and lower lobe of tail of the silky shark and pectoral fins of sandbar shark gave the heighest yield.

9- White fins had a lower cartilage content and a higher yield in processed fins than black fins.

10- Caudal fins of dogfish had a similar skeletal structure as the white fins in which both the upper and lower lobe of the tail can be utilized for fin needles extraction.

11- Extraction of fin needles from tails of dogfish was less economical and more time consuming than the pectoral fins of dogfish.

12- Thickness of fin needles was directly proportional to the size of the fins within the shark species but slightly varied among the different species.

13- Physical characteristics of native fin needles changed during shrinkage at 60-70^{o}C as follow: length and transparency decreased, thickness increased, and fibers or needles became softer and rubber like.

14- According to the proximate analysis, fin needles have a very high content of nitrogen, very little ash and no oil content.

15- The non-protein nitrogen was absent in fin needles which indicate a very high content of crude protein.

16- Fin's flesh contained a higher content of ash, fat and

non-protein nitrogen than the fin needles.

17- There is no significant difference in the chemical composition of amino acids of the elastoidins extracted from hammerhead (black fin), guitarfish (white fin) and dogfish.

18- The amino acids of elastoidin follows the pattern of collagen in that it contain a high glycine and similar percentage of non-polar amino acids.

19- The elastoidin's amino acid profile differ from collagen in having a very high content of tyrosine and the presence of cystine.

20- The calculated protein efficiency ratio of elastoidin is low (42.95-45.56) and about half that of casein (95.25). Thus shark-fin is not a nutritious food.

21- Elastoidin is very rich in sulfur which may explain the peculiar hydrothermal properties of elastoidin.

22- Shark-fin processing and fin needle preparation can provide job opportunities for fishermen in Oman or in the U.S. which could provide them with a good income. Shark-fin needles or nets could be processed in Oman or the U.S. and exported to the oriental market. Thus a value-added product can be produced instead of exporting the shark-fin as such at a relatively lower price.

23- Artificial needles should be considered for future studies by food scientists to satisfy the high demand for such product and make needles more accesible to people.

Table 1. Major differences between collagen and elastin*.

Collagen	Elastin
1. Many different genetic types	One genetic type
2. Triple helix	No triple helix
3. (Gly-X-Y) repeating structure	NO (Gly-X-Y) repeating structure
4. Presence of hydroxylysine	No hydroxylysine
5. Contains carbohydrate	No carbohydrate
6. Intramolecular aldol cross-links	Intramolecular desmosine crosslinks
7. Presence of extension peptides during biosynthesis	No extension peptides present

* Murray et al. (1990)

Table 2. The chemical composition of bovine collagen and elastin*, shark-fin elastoidin**, and whole egg***, (gram of residues or of N in 100 gm of protein), and percentage deficits of essential amino acids of elastoidin compared to whole egg.

Amino Acids	Collagen	Elastin	Elastoidin	Whole Egg	Percentage Deficits
Glycine	19.9	22.5	25.37		
Alanine	7.6	15.1	11.4		
Phenylalanine	3.7	4.4	2.1	6.3	66
Leucine	4.8	10.1	2.62	9.2	72
Isoleucine			2.69	7.7	65
Valine	2.9	12.5	2.72	7.2	62
Proline	12.7	13.4	13.27		
Methionine	0.7	0.18	1.78	4	55
Cystine	0	0.28	0.35		
Tyrosine	1.3	1.4	7.15		
Tryptophan	0	0	0	1.5	100
Hydroxyprolin	12.1	1.7	8.76		
Glutamic acid	10	2.4	11.01		
Aspartic acid	5.5	0.35	6.4		
Arginine	7.9	0.88	8.61	6.6	--
Lysine	4	0.39	3.73	7	46
Hydroxylysine	1.1		0.88		
Histidine	0.7	0.04	1.73	2.4	28
Serine	2.7	0.68	3.31		
Threonine	2	0.87	2.42	4.3	44
Total N	18.6	16.9	17.52		
% Non-polar	54	91.6	60		

* Bear (1952)

** Damodaran et al (1956)

*** Ambe and Sohonie (1957)

Table 3. Common defects in dried shark-fins.

Defect	Causes
Blemishes	Bad handling and delay in cutting the fins
Defective cuts	Inexpert or careless handlers resulting in excess residual flesh on the fins or crude cuts
Burns	Deep, hard furrows caused by prolonged exposure to the sun or improper mechanical drying
Curling	Exposure of fins to uneven, non uniform drying
Insects	Small insects which attack the dried fin

Table 4. Price indications for shark-fins in Singapore market in1992 in US $/kg based on Infofish Trade Newsletter no. 92/21.

Type of Fins	Grades of Fins				
	>40 CM	30 - 40 CM	20 - 30 CM	20 - 10 CM	<10 CM
White Fins (D, P, & T)*	88.95	72.40	58.30	53.35	41.70
Black Fins (D & P)	52.15	44.80	34.35	32.20	13.50
Black Tails (T)	141.70	126.40	100.00	87.75	36.80

* Abreviatted for dorsal,pectoral and tail.

Table 5. World trade in shrak-fins (1988-1990)*, Quantity= Metric tons, Value= 1000 US $.

Country	1988		1989		1990	
	Quantity	Value	Quantity	Value	Quantity	Value
Exports						
Hong Kong	1208	22657	1434	28584	1609	24326
China	463	8753	563	11408	809	18603
Indonesia	458	6293	516	11059	558	11161
Japan	527	14087	503	12617	451	10310
Singapore	871	18091	1519	16090	806	15899
Pakistan	251	2725	377	3692	240	2521
Mexico	138	2056	130	2000	100	1500
India	141	2078	180	2655	100	1366
Brazil	217	2004	212	1807	270	1580
Others	538	8145	581	4675	659	7439
World Total	4812	86899	5602	94587	5602	94705
Imports						
Hong Kong	3738	96777	3554	93308	3638	94951
China	902	10836	1066	10193	1335	12088
Singapore	1878	20255	1173	19556	1006	18416
Others	299	4896	508	9346	535	6787
World Total	6817	132764	6301	132403	6514	132242

* Subasinghe (1992)

Table 6. Identified shark species valued for their fins during data collection between July 1991 and June 1992.

Scientific Name	Common Name
Carcharhinidae:	Requiem sharks:
Charcharhinus amboinensis	Pigeye shark
Carcharhinus brevipinna	Spinner shark
Carcharhinus falciformis	Silky shark
Carcharhinus limbatus	Black-tip shark
Carcharhinus melanopterus	Blacktip reef shark
Carcharhinus plumbeus	Sandbar shark
Carcharhinus sorrah	Spottail shark
Negaprion acutidens	Sicklefin lemon shark
Sphyrnidae:	Hammerhead sharks
Sphyrna lewini	Scalloped hammerhead
Rhinchobatidae:	Guitarfish
Rhynchobatus djiddensis	White spotted shovel nose ray / guitarfish.

Table 7. Summary of average precaudal lengths of the seven shark species identified for their valued fins during the study.

Shark Species	Precaudal Length	Dorsal Fin	Pectoral Fin	Tail	Lower Lobe of Tail
Spottail shark	98.3±13.9	12.6±1.6	19.6±2.8	36.8±3.9	12.5±1.9
Sandbar shark	116.4±18.6	22.9±6.5	30.3±8.4	42.4±7.7	15.8±3.1
Silky shark	117.5±19.5	12.9±2.5	24.7±5.8	42.0±7.1	14.5±3.6
Spinner shark	133.1±25.9	15.5±3.1	25.2±5.9	46.1±8.4	16.8±3.7
Hammerhead shark	134.3±29.3	26.3±7.8	23.8±6.6	58.5±10.	20.1±4.7
Black-tip shark	151.6±19.1	24.9±3.4	34.8±3.9	55.3±5.5	21.99±2.8
Pigeye shark	152.1±11.4	26.6±2.1	42.1±2.9	60.1±3.1	23.6±1.8

Table 8. Comparison of fin lengths with body size (precaudal length) of the seven shark species. Values expressed as percentage fin length to precaudal length.

Shark Species	Dorsal Fin	Pectoral Fin	Tail	Lower Lobe of Tail
Spottail shark	12.8±0.96	20.03±1.2	37.6±1.95	12.7±0.84
Sandbar shark	19.3±3.3	25.7±4.8	36.3±2.2	13.6±1.1
Silky shark	10.9±1.1	20.86±2.4	35.9±3.2	12.2±1.5
Spinner shark	11.65±0.6	18.8±1.3	34.7±1.7	12.6±0.78
Hammerhead shark	19.4±1.6	17.6±1.4	43.8±2.3	14.9±0.87
Black-tip shark	16.45±0.9	23.0±0.8	36.7±2.1	14.5±0.8
Pigeye shark	17.5±1.3	17.6±1.4	43.8±2.3	14.9±0.9

Table 9. Linear regressions between body size and fin sizes of Silky shark. PL= Precaudal length; D= Dorsal fin length; P= Pectoral fin length; T= Tail length; LL= Length of lower lobe of tail.

Lengths	Regression	R*	N**
D, P, T & LL and PL	(PL)=(20.5)+(2.8*(D))+(0.18*(P))+(0.86*(T))+(1.4*(LL))	0.92	249
PL and D	(D)=(-1.12)+(0.12*(PL))	0.88	249
PL and P	(P)=(-8.28)+(0.28*(PL))	0.88	249
PL and T	(T)=(2.19)+(0.34*(PL))	0.88	249
PL and LL	(LL)=(-5.8)+(0.17*(PL))	0.88	249

* Correlation coefficient

** Sample size

Table 10. Linear regressions between body size and fin sizes of Hammerhead shark. PL= Precaudal length; D= Dorsal fin length; P= Pectoral fin length; T= Tail length; LL= Length of lower lobe of tail.

Lengths	Regression	R*	N**
D, P, T & LL and PL	(PL)=(12.95)+(1.4*(D))+(0.36*(P))+(0.65*(T))+(1.9*(LL))	0.95	62
PL and D	(D)=(-7.9)+(0.25*(PL))	0.91	62
PL and P	(P)=(-5.56)+(0.22*(PL))	0.93	62
PL and T	(T)=(12.2)+(0.345*(PL))	0.90	62
PL and LL	(LL)=(-0.58)+(0.15*(PL))	0.93	62

* Correlation coefficient

** Sample size

Table 11. Linear regressions between body size and fin sizes of Spinner shark. PL= Precaudal length; D= Dorsal fin length; P= Pectoral fin length; T= Tail length; LL= Length of lower lobe of tail.

Lengths	Regression	R*	N**
D, P, T & LL and PL	(PL)=(7.9)+(2.5*(D))+(1.1*(P))+(0.6*(T))+(1.7*(LL))	0.97	231
PL and D	(D)=(-0.12)+(0.12*(PL))	0.93	231
PL and P	(P)=(-3.55)+(0.22*(PL))	0.90	231
PL and T	(T)=(4.47)+(0.31*(PL))	0.92	231
PL and LL	(LL)=(-1.28)+(0.14*(PL))	0.92	231

* Correlation coefficient

** Sample size

Table 12. Linear regressions between body size and fin sizes of Sandbar shark. PL= Precaudal length; D= Dorsal fin length; P= Pectoral fin length; T= Tail length; LL= Length of lower lobe of tail.

Lengths	Regression	R*	N**
D, P, T & LL and PL	(PL)=(15.9)+(-0.6*(D))+(0.6*(P))+(1.97*(T))+(0.79*(LL)	0.91	38
PL and D	(D)=(-14.9)+(0.32*(PL))	0.86	38
PL and P	(P)=(-11.4)+(0.36*(PL))	0.84	38
PL and T	(T)=(-3.5)+(0.39*(PL))	0.90	38
PL and LL	(LL)=(-1.6)+(0.15*(PL))	0.82	38

* Correlation coefficient

** Sample size

Table 13. Linear regressions between body size and fin sizes of Black-tip shark. PL= Precaudal length; D= Dorsal fin length; P= Pectoral fin length; T= Tail length; LL= Length of lower lobe of tail.

Lengths	Regression	R*	N**
D, P, T & LL and PL	(PL)=(-17.5)+(1.46*(D))+(3.06*(P))+(0.68*(T))+(-0.5*(LL))	0.94	46
PL and D	(D)=(0.55)+(0.16*(PL))	0.83	46
PL and P	(P)=(5.4)+(0.19*(PL))	0.91	46
PL and T	(T)=(16.07)+(0.26*(PL))	0.80	46
PL and LL	(LL)=(2.05)+(0.13*(PL))	0.80	46

* Correlation coefficient

** Sample size

Table 14. Linear regressions between body size and fin sizes of Spottail shark. PL= Precaudal length; D= Dorsal fin length; P= Pectoral fin length; T= Tail length; LL= Length of lower lobe of tail.

Lengths	Regression	R*	N**
D, P, T & LL and PL	(PL)=(-17.1)+(1.1*(D))+(1.1*(P))+(1.76*(T))+(1.15*(LL))	0.92	94
PL and D	(D)=(2.78)+(0.10*(PL))	0.72	94
PL and P	(P)=(1.86)+(0.18*(PL))	0.83	94
PL and T	(T)=(10.90)+(0.26*(PL))	0.88	94
PL and LL	(LL)=(0.11)+(0.13*(PL))	0.80	94

* Correlation coefficient

** Sample size

Table 15. Linear regressions between body size and fin sizes of Pigeye shark. PL= Precaudal length; D= Dorsal fin length; P= Pectoral fin length; T= Tail length; LL= Length of lower lobe of tail.

Lengths	Regression	R*	N**
D, P, T & LL and PL	(PL)=(-40.98)+(-1.35*(D))+(1.2*(P))+(1.75*(T))+(3.1*(LL))	0.77	43
PL and D	(D)=(12.2)+(0.10*(PL))	0.27	43
PL and P	(P)=(24.9)+(0.11*(PL))	0.19	43
PL and T	(T)=(27.35)+(0.22*(PL))	0.64	43
PL and LL	(LL)=(4.64)+(0.12*(PL))	0.60	43

* Correlation coefficient

** Sample size

Table 16. A comparison of coefficient of determination (R square) values for seven species of sharks determined from regression of Precaudal length on selected morphometric measurements.

Shark Species	Dorsal Fin	Pectoral Fin	Tail	Lower lobe of Tail	All Four Fins
Spinner Shark	0.93	0.9	0.92	0.92	0.97
Hammerhead Shark	0.91	0.93	0.9	0.93	0.95
Black-tip Shark	0.83	0.91	0.8	0.8	0.94
Silky Shark	0.88	0.88	0.88	0.88	0.92
Spottail shark	0.72	0.83	0.88	0.8	0.92
Sandbar Shark	0.86	0.84	0.9	0.82	0.91
Pigeye Shark	0.27	0.19	0.64	0.6	0.77

Table 17-a. Average yield percentage of dried fin needles to the shark total body weight.

Shark Species	Dried fin needle (%)
1- Blacktip reef shark	0.183
2- Silky shark	0.195
3- Spinner shark	0.117
4- Spottail shark	0.137
5- Sandbar shark	0.250
6- Hammerhead shark	0.185
7- Guitarfish	0.170

Table 18. Average percentage of dried cartilage content in dried fins from different shark species processed during the study based on half-moon cut.

Shark Species	Dorsal Fin	Pectoral Fin	Lower Lobe Of Tail	Whole Tail
1- Blacktip reef shark	7.77±1.25	12.6±1.98	2.0±0.92	--
2- Silky shark	13.66±2.6	29.4±4.36	2.8±0.26	--
3- Spinner shark	16.3±2.5	25.8±3.1	4.17±0.42	--
4- Spottail shark	20.2±1.66	23.97±0.9	3.0±0.7	--
5- Sandbar shark*	10.0±0.0	17.5±0.71	3.0±0.0	--
6- Hammerhead	23.5±2.5	21.97±2.7	2.66±0.15	--
Average (Black Fins)	16.35±6.1	22.25±6.1	2.9±0.84	--
7- Dogfish (Unclassified)	4.4±1.7 [3.7±1.9]	5.72±1.07 [11.9±2.56]	--	11.5±0.17 [13.6±1.5]
8- Guitarfish (White Fins)	6.57±0.59	3.3±1.04**	--	29.7±2.3

* Single test

** Values expressed for second dorsal fin

[ ] Values expressed on wet basis

Table 19. Average percentage of dried processed fins in dried fins of different shark species processed during the study based on half-moon cut.

Shark Species	Dorsal Fin	Pectoral Fin	Lower Lobe Of Tail	Whole Tail
1- Blacktip reef shark	59.7±3.05	54.7±2.96	65.0±2.0	--
2- Silky shark	77.0±2.65	72.5±2.74	83.0±3.6	--
3- Spinner shark	70.9±5.9	67.2±5.07	76.3±5.86	--
4- Spottail shark	67.3±5.51	65.83±3.3	82.0±4.58	--
5- Sandbar shark*	81.0±0.0	66.5±0.71	71.0±0.0	--
6- Hammerhead	68.3±2.75	62.3±4.8	73±2.64	--
Average (Black Fins)	69.3±7.1	64.3±6.9	75.6±7.4	--
7- Dogfish (Unclassified)	47.7±2.52 [57.1±5.8]	60.3±2.97 [70.5±4.5]	--	40.9±2.8 [45.87±7.1]
8- Guitarfish (White Fins)	85.66±3.5	78.66±4.0**	--	81.0±8.9

* Single test

** Values expressed for second dorsal fin

[ ] Values expressed on wet basis

Table 20-a. Yield of wet fin needles from fresh pectoral and caudal fins of dogfish based on half-moon cut.

No. and type of fins	Weight (gm)	Size (cm)	Processed fi wt. (gm)	Cartilage wt. (gm)	wet needles wt. (gm)	%processe fin	%cartilage	%fin needles
30 pectoral fins	372	11.2±1.2	281.3	53.5	131.55	75.62	14.4	35.36
30 caudal fins	1174.3	17.35±1.3	539.0	183.4	110.06	45.89	15.62	9.37

Table 20-b. Time and effort to process and extract fin needles from 30 pectoral and 30 caudal fins of dogfish based on half-moon cut.

No.and type of fins	Washing & weighing	Cutting & trimming	Deskinning	Fin needle extraction	Washing & drainage	Total time (min)
30 pectoral fins	15.0	15.0	40.0	138.0	15.0	223.0
30 caudal fins	20.0	0.0	65.0	281.0	30.0	396.0

Table 21. Physical and hydrothermal characteristics of fin needles from pectoral fins from black and dorsal fins from white before and after treatment with water at 60-70 C and cold acetic acid; Av. Ln. = Average Length (mm); Av. Tk. = Average Thickness (mm); No. = Number of Observations.

Fin Type and Species	Before Boiling			After Boiling		
	Av. Ln.	Av. Tk.	No.	Av. Ln.	Av. Tk.	No.
1- Silky shark (P) (24 cm, 136 gm)	102.5±44.	0.63±0.25	173	41.2±17.0	1.2±0.5	166
2- Silky shark (P) (21 cm, 101 gm)	83.2±43.0	0.62±0.26	139	34.9±18.3	1.03±0.4	143
3- Spinner shark (P) (20 cm, 86 gm)	78.2±40.1	0.58±0.25	135	33.5±17.5	0.97±0.3	112
4- Spinner shark (P) (15.6 cm, 49 gm)	67.6±23.7	0.46±0.18	128	29.2±9.8	0.84±0.3	121
5- Spottail shark (P) (18 cm, 78 gm)	84.1±26.4	0.58±0.24	189	37.4±11.5	1.11±0.4	187
6- Spottail shark (P) (14.4 cm, 26 gm)	68.9±21.0	0.44±1.8	148	27.8±7.9	0.9±0.3	142
7- Blacktip reef shark (P) (20 cm, 112 gm)	79.4±35.2	0.7±0.35	183	37.6±15.7	1.19±0.5	183
8- Hammerhead (P) (18 cm, 98 gm)	90.7±23.3	0.59±0.18	159	39.2±9.5	1.1±0.3	157
9- Hammerhead (P) (14 cm, 63 gm)	63.4±24.0	0.48±0.26	160	28±11.2	0.85±0.4	163
10- Hammerhead (P) (9.6 cm, 17 gm)	50.9±13.8	0.37±0.12	143	19.5±5.0	0.7±0.25	138
11- White (D) (20 cm, 161 gm)	97.1±29.4	0.67±0.28	163	41.9±12.4	1.06±0.45	160
12- White (D) (15 cm, 67 gm)	68.0±25.5	0.49±0.20	199	31.3±11.6	0.86±0.34	189
13- Spottail shark (P) (17 cm, 47.5 gm, in 10% acetic acid)	62.0±25.0	1.0±0.33	128	32.5±13.5	1.3±0.37	122

Table 22. Hydrothermal properties of fin needles from pectoral fins from black and dorsal fins from white treated with water at 60-70 C and cold acetic acid. Values expressed as percentage decrease in length and increase in thickness in shrunk needles.

Fin Type and Species	% Decrease in Length	% Increase in Thickness
1- Silky shark (P) (24 cm, 136 gm)	59.8	90.5
2- Silky shark (P) (21 cm, 101 gm)	58.0	66.0
3- Spinner shark (P) (20 cm, 86 gm)	57.2	67.0
4- Spinner shark (P) (15.6 cm, 49 gm)	56.8	82.6
5- Spottail shark (P) (18 cm, 78 gm)	55.5	91.4
6- Spottail shark (P) (14.4 cm, 26 gm)	59.7	104.0
7- Blacktip reef shark (P) (20 cm, 112 gm)	52.6	70.0
8- Hammerhead (P) (18 cm, 98 gm)	56.8	86.0
9- Hammerhead (P) (14 cm, 63 gm)	55.8	77.1
10- Hammerhead (P) (9.6 cm, 17 gm)	61.7	89.2
11- White (D) (20 cm, 161 gm)	56.8	58.2
12- White (D) (15 cm, 67 gm)	54	75.5
Average	57.05	79.8
13- Spottail shark (P) (17 cm, 47.5 gm, in 10 % cold acetic acid, 24 hrs)	47.6	28.0

Table 23. Percentage chemical composition of fin needles extracted from different shark species during the study; NPN= Non-protein nitrogen; AIA= Acid insoluble ash. D= Dorsal fin; P= Pectoral fin; T= Tail.

Species and fin types		Moisture	Total Nitrogen	NPN	Fat	Ash	AIA
Silky shark	(D)	65.4±0.0	5.9±0.06	0.0	0.0	0.09±0.0	0.0
	(P)	66.4±0.0	5.6±0.07	0.0	0.0	0.08±0.0	0.0
	(T)	66.4±0.0	5.6±0.0	0.0	0.0	0.08±0.01	0.0
			[16.8±0.3]			[0.23±0.03]	
Spottail shark	(D)	66.3±0.6	5.8±0.03	0.0	0.0	0.04	0.0
	(P)	66.6±1.1	5.5±0.1	0.0	0.0	0.04	0.0
	(T)	66.4±0.7	5.8±0.1	0.0	0.0	0.045	0.0
			[16.9±0.3]			[0.13±0.01]	
Spinner shark	(D)	65.6±0.5	5.6±0.03	0.0	0.0	0.12±0.03	0.0
	(P)	67.5±1.8	5.2±0.3	0.0	0.0	0.09±0.02	0.0
	(T)	65.7±0.1	5.6±0.05	0.0	0.0	0.13±0.02	0.0
			[16.2±0.2]			[0.35±0.08]	
Black-tip reef shark	(D)	70.2±0.0	5.1±0.11	0.0	0.0	0.01±0.01	0.0
	(P)	69.6±0.0	5.2±0.08	0.0	0.0	0.014±0.01	0.0
	(T)	68.9±0.0	5.15±0.01	0.0	0.0	0.017±0.01	0.0
			[16.9±0.4]			[0.05±0.02]	
Guitarfish	(D)	68.2±0.6	5.3±0.01	0.0	0.0	0.1±0.02	0.0
	(D)	67.9±1.6	5.3±0.2	0.0	0.0	0.09±0.03	0.0
	(T)	65.7±0.6	5.7±0.0	0.0	0.0	0.11±0.01	0.0
			[16.6±0.2]			[0.3±0.06]	
Sandbar shark	(D)	69.8±0.3	4.99±0.02	0.0	0.0	0.15±0.01	0.0
	(P)	70.7±0.6	4.7±0.06	0.0	0.0	0.15±0.01	0.0
	(T)	69.5±0.7	5.15±0.2	0.0	0.0	0.15±0.02	0.0
			[16.4±0.4]			[0.5±0.03]	
Hammerhead	(D)	68.8±0.1	5.4±0.06	0.0	0.0	0.2	0.0
	(P)	68.9±0.0	5.5±0.04	0.0	0.0	0.2	0.0
	(T)	67.8±1.9	5.3±0.14	0.0	0.0	0.18	0.0
			[17.4±0.3]			[0.6±0.02]	
Dogfish*	(P)	--	16.1±0.1	0.0	0.0	0.14±0.01	0.0
	(T)	--	15.9±0.3	0.0	0.0	0.18±0.00	0.0
			[15.99±0.2]			[0.16±0.03]	

[ ] Values expressed as the average percentage in dry basis

* Values expressed on dry basis only

Table 24. Percentage chemical composition of fin flesh from different shark species identified during the study; NPN= Non-protein nitrogen. D= Dorsal fin; P= Pectoral fin; T= Tail.

Species and fin types		Moisture	Total Nitrogen	NPN	Fat	Ash
Silky shark	(D)	73.7±0.0	4.6±0.1	1.3	0.4±0.0	1.3
	(P)	74.0±0.0	4.3±0.1	1.3	0.3±0.02	1.3
	(T)	73.1±0.0	4.5±0.07	1.2	0.4±0.08	1.4
Spottail shark	(D)	73.1±0.8	4.5±0.1	1.27	0.58±0.03	1.35
	(P)	73.1±0.4	4.5±0.01	1.28	0.55±0.06	1.38
	(T)	72.9±0.6	4.6±0.07	1.26	0.59±0.01	1.37
Spinner shark	(D)	75.0±1.0	4.2±0.07	1.27	0.3±0.04	1.3
	(P)	74.5±0.1	4.2±0.03	1.28	0.37±0.02	1.3
	(T)	74.6±0.1	4.2±0.06	1.27	0.34±0.04	1.3
Blacktip reef shark	(D)	74.4±0.8	4.2±0.0	1.22	0.47±0.02	1.25
	(P)	74.9±0.07	4.2±0.06	1.24	0.43±0.02	1.26
	(T)	74.5±0.5	4.2±0.08	1.20	0.37±0.01	1.26
Guitarfish	(D)	75.3±0.4	4.3	1.4±0.0	0.6±0.08	0.99±0.04
	(D)	74.9±0.07	4.4	1.4±0.0	0.6±0.02	1.0±0.03
	(T)	75.5±0.6	4.4	1.3±0.0	0.58±0.02	1.0±0.05
Hammerhead	(D)	74.3±0.6	4.2±0.2	1.27	0.5±0.01	1.3
	(P)	74.6±0.2	4.27±0.3	1.28	0.65±0.01	1.4
	(T)	74.6±0.5	4.1±0.05	1.27	0.5±0.0	1.4

Table 25. Percentage amino acids of bovine collagen*, elastoidin from hammerhead shark (1), guitarfish (2), dogfish (3), and casein**, and the average percentage deficits of essential amino acids of elastoidin compared to casein.

Amino Acids	Collagen	Elastoidin (1)	Elastoidin (2)	Elastoidin (3)	Casein	% Deficits
Glycine	19.9	17.37	17.07	17.49		
Alanine	7.6	9.87	8.99	9.54		
Phenylalanine	3.7	1.67	1.66	1.71	6.3	73
Leucine	4.8	1.76	1.88	2.01	10	81
Isoleucine		1.6	1.59	1.62	7.5	78.7
Valine	2.9	2.96	2.68	2.58	7.7	64
Proline	12.7	11.21	11.08	10.53		
Methionine	0.7	1.88	1.99	1.89	3.5	45
Cystine	0	0.93	1.12	0.99	0.4	0
Tyrosine	1.3	8.62	10.17	7.66	6.4	0
Tryptophan	0	0.6	0.71	0.35	1.35	59
Hydroxyprolin	12.1	5.65	4.88	4.29		
Glutamic acid	10	10.53	9.89	10.99		
Aspartic acid	5.5	5.5	5.52	6.48		
Arginine	7.9	8.71	7.88	8.56		
Lysine	4	2.91	2.92	3.57	8.5	63
Hydroxylysine	1.1					
Histidine	0.7	2.37	3.28	1.83	1.83	22
Serine	2.7	2.97	3.25	4.29		
Threonine	2	1.99	2.55	2.44	4.5	48
Taurine		0.00	0.00	0.00		
Glucosamine		0.21	0.24	0.27		
% Non-polar	54	59	59	57		

* Bear (1952)

** Ambe and Sohonie (1957)

Table 26. Calculated protein efficiency ratio (C-PER) of elastoidin extracted from hammerhead shark (1), guitarfish (2) and dogfish (3) compared to that of casein.

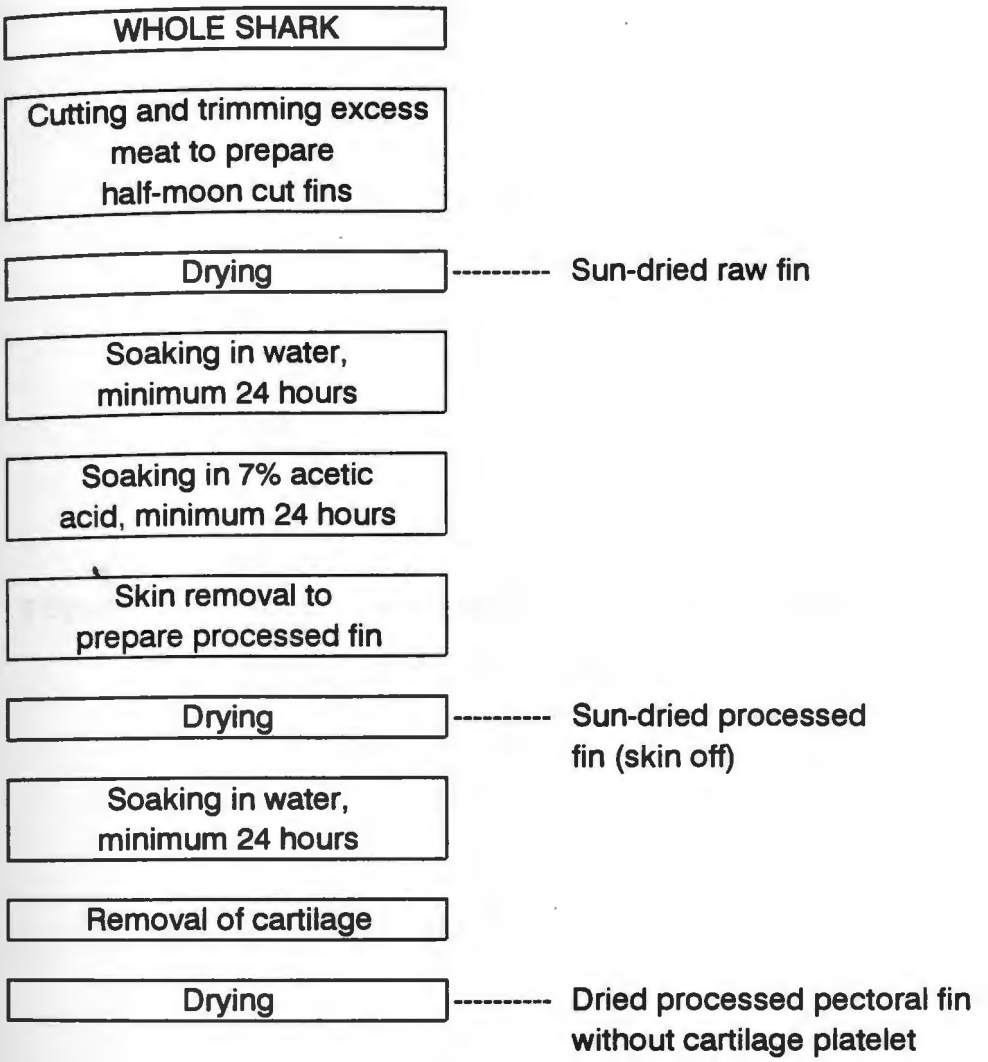
Essential Amino Acid Score for casein	95.25 = 100%
Essential Amino Acid Score for Elastoidin (1)	42.95 = 45.1%
Essential Amino Acid Score for Elastoidin (2)	43.26 = 45.42%
Essential Amino Acid Score for Elastoidin (3)	45.56 = 47.83%

Table 27. Minerals analysis of elastoidins from hammerhead shark (1), guitarfish (2), and dogfish (3). Units expressed as part per million (ppm).

Metals/ Minerals	Elastoidin (1)	Elastoidin (2)	Elastoidin (3)
Arsenic*	<125	<125	<125
Cadmium	<0.20	<0.20	<0.20
Calcium	72.9	383	108
Iron	29.4	51.7	31.1
Lead*	1757	1859	1131
Magnesium	86.9	623	136
Manganese	2.9	1.88	2.7
Mercury*	<100	<100	<100
Phosphorus	204	92.2	208
Potassium	<100	<100	<100
Sulfur	6432	5895	6485
Zinc	25.3	90.9	28.4

* Units expressed as part per billion (ppb)

Figure 1. Stages of shark-fin processing and fin needle preparation during the study and end products.



PREPARATION OF FIN NEEDLES

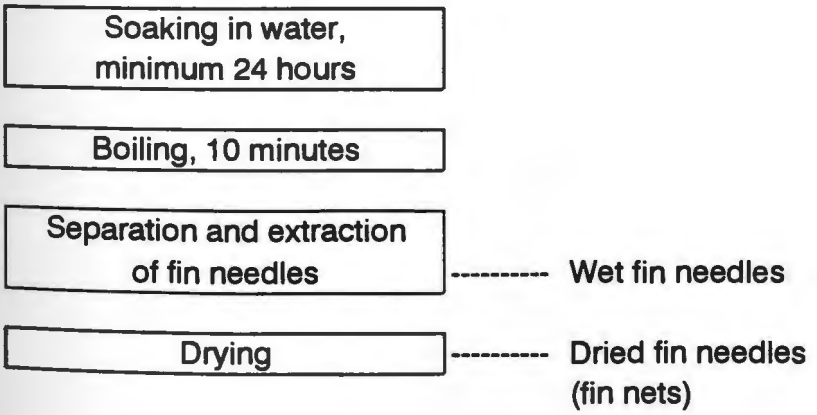


Figure 2. Length frequency of shark species measured during data collection.

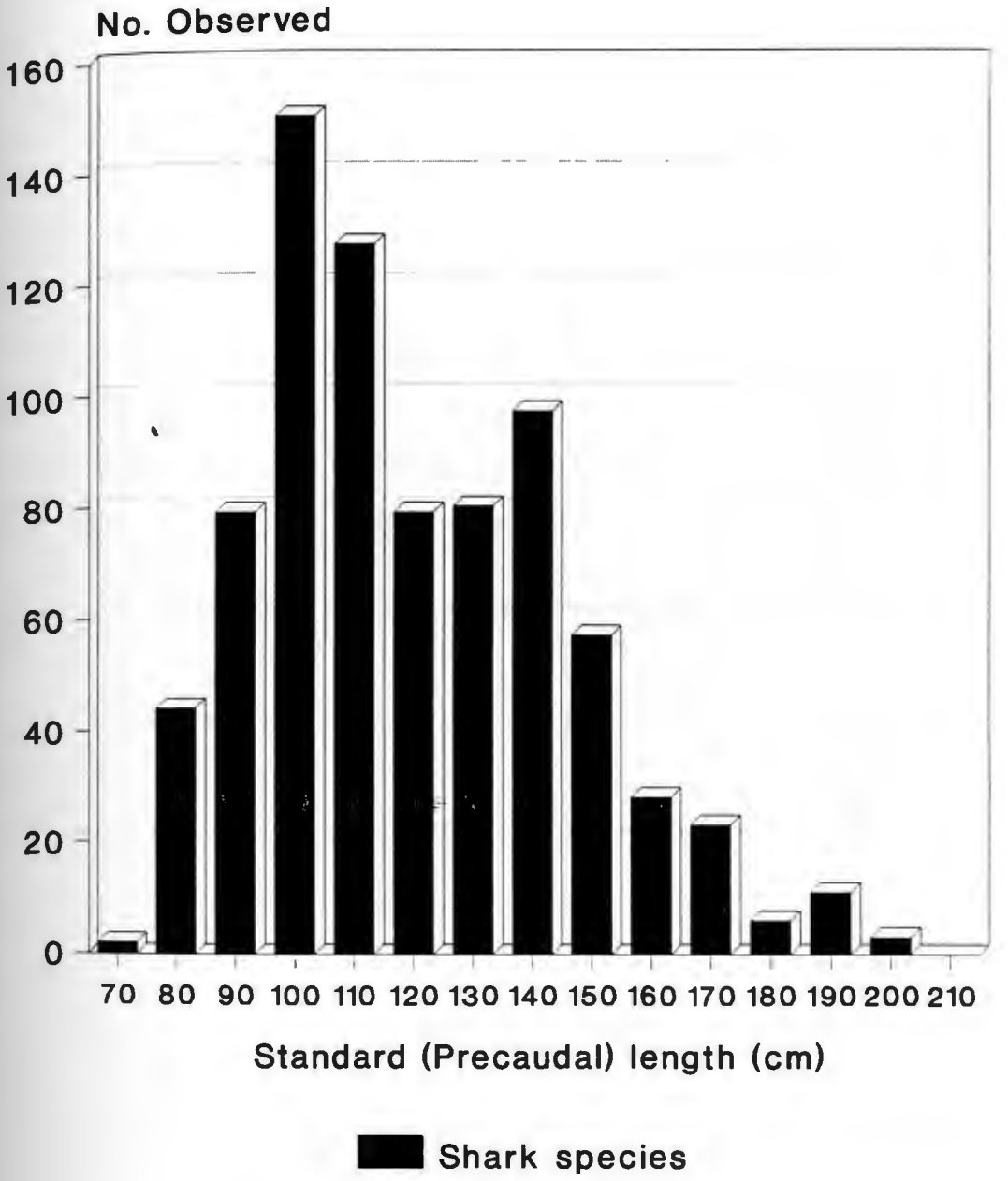

No. Observed
160
140
120
100
80
60
40
20
0
70 80 90 100 110 120 130 140 150 160 170 180 190 200 210
Standard (Precaudal) length (cm)
Shark species

Figure 3. Abundance of shark species identified during the study.

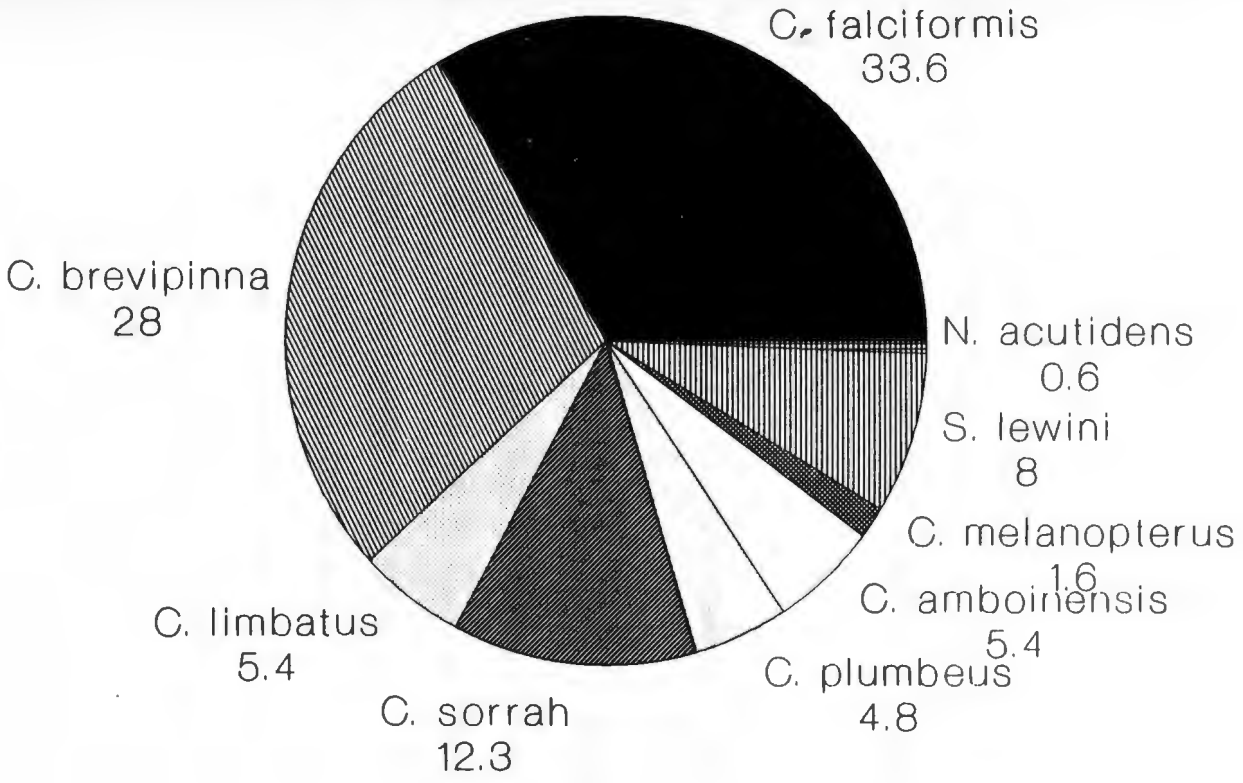

C. falciformis
33.6
C. brevipinna
28
N. acutidens
0.6
S. lewini
8
C. melanopterus
1.6
C. amboinensis
5.4
C. limbatus
5.4
C. plumbeus
4.8
C. sorrah
12.3

Figure 4. Seasonal variation of shark species during the study between July 1991 and June 1992.

A- Shark length frequency, July 1991

B- Shark length frequency, August 1991

C- Shark length frequency, September, 1991

D- Shark length frequency, October, 1991

E- Shark length frequency, Novermber, 1991

F- Shark length frequency, December, 1991

G- Shark length frequency, January, 1992

H- Shark length frequency, February, 1992

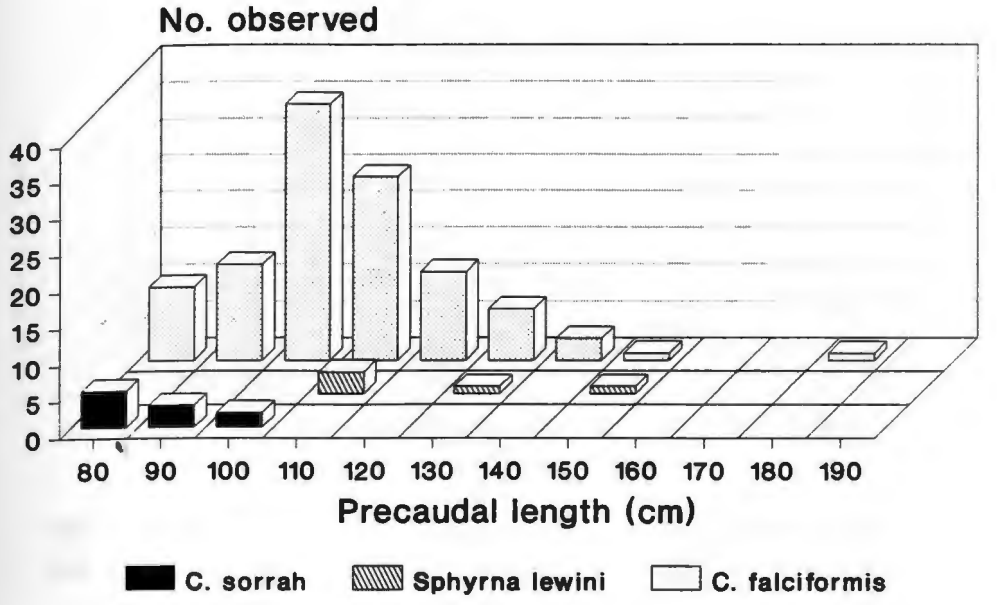
I- Shark length frequency, March, 1992

J- Shark length frequency, April, 1992

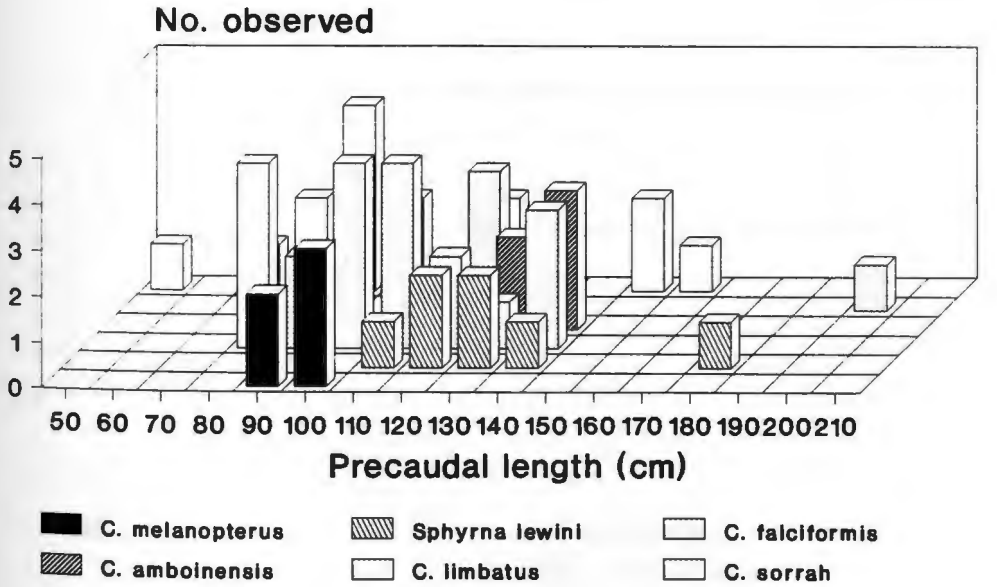
K- Shark length frequency, May, 1992

L- Shark length frequency, June, 1992

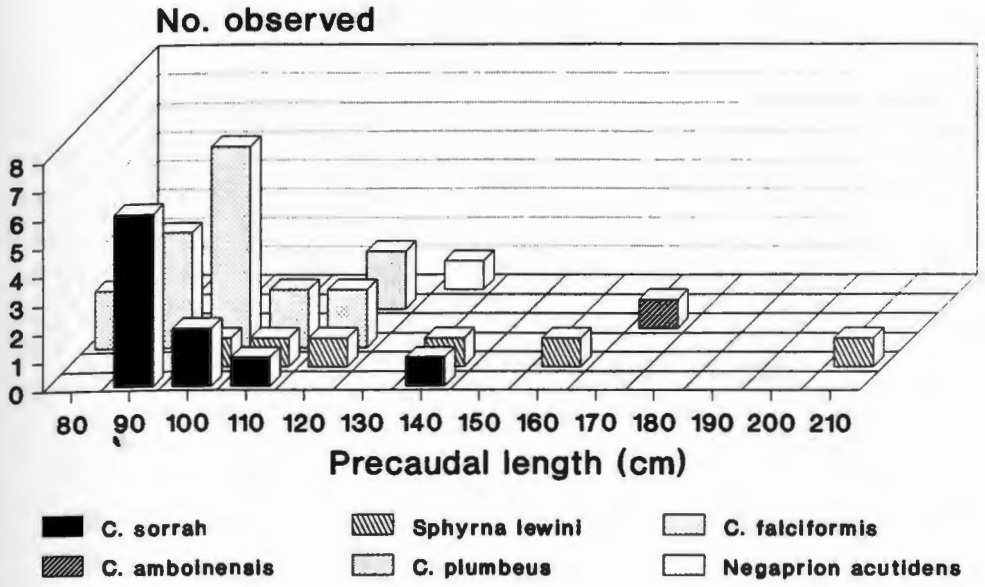
A- Shark Length Frequency
July, 91



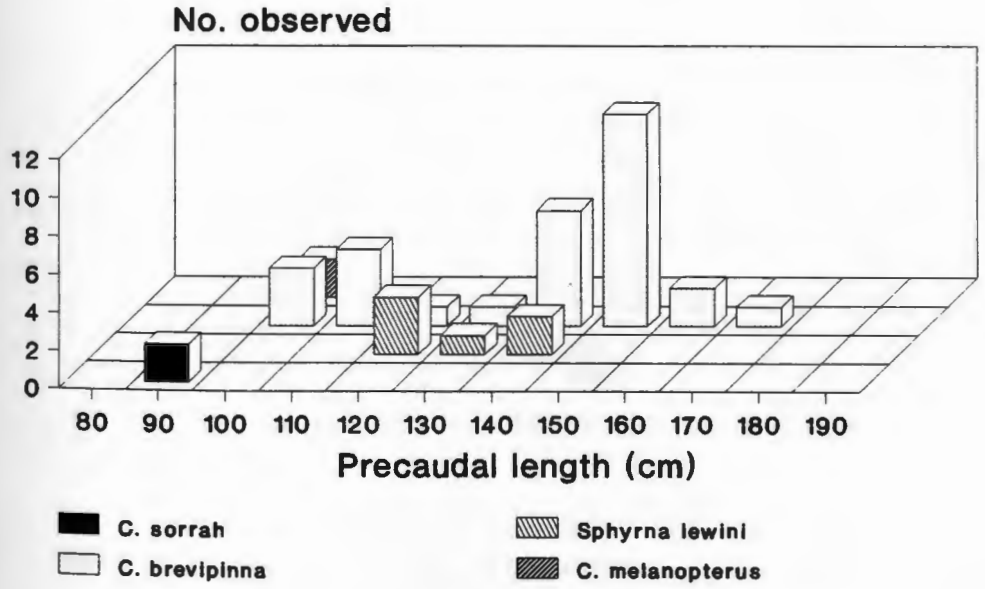
B- Shark Length Frequency
Aug., 91



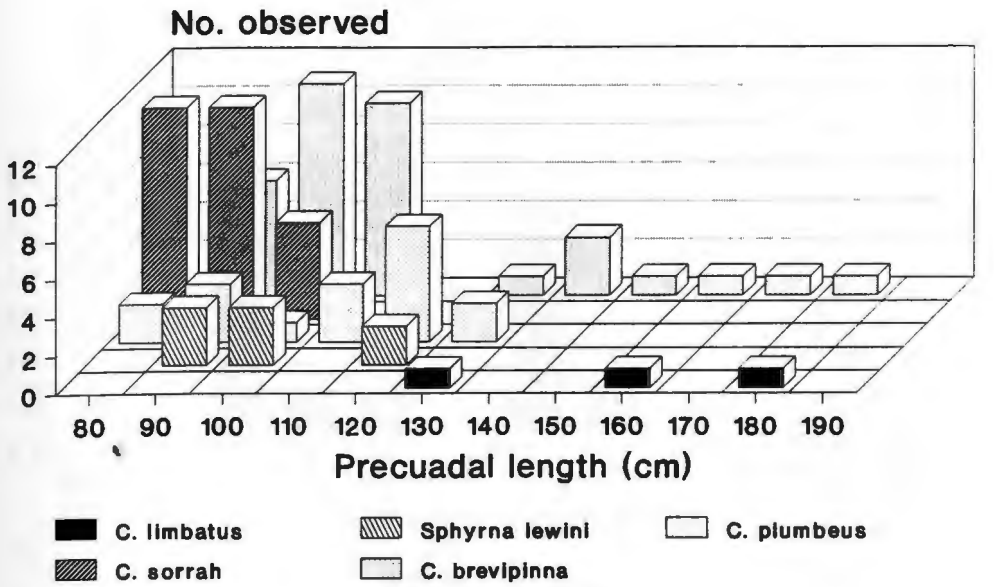
C- Shark Length Frequency
Sept., 91



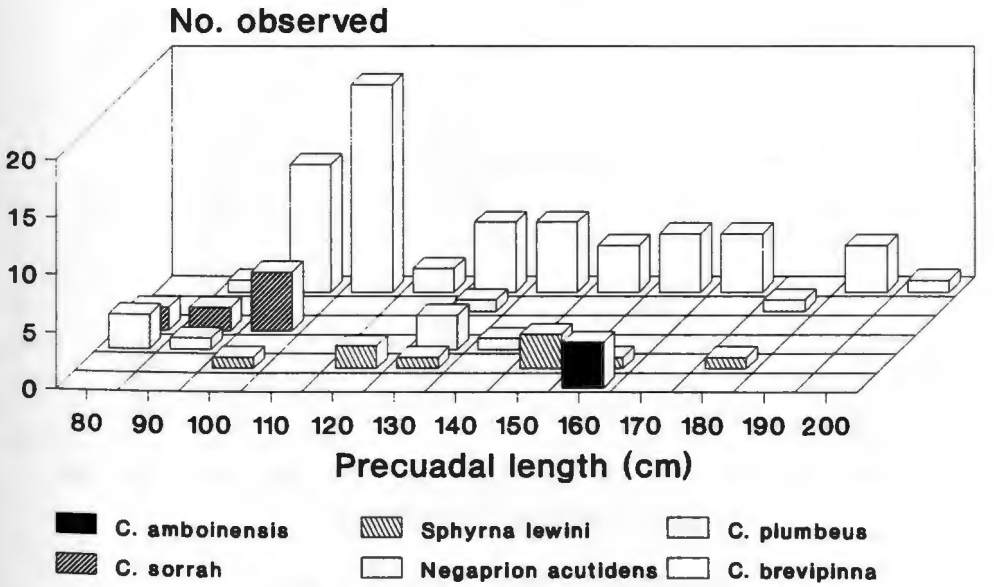
D- Shark Length Frequency
Oct., 91



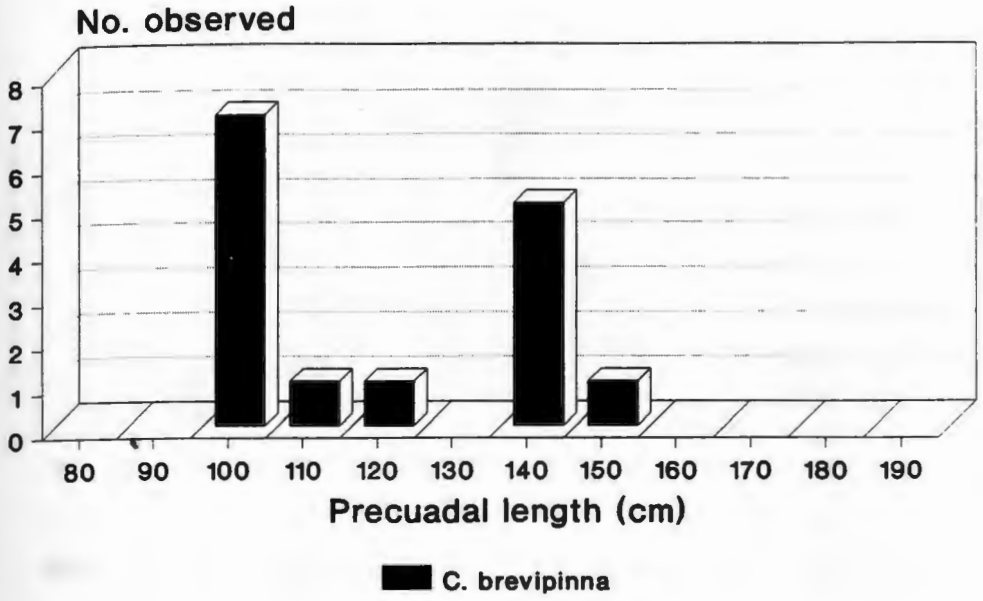
E- Shark Length Frequency
Nov., 91



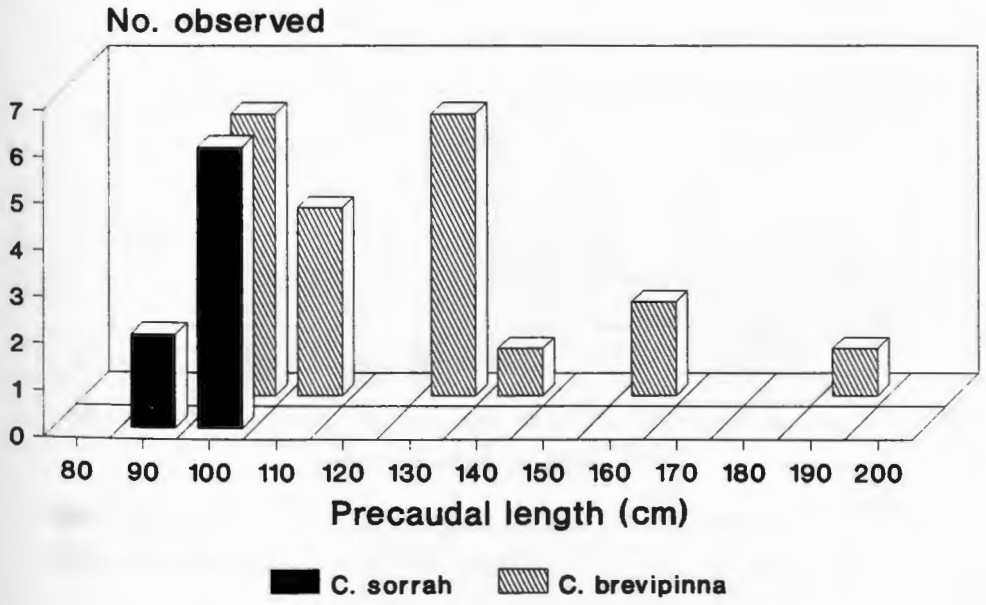
F- Shark Length Frequency
Dec., 91



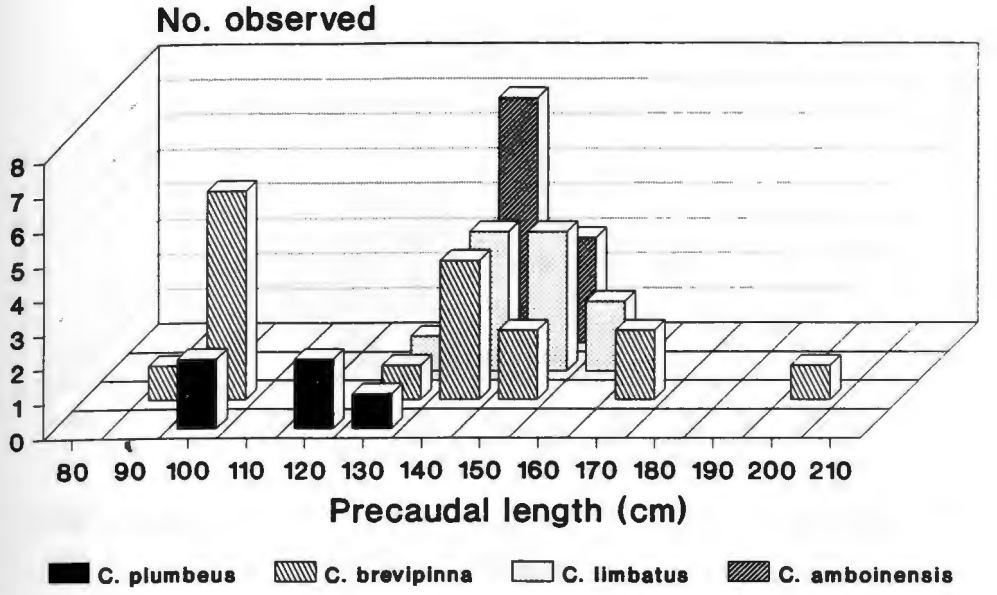
G- Shark Length Frequency
Jan., 92



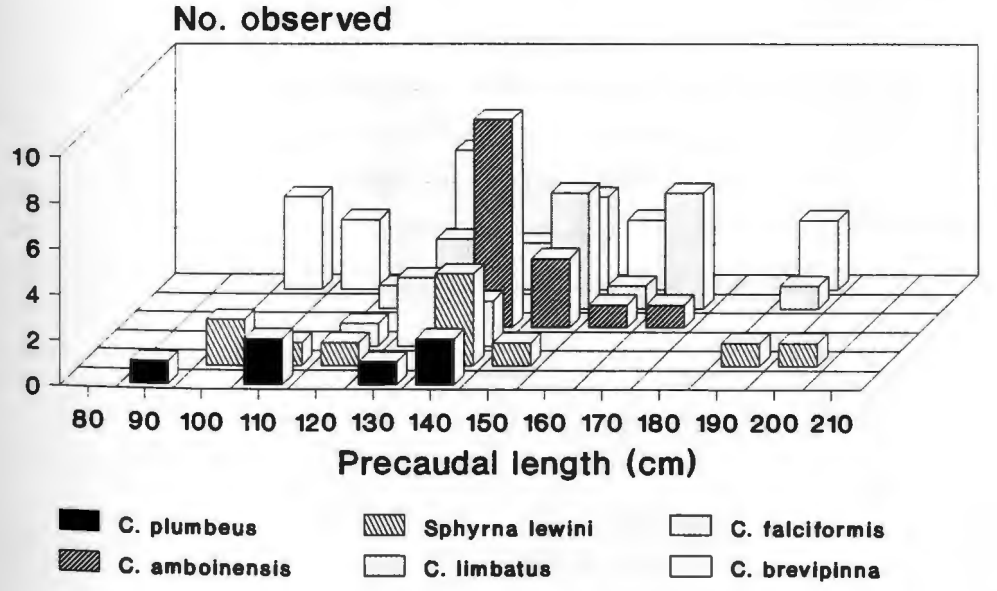
H- Shark Length Frequency
Feb., 92



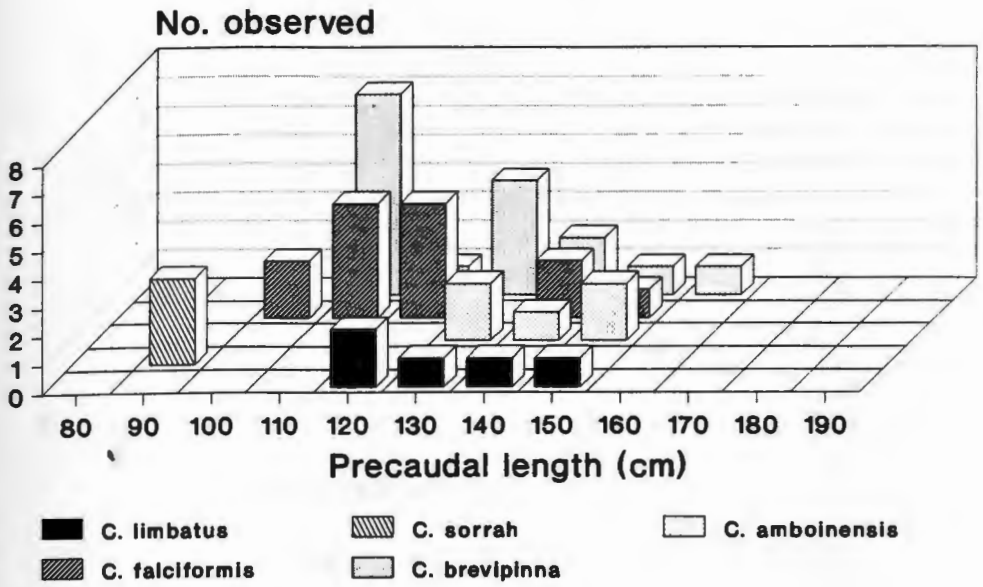
I- Shark Length Frequency
Mar., 92



J- Shark Length Frequency
Apr., 92



K- Shark Length Frequency
May, 92



L- Shark Length Frequency
Jun., 92

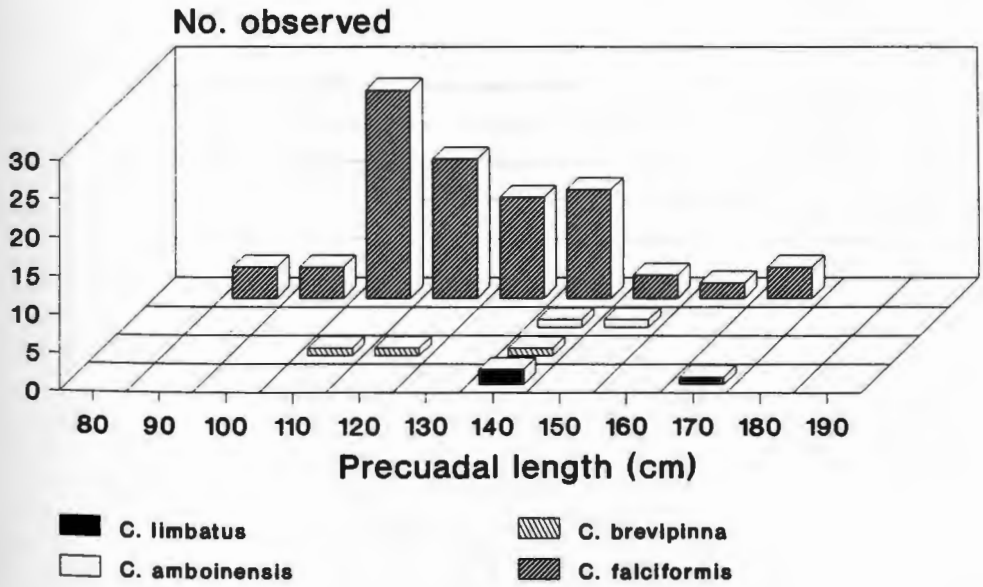
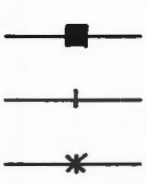


Figure 5. Percentage moisture loss in fins of dogfish at 100°C.



Caudal fin (whole tail)

Pectoral fin (straight cut)

Pectoral fin (half-moon cut)

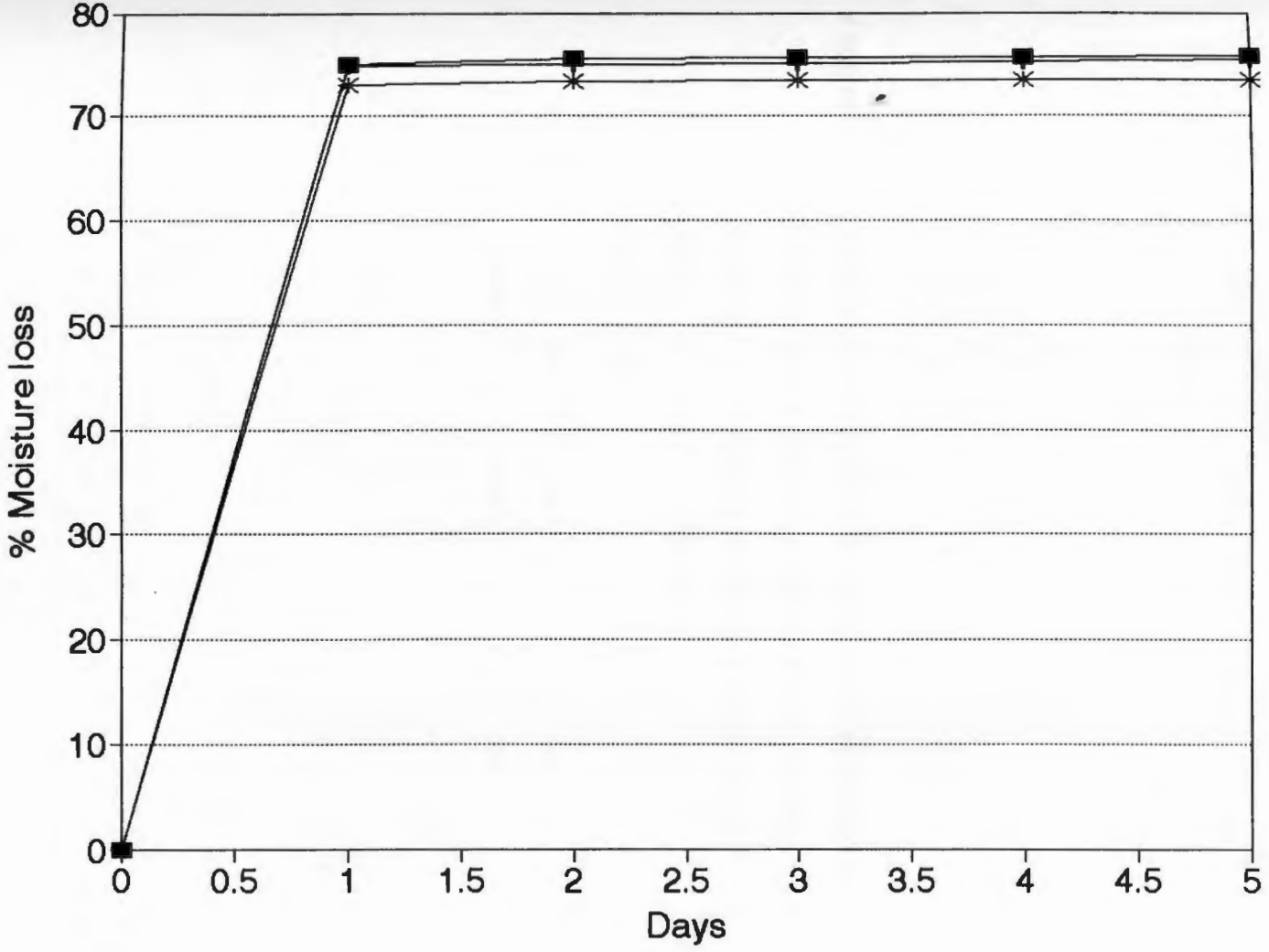

80
70
60
50
40
30
20
10
0
% Moisture loss
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Days

Figure 6. Dried half-moon cut fins of hammerhead shark with the skin on (black fins), pectoral (left) and dorsal fin (right) soaked in water for 24 hours.

Dimensions:

Pectoral fin length	24.5 cm
Dorsal fin length	27.5 cm


HAMMERHEAD SHARK
(BLACK FINS)

Figure 7. Processed dorsal fin of hammerhead with the skin removed with acetic acid.

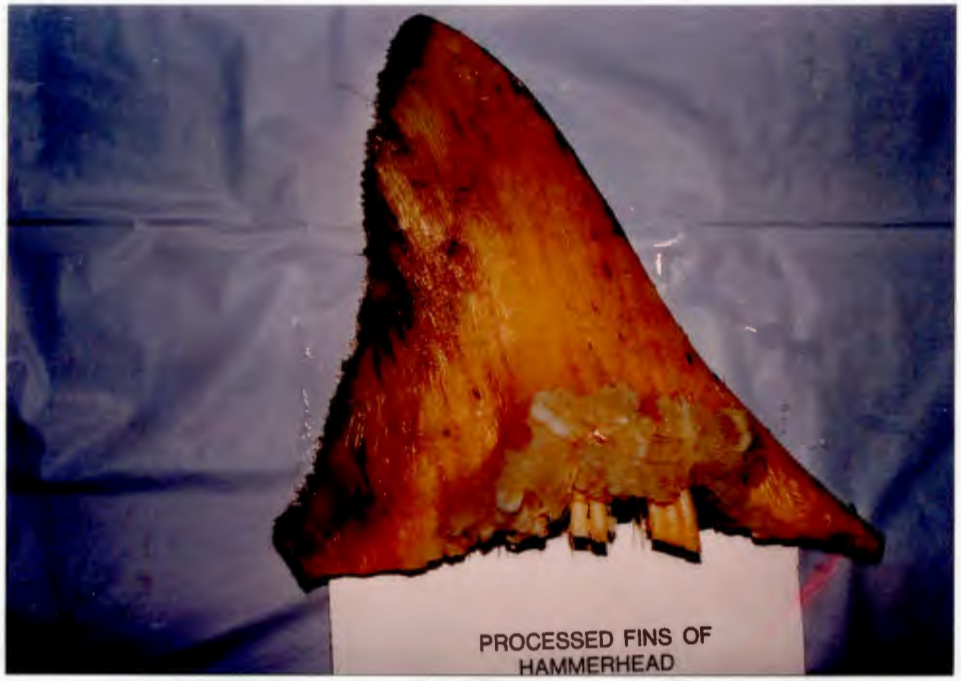

PROCESSED FINS OF
HAMMERHEAD

Figure 8. Dried half-moon cut fin of guitarfish with the skin on (white fin).

Dimensions:

1st dorsal fin length	16.4 cm
2nd dorsal fin length	12.2 cm
Caudal fin length	21.2 cm


WHITESPOTTED SHOVEL-NOSE
(WHITE FINS)

Figure 9. Processed first dorsal and caudal fins of a guitarfish with the skin removed with acetic acid.


PROCESSED WHITE FINS

Figure 10. Cartilage platelet of the hammerhead pectoral fin (left) and the guitarfish first dorsal fin (right)

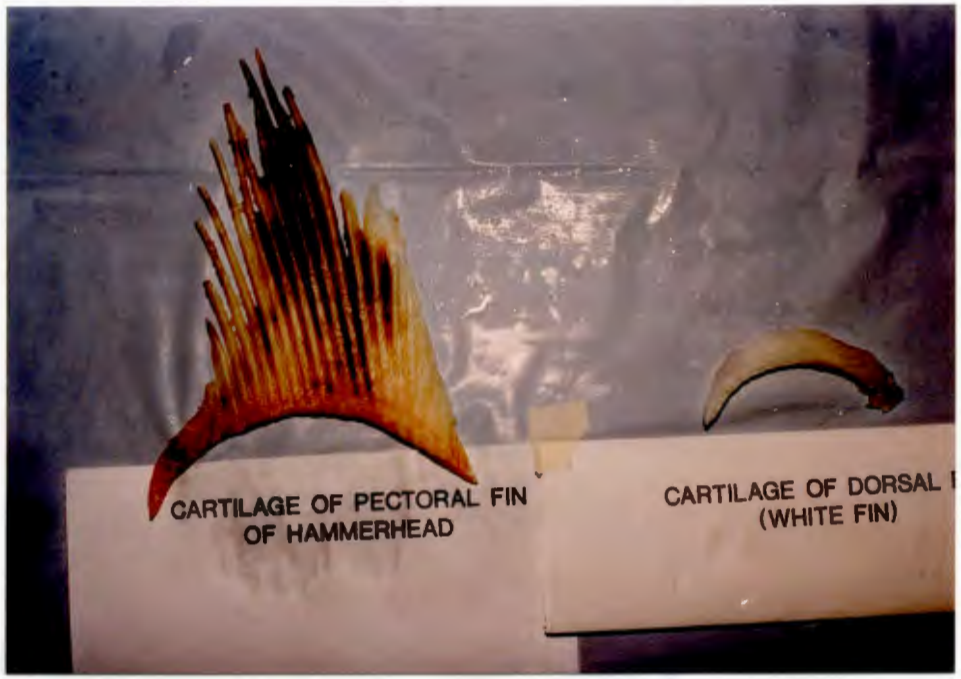

CARTILAGE OF PECTORAL FIN
OF HAMMERHEAD
CARTILAGE OF DORSAL
(WHITE FIN)

Figure 11. Dried fin needles of hammerhead (left) and dried fin needles of guitarfish (right)

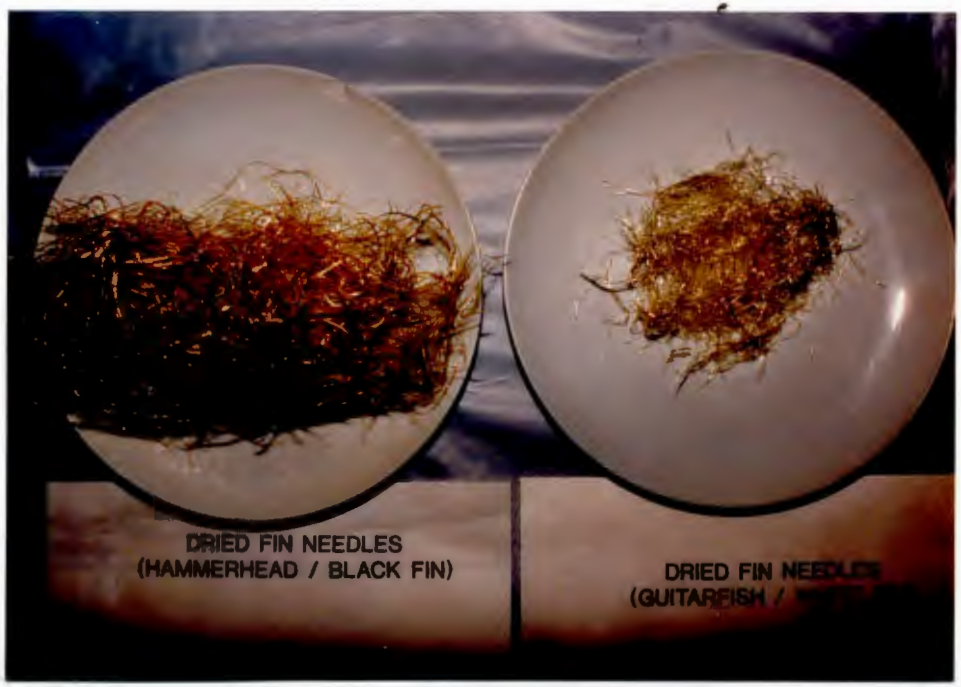

DRIED FIN NEEDLES
(HAMMERHEAD / BLACK FIN)
DRIED FIN NEEDLES
(GUITARFISH /

Figure 12. A set of fresh fins of dogfish (straight cut) with the skin on.

Dimensions:

Dorsal fin length (front)	5.2 cm
Pectoral fin length (middle)	10.1 cm
Caudal fin length (rear)	18.7 cm

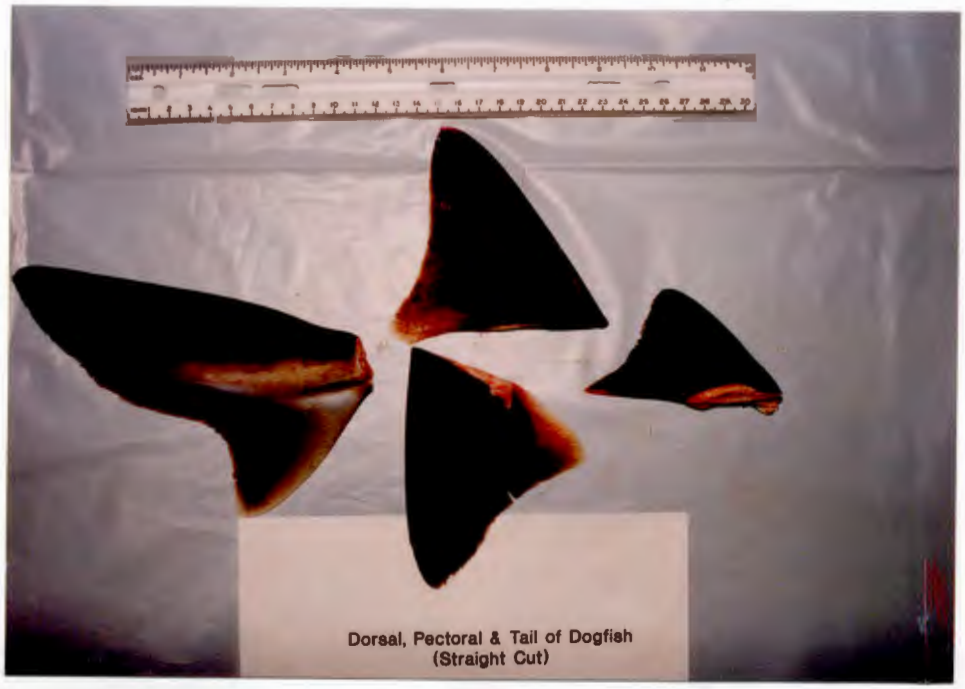

Dorsal, Pectoral & Tail of Dogfish
(Straight Cut)

Figure 13. A set of fresh fins of dogfish (half-moon cut).

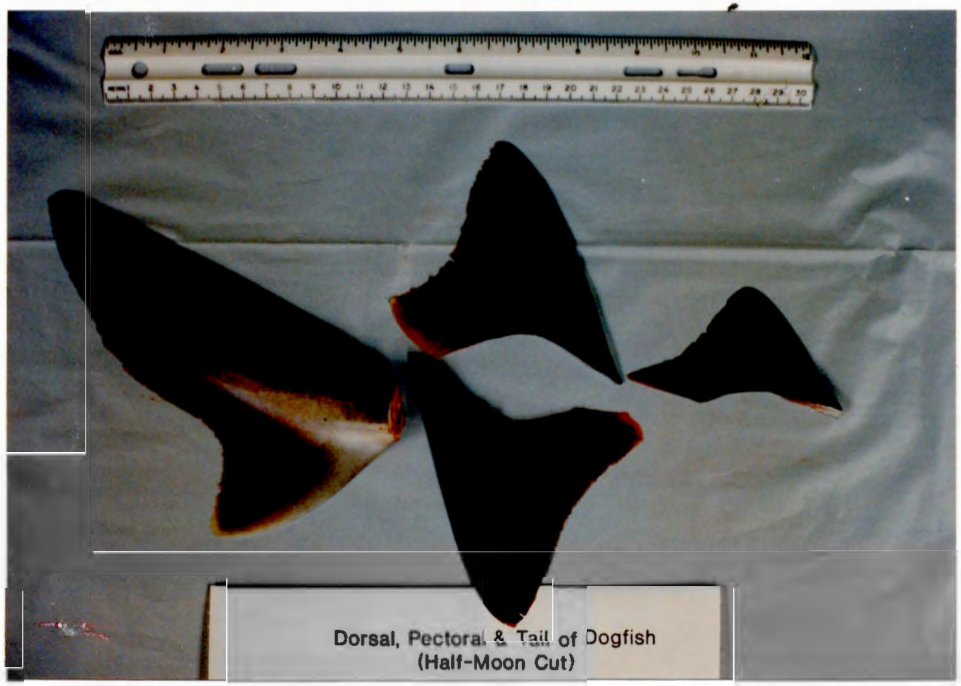

Dorsal, Pectoral & Tail of Dogfish
(Half-Moon Cut)

Figure 14. Processed fins of dogfish with the skin removed with acetic acid.

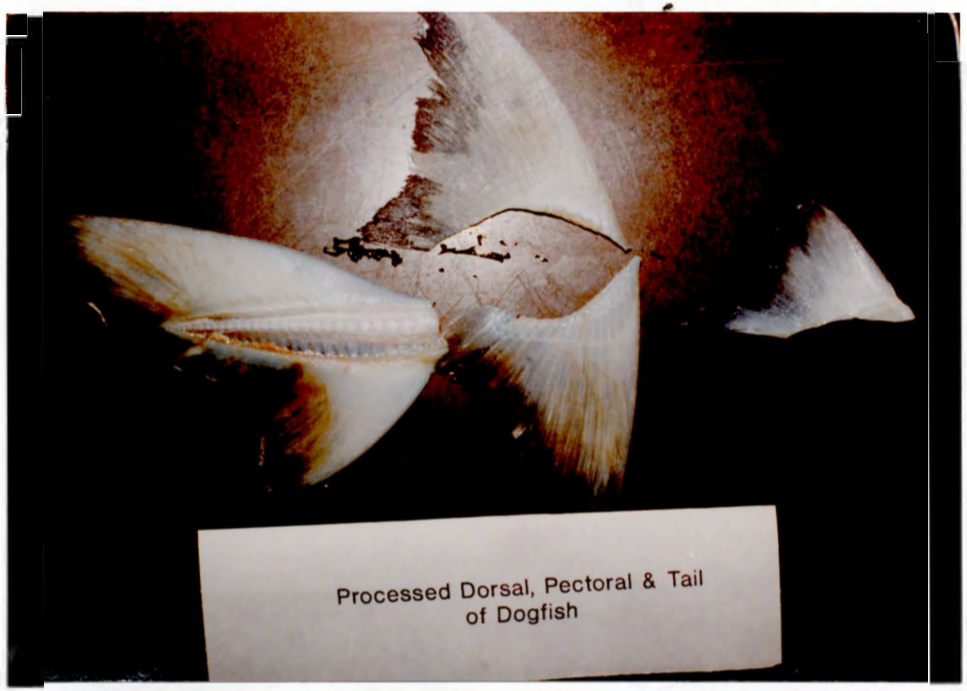

Processed Dorsal, Pectoral & Tail
of Dogfish

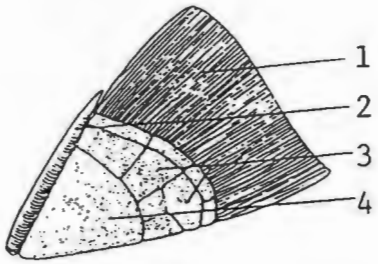
Figure 15. Dried fin needles of dogfish.


FIN NEEDLES OF DOGFISH

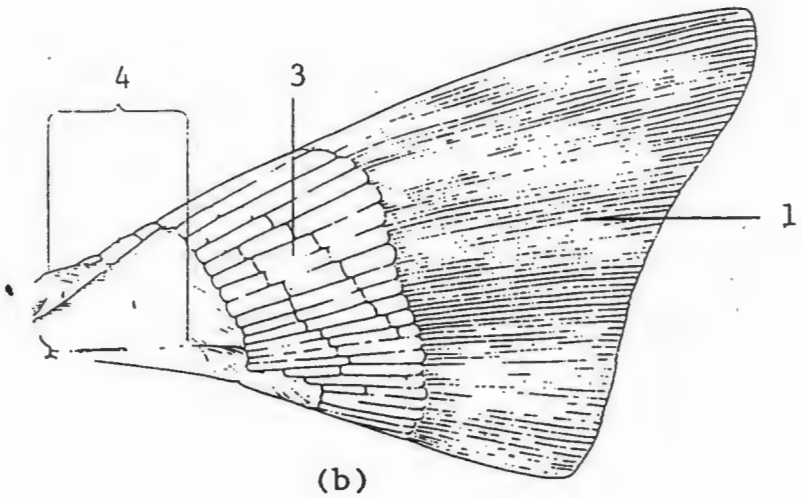
APPENDICES

Appendix 1. Skeletal anatomy of dogfish fins
a) dorsal fin, b) pectoral fin,
c) caudal fin.
(Gilbert 1973)

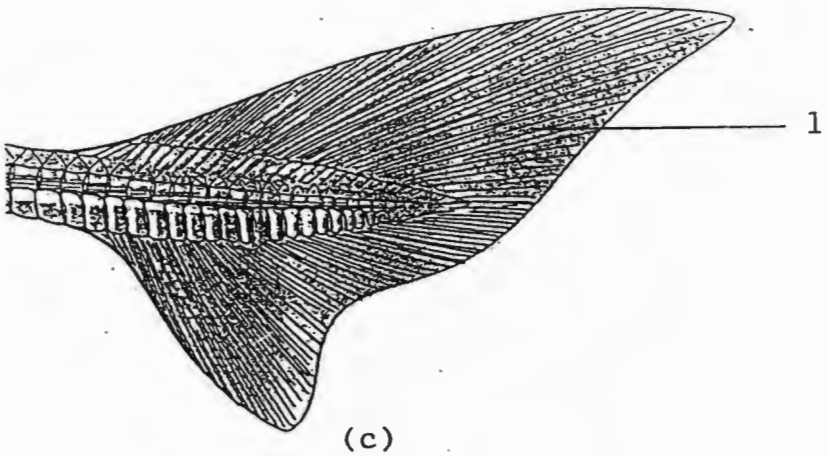
1- Ceratotrichia (fin needles or rays)
2- Spine
3- Radial cartilage
4- Basal cartilage



(a)

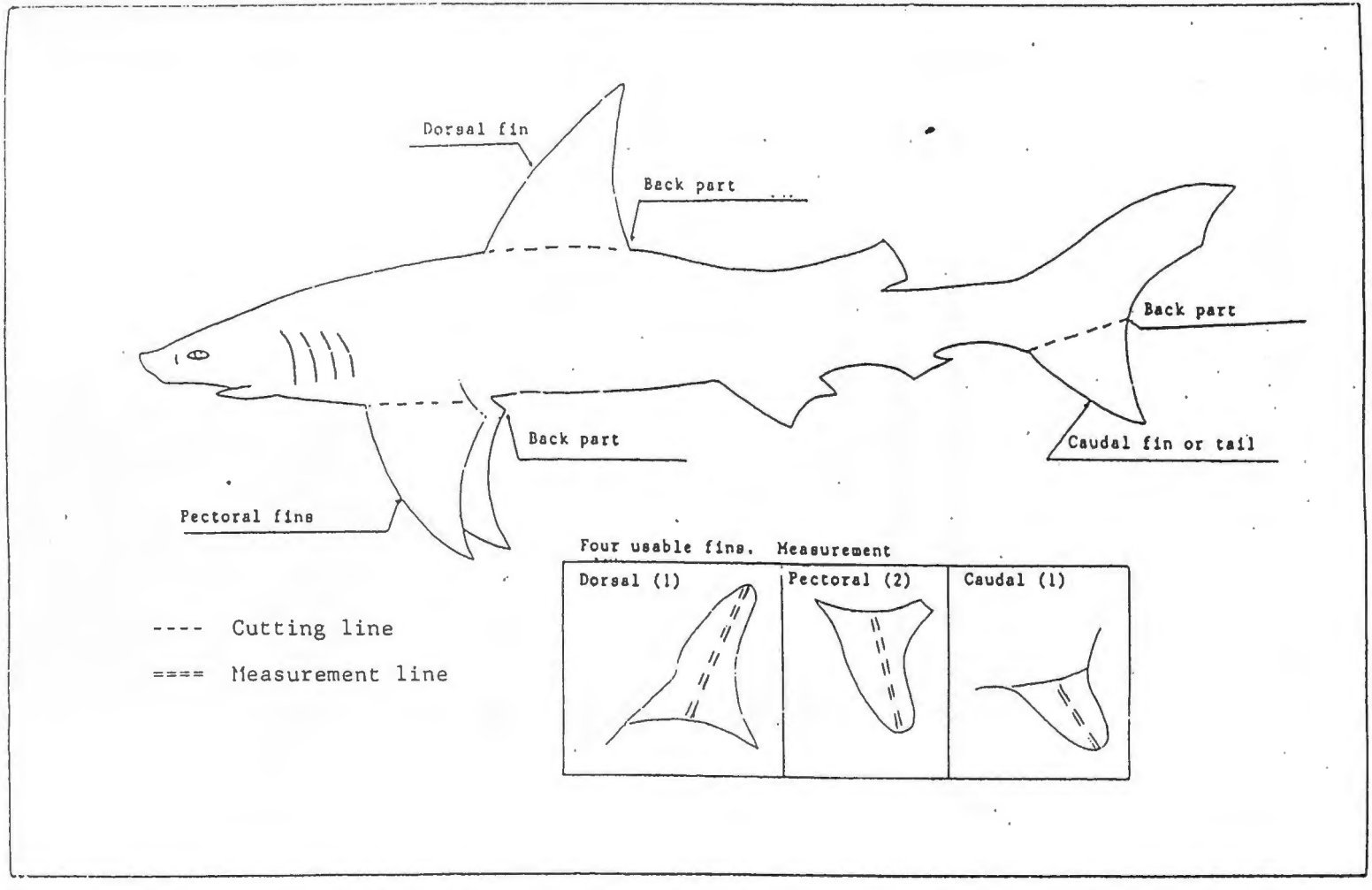


(b)

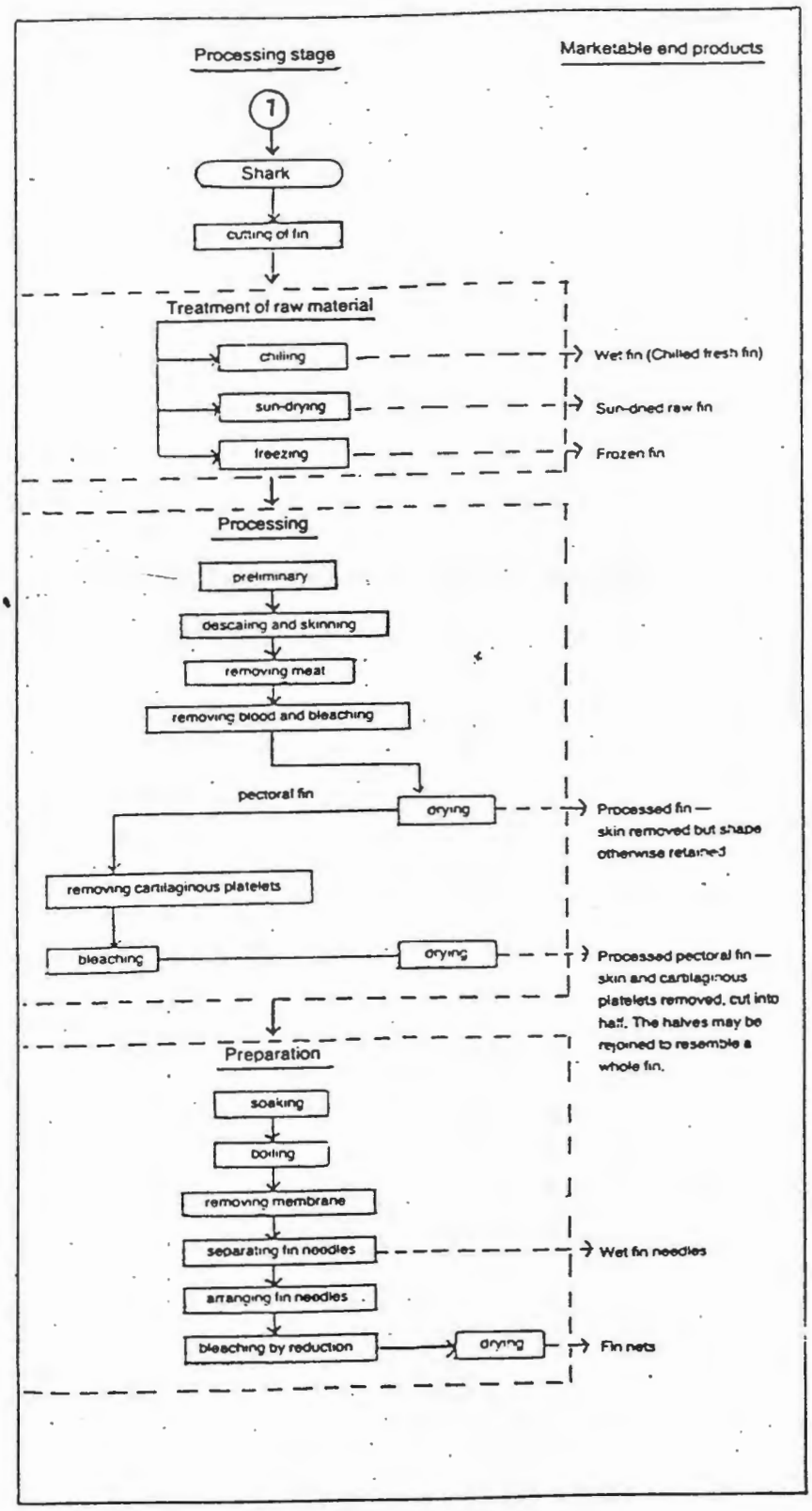


(c)

Appendix 2. Measurement and cutting lines of shark-fins during the study. (FAO/WHO 1987)

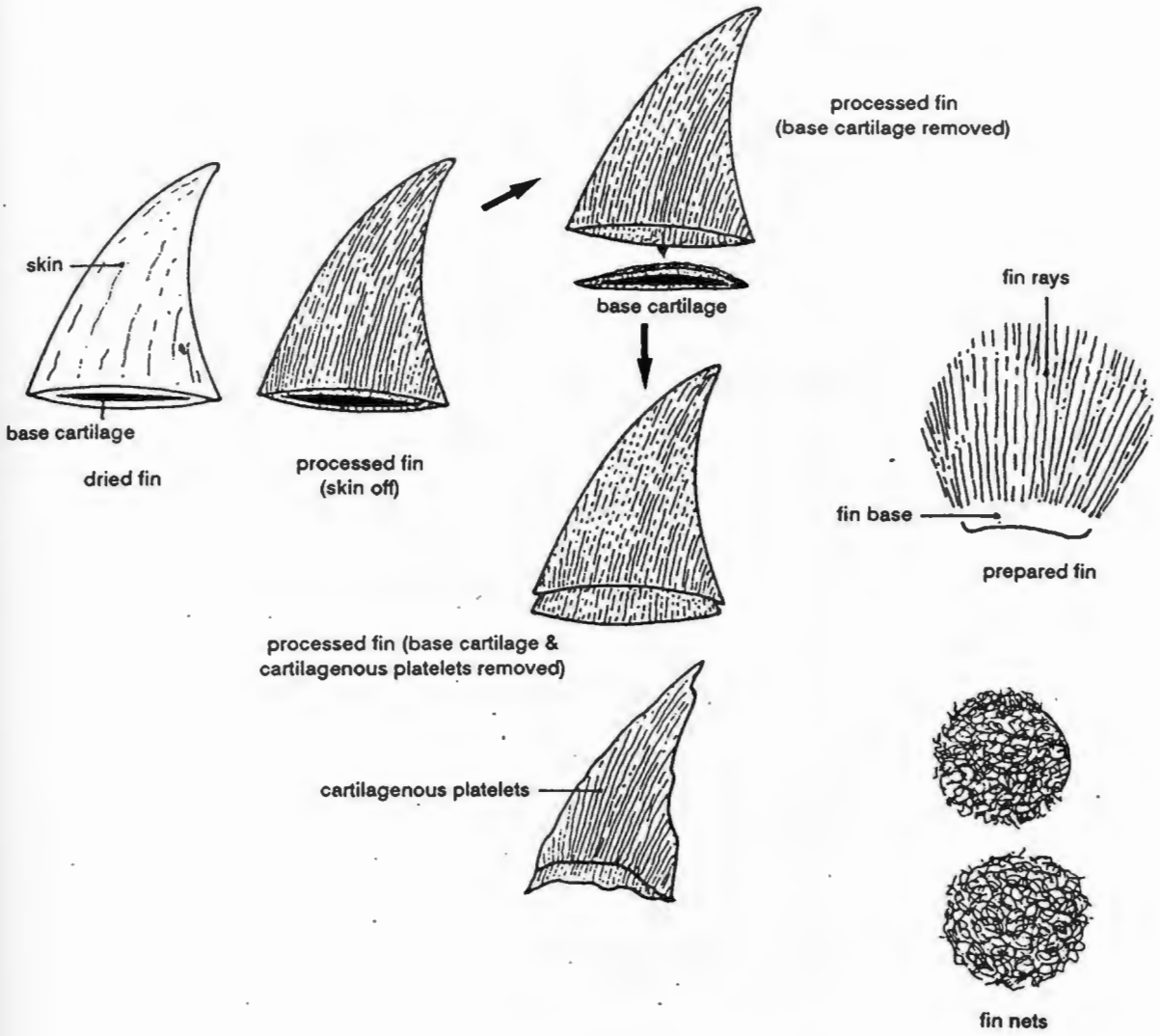

Dorsal fin
Back part
Back part
Back part
Caudal fin or tail
Pectoral fins
---- Cutting line
==== Measurement line
Four usable fins. Measurement
Dorsal (1)
Pectoral (2)
Caudal (1)

Appendix 3. Shark-fins processing stages and the related end products.
(Ka-keong 1983)


Processing stage
Marketable end products
1
Shark
cutting of fin
Treatment of raw material
chilling
Wet fin (Chilled fresh fin)
sun-drying
Sun-dried raw fin
freezing
Frozen fin
Processing
preliminary
descaling and skinning
removing meat
removing blood and bleaching
pectoral fin
drying
Processed fin — skin removed but shape otherwise retained
removing cartilaginous platelets
bleaching
drying
Processed pectoral fin — skin and cartilaginous platelets removed, cut into half. The halves may be rejoined to resemble a whole fin.
Preparation
soaking
boiling
removing membrane
separating fin needles
Wet fin needles
arranging fin needles
bleaching by reduction
drying
Fin nets

Appendix 4. Product forms of shark-fins.

(Subasinghe 1992)

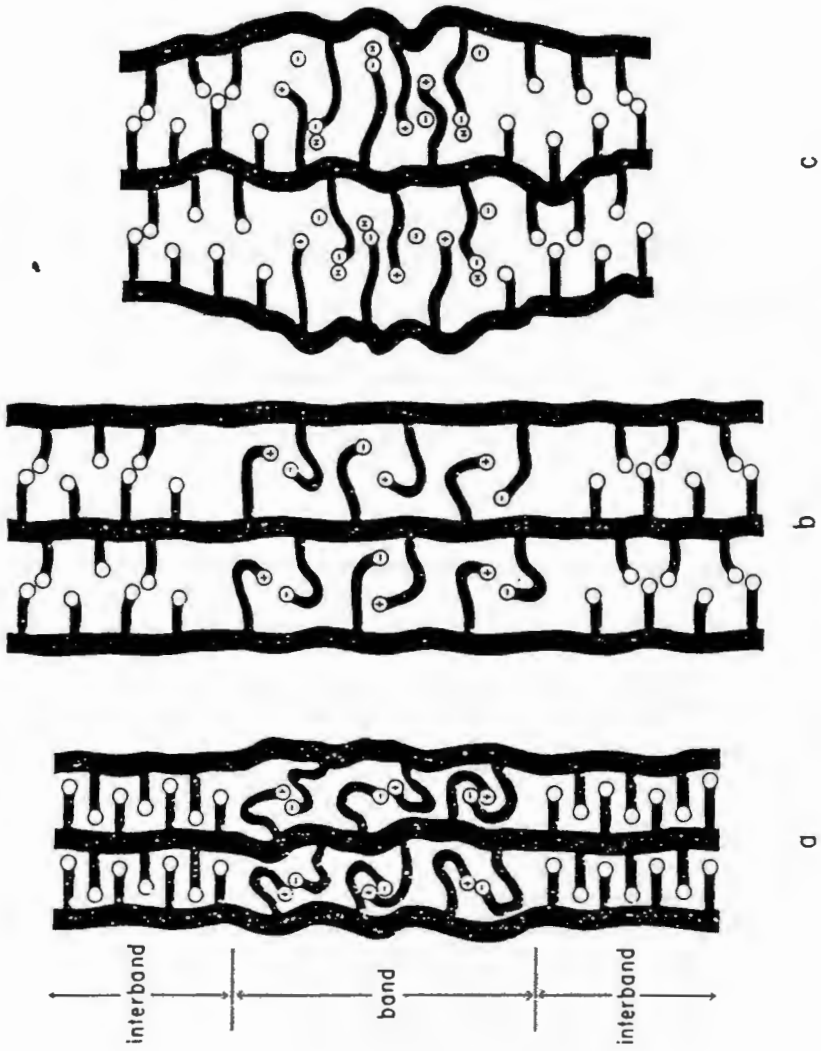

skin
base cartilage
dried fin
processed fin
(skin off)
processed fin
(base cartilage removed)
base cartilage
processed fin (base cartilage &
cartilagenous platelets removed)
cartilagenous platelets
fin rays
fin base
prepared fin
fin nets

Appendix 5. Diagrammatic representation of the swelling in collagen fibrils.
a) A dry fibril; b) a fibril swelling in neutral water; c) acid swelling.
(Bear 1952)

H : Hydrogen ions

\+ : Positive charged heads

\- : Negative charged heads


c
b
a
interband
band
interband

Appendix 6. Data collections at Muttrah Souq and regression outputs on the relationship between body size and fin sizes for the silky shark.

PL : Precaudal Length (cm)

D Fin : Dorsal Fin Length (cm)

P Fin : Pectoral Fin Length (cm)

L L : Lower Lobe of Tail (cm)

P L	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
115.00	12.00	22.20	39.90	12.80	10.43	19.30	34.70	11.13
109.00	11.60	21.50	38.50	12.00	10.64	19.72	35.32	11.01
110.00	12.00	23.00	40.00	13.00	10.91	20.91	36.36	11.82
101.00	11.00	20.50	37.00	12.00	10.89	20.30	36.63	11.88
105.00	12.00	22.00	39.00	12.10	11.43	20.95	37.14	11.52
133.00	14.00	27.50	46.30	19.00	10.53	20.68	34.81	14.29
97.00	11.00	20.00	33.50	11.00	11.34	20.62	34.54	11.34
99.00	11.00	19.00	34.00	11.00	11.11	19.19	34.34	11.11
96.00	10.50	19.50	34.00	10.60	10.94	20.31	35.42	11.04
144.00	15.50	34.00	50.00	20.00	10.76	23.61	34.72	13.89
140.00	16.60	35.00	53.00	20.50	11.86	25.00	37.86	14.64
130.10	13.00	21.00	38.50	12.20	9.99	16.14	29.59	9.38
109.00	12.40	21.00	40.00	13.00	11.38	19.27	36.70	11.93
102.00	12.60	22.00	40.00	13.00	12.35	21.57	39.22	12.75
125.70	14.50	26.50	46.00	17.00	11.54	21.08	36.60	13.52
108.50	11.20	21.50	38.50	13.50	10.32	19.82	35.48	12.44
125.20	11.70	21.80	40.80	14.10	9.35	17.41	32.59	11.26
129.00	12.00	22.00	41.00	14.30	9.30	17.05	31.78	11.09
108.70	11.40	21.50	40.30	13.70	10.49	19.78	37.07	12.60
146.00	15.00	32.00	51.60	20.60	10.27	21.92	35.34	14.11
102.00	12.00	21.00	38.00	13.20	11.76	20.59	37.25	12.94
105.40	12.10	20.40	37.00	13.40	11.48	19.35	35.10	12.71
102.60	12.40	20.20	37.40	12.80	12.09	19.69	36.45	12.48
140.00	16.00	32.00	50.00	19.00	11.43	22.86	35.71	13.57
107.20	12.40	21.10	38.80	13.70	11.57	19.68	36.19	12.78
106.50	12.20	21.00	38.50	13.50	11.46	19.72	36.15	12.68
108.80	11.50	21.50	40.20	13.80	10.57	19.76	36.95	12.68
122.50	13.60	21.60	40.50	14.00	11.10	17.63	33.06	11.43
121.50	13.60	21.60	40.50	14.10	11.19	17.78	33.33	11.60
106.30	11.10	21.00	38.70	13.70	10.44	19.76	36.41	12.89
104.00	11.00	21.00	38.00	13.10	10.58	20.19	36.54	12.60
105.80	11.10	21.20	38.20	13.30	10.49	20.04	36.11	12.57
108.50	11.20	21.50	38.50	13.50	10.32	19.82	35.48	12.44
124.00	12.80	25.00	39.00	15.20	10.32	20.16	31.45	12.26
104.30	10.60	20.10	35.70	12.00	10.16	19.27	34.23	11.51
113.30	10.80	20.50	35.80	12.80	9.53	18.09	31.60	11.30
115.50	12.10	23.00	36.00	13.00	10.48	19.91	31.17	11.26
118.00	12.30	25.00	37.00	14.10	10.42	21.19	31.36	11.95
111.10	10.60	21.00	35.90	12.80	9.54	18.90	32.31	11.52

P L	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
108.70	10.70	20.50	35.70	12.80	9.84	18.86	32.84	11.78
106.70	10.50	20.50	35.50	12.50	9.84	19.21	33.27	11.72
111.40	10.30	21.00	35.60	12.70	9.25	18.85	31.96	11.40
112.00	12.00	23.60	37.00	14.00	10.71	21.07	33.04	12.50
116.00	13.50	24.20	40.00	13.00	11.64	20.86	34.48	11.21
114.50	13.40	24.00	42.00	13.50	11.70	20.96	36.68	11.79
121.00	13.10	24.50	43.00	15.60	10.83	20.25	35.54	12.89
81.00	8.10	15.20	29.00	8.80	10.00	18.77	35.80	10.86
87.00	9.50	16.50	33.00	9.50	10.92	18.97	37.93	10.92
82.10	8.20	15.20	29.10	8.80	9.99	18.51	35.44	10.72
85.00	8.50	15.80	30.00	8.70	10.00	18.59	35.29	10.24
115.00	13.10	24.00	42.00	13.70	11.39	20.87	36.52	11.91
81.00	8.10	15.20	29.00	8.80	10.00	18.77	35.80	10.86
98.00	10.00	18.50	35.00	11.40	10.20	18.88	35.71	11.63
111.10	12.00	24.80	38.50	13.50	10.80	22.32	34.65	12.15
106.00	11.50	18.00	37.20	11.10	10.85	16.98	35.09	10.47
113.00	11.60	19.60	39.80	11.60	10.27	17.35	35.22	10.27
101.00	11.10	18.00	35.00	10.60	10.99	17.82	34.65	10.50
107.00	11.50	18.50	36.00	10.70	10.75	17.29	33.64	10.00
110.20	11.60	19.00	37.60	11.00	10.53	17.24	34.12	9.98
111.50	12.70	19.00	38.00	11.60	11.39	17.04	34.08	10.40
109.00	11.20	18.70	35.00	10.90	10.28	17.16	32.11	10.00
114.00	12.60	19.00	38.00	11.60	11.05	16.67	33.33	10.18
115.20	12.60	20.00	39.00	12.00	10.94	17.36	33.85	10.42
100.20	10.50	17.70	34.50	11.60	10.48	17.66	34.43	11.58
112.00	11.10	20.50	38.50	11.00	9.91	18.30	34.38	9.82
116.00	13.00	21.00	39.00	11.50	11.21	18.10	33.62	9.91
93.00	10.20	18.00	34.00	10.30	10.97	19.35	36.56	11.08
102.00	11.50	18.00	35.00	10.30	11.27	17.65	34.31	10.10
104.00	11.40	19.00	35.00	10.70	10.96	18.27	33.65	10.29
88.00	10.00	17.00	33.00	10.30	11.36	19.32	37.50	11.70
96.00	10.30	17.00	34.00	11.00	10.73	17.71	35.42	11.46
92.00	10.00	17.60	34.20	10.30	10.87	19.13	37.17	11.20
92.00	10.00	17.70	32.00	10.40	10.87	19.24	34.78	11.30
91.00	10.50	17.00	32.30	10.00	11.54	18.68	35.49	10.99
95.00	9.90	17.00	34.00	10.50	10.42	17.89	35.79	11.05
111.70	11.50	20.00	38.00	11.50	10.30	17.91	34.02	10.30
94.00	10.00	17.50	33.00	10.50	10.64	18.62	35.11	11.17
99.00	10.30	18.80	33.40	10.40	10.40	18.99	33.74	10.51

P L	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
118.00	13.00	23.00	42.00	13.30	11.02	19.49	35.59	11.27
89.00	9.00	17.50	31.20	10.10	10.11	19.66	35.06	11.35
140.50	14.50	28.00	45.50	18.00	10.32	19.93	32.38	12.81
130.00	15.00	32.00	46.00	19.00	11.54	24.62	35.38	14.62
115.60	12.00	23.00	41.00	13.00	10.38	19.90	35.47	11.25
117.00	12.00	23.00	42.00	13.00	10.26	19.66	35.90	11.11
108.00	11.00	21.00	38.80	12.00	10.19	19.44	35.93	11.11
120.50	14.00	25.00	42.00	13.20	11.62	20.75	34.85	10.95
133.00	15.00	30.00	47.00	18.00	11.28	22.56	35.34	13.53
146.00	15.00	32.00	51.60	20.60	10.27	21.92	35.34	14.11
134.00	14.00	31.00	48.00	18.20	10.45	23.13	35.82	13.58
110.00	11.40	24.50	38.20	12.60	10.36	22.27	34.73	11.45
90.00	10.00	17.40	32.00	10.70	11.11	19.33	35.56	11.89
96.00	10.60	18.00	32.50	10.80	11.04	18.75	33.85	11.25
107.00	11.00	21.00	40.00	12.30	10.28	19.63	37.38	11.50
101.00	10.00	20.00	38.00	12.00	9.90	19.80	37.62	11.88
109.00	11.00	20.60	38.80	12.20	10.09	18.90	35.60	11.19
84.00	8.40	15.50	29.00	8.80	10.00	18.45	34.52	10.48
88.00	8.60	15.10	29.00	8.70	9.77	17.16	32.95	9.89
86.00	9.00	15.20	28.80	8.70	10.47	17.67	33.49	10.12
104.00	11.00	20.00	36.60	13.10	10.58	19.23	35.19	12.60
139.00	15.00	31.00	49.00	18.80	10.79	22.30	35.25	13.53
121.00	13.00	26.00	40.00	13.60	10.74	21.49	33.06	11.24
185.00	20.60	41.50	62.20	24.60	11.14	22.43	33.62	13.30
106.00	12.00	22.00	40.00	13.00	11.32	20.75	37.74	12.26
128.00	13.80	28.50	42.50	16.20	10.78	22.27	33.20	12.66
119.00	13.00	27.00	40.20	15.80	10.92	22.69	33.78	13.28
148.00	16.00	34.50	53.70	21.00	10.81	23.31	36.28	14.19
109.00	12.00	24.00	38.00	11.90	11.01	22.02	34.86	10.92
103.40	11.00	21.00	38.00	11.20	10.64	20.31	36.75	10.83
104.00	11.00	21.00	38.00	11.50	10.58	20.19	36.54	11.06
86.00	9.00	17.00	32.00	10.20	10.47	19.77	37.21	11.86
92.00	10.00	18.00	32.50	10.50	10.87	19.57	35.33	11.41
112.00	12.00	23.00	42.00	13.30	10.71	20.54	37.50	11.88
120.00	12.50	24.00	42.50	13.50	10.42	20.00	35.42	11.25
148.00	16.00	32.00	52.00	20.00	10.81	21.62	35.14	13.51
92.00	9.90	18.00	35.00	10.50	10.76	19.57	38.04	11.41
89.00	10.00	18.00	32.00	10.00	11.24	20.22	35.96	11.24
118.00	12.60	24.00	44.00	13.40	10.68	20.34	37.29	11.36

P L	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
110.00	11.80	24.00	42.00	13.00	10.73	21.82	38.18	11.82
104.00	11.00	20.00	35.50	13.10	10.58	19.23	34.13	12.60
101.00	11.00	20.20	35.00	13.00	10.89	20.00	34.65	12.87
89.00	10.00	16.80	32.00	9.60	11.24	18.88	35.96	10.79
44.00	11.00	18.80	34.00	11.20	25.00	42.73	77.27	25.45
102.00	12.00	19.50	35.00	12.00	11.76	19.12	34.31	11.76
99.00	11.00	19.00	34.00	11.30	11.11	19.19	34.34	11.41
125.00	13.60	29.00	45.50	15.00	10.88	23.20	36.40	12.00
115.00	13.50	28.60	44.60	14.50	11.74	24.87	38.78	12.61
122.00	13.50	29.00	45.40	15.00	11.07	23.77	37.21	12.30
100.00	11.00	18.10	35.00	11.40	11.00	18.10	35.00	11.40
82.00	9.60	17.00	31.00	10.00	11.71	20.73	37.80	12.20
93.00	10.00	18.00	32.50	11.00	10.75	19.35	34.95	11.83
109.00	11.90	24.00	43.00	13.00	10.92	22.02	39.45	11.93
104.00	11.50	23.00	39.00	11.70	11.06	22.12	37.50	11.25
102.00	11.50	21.00	38.00	12.20	11.27	20.59	37.25	11.96
148.00	17.00	35.00	53.00	20.50	11.49	23.65	35.81	13.85
140.50	17.00	34.00	49.00	20.50	12.10	24.20	34.88	14.59
137.00	17.00	34.00	48.00	20.00	12.41	24.82	35.04	14.60
132.00	16.00	32.00	46.00	19.00	12.12	24.24	34.85	14.39
120.00	13.00	27.50	44.00	17.50	10.83	22.92	36.67	14.58
118.00	13.00	27.00	41.00	15.00	11.02	22.88	34.75	12.71
112.00	12.00	25.00	41.00	13.00	10.71	22.32	36.61	11.61
102.00	11.50	22.00	39.00	12.50	11.27	21.57	38.24	12.25
154.50	17.70	35.50	53.50	21.00	11.46	22.98	34.63	13.59
128.00	13.40	28.00	46.00	17.70	10.47	21.88	35.94	13.83
140.00	14.00	30.00	52.00	19.00	10.00	21.43	37.14	13.57
144.00	16.00	32.00	54.00	19.60	11.11	22.22	37.50	13.61
124.00	14.20	31.00	45.00	18.00	11.45	25.00	36.29	14.52
130.00	14.50	29.00	49.00	18.50	11.15	22.31	37.69	14.23
105.00	11.00	21.00	38.00	13.90	10.48	20.00	36.19	13.24
116.00	12.30	23.00	41.00	13.60	10.60	19.83	35.34	11.72
128.00	15.00	30.00	48.50	18.50	11.72	23.44	37.89	14.45
115.00	12.00	23.50	42.00	13.50	10.43	20.43	36.52	11.74
126.50	13.80	28.50	47.00	17.00	10.91	22.53	37.15	13.44
116.50	12.00	24.00	42.00	13.50	10.30	20.60	36.05	11.59
117.00	13.00	24.00	44.00	13.50	11.11	20.51	37.61	11.54
142.00	16.00	35.50	54.00	20.00	11.27	25.00	38.03	14.08
142.00	17.00	33.00	53.00	19.50	11.97	23.24	37.32	13.73

P L	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
141.00	15.00	31.00	52.50	19.50	10.64	21.99	37.23	13.83
140.50	15.50	32.00	51.00	19.70	11.03	22.78	36.30	14.02
121.00	12.50	25.50	43.00	14.00	10.33	21.07	35.54	11.57
139.00	15.50	31.50	52.00	17.50	11.15	22.66	37.41	12.59
144.00	17.50	35.00	54.00	20.00	12.15	24.31	37.50	13.89
117.50	13.00	23.50	44.00	13.50	11.06	20.00	37.45	11.49
116.00	12.00	23.00	42.00	13.50	10.34	19.83	36.21	11.64
116.50	12.00	23.00	42.00	13.50	10.30	19.74	36.05	11.59
120.00	13.00	26.00	44.00	14.00	10.83	21.67	36.67	11.67
124.00	13.50	27.00	44.00	14.00	10.89	21.77	35.48	11.29
126.00	13.50	27.00	45.00	14.50	10.71	21.43	35.71	11.51
138.00	14.00	32.00	50.00	19.50	10.14	23.19	36.23	14.13
145.00	16.00	34.00	53.00	20.00	11.03	23.45	36.55	13.79
141.00	15.00	31.50	51.00	19.50	10.64	22.34	36.17	13.83
142.00	16.00	34.00	54.00	20.00	11.27	23.94	38.03	14.08
139.00	15.00	32.00	52.00	18.00	10.79	23.02	37.41	12.95
133.00	14.00	30.00	47.00	17.50	10.53	22.56	35.34	13.16
116.00	12.00	23.50	42.00	13.50	10.34	20.26	36.21	11.64
115.50	12.00	23.00	42.00	13.50	10.39	19.91	36.36	11.69
112.00	12.00	22.50	41.00	13.00	10.71	20.09	36.61	11.61
117.00	13.00	24.00	45.00	13.50	11.11	20.51	38.46	11.54
117.50	13.00	24.00	44.00	13.50	11.06	20.43	37.45	11.49
116.50	12.00	23.50	43.00	13.00	10.30	20.17	36.91	11.16
115.00	12.00	23.00	42.00	13.00	10.43	20.00	36.52	11.30
110.00	11.00	21.00	41.00	12.50	10.00	19.09	37.27	11.36
118.00	13.00	24.00	43.00	13.50	11.02	20.34	36.44	11.44
120.00	13.20	23.00	43.00	13.50	11.00	19.17	35.83	11.25
121.00	13.00	25.00	43.00	14.00	10.74	20.66	35.54	11.57
115.00	12.00	24.00	42.00	12.50	10.43	20.87	36.52	10.87
142.00	17.00	34.00	52.00	19.50	11.97	23.94	36.62	13.73
140.00	16.00	33.00	52.00	19.00	11.43	23.57	37.14	13.57
144.00	17.50	36.00	53.00	20.00	12.15	25.00	36.81	13.89
137.00	16.00	32.00	52.00	17.50	11.68	23.36	37.96	12.77
121.00	13.00	27.00	44.00	14.00	10.74	22.31	36.36	11.57
141.00	16.00	32.00	51.00	19.50	11.35	22.70	36.17	13.83
131.00	15.00	29.00	47.00	17.00	11.45	22.14	35.88	12.98
133.00	15.00	29.00	47.20	17.00	11.28	21.80	35.49	12.78
103.00	10.50	20.00	36.00	11.20	10.19	19.42	34.95	10.87
97.00	10.00	20.00	36.50	11.20	10.31	20.62	37.63	11.55

P L	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
97.00	10.00	20.00	36.00	11.00	10.31	20.62	37.11	11.34
98.00	10.00	20.20	37.00	11.50	10.20	20.61	37.76	11.73
95.00	9.60	20.00	35.50	10.50	10.11	21.05	37.37	11.05
130.00	15.00	28.50	46.60	16.70	11.54	21.92	35.85	12.85
127.00	14.20	28.00	46.00	16.50	11.18	22.05	36.22	12.99
122.00	14.00	27.00	45.00	16.00	11.48	22.13	36.89	13.11
131.00	14.50	28.00	46.00	16.50	11.07	21.37	35.11	12.60
112.00	12.50	24.50	40.60	13.50	11.16	21.88	36.25	12.05
110.00	12.50	24.00	40.60	13.50	11.36	21.82	36.91	12.27
115.00	12.00	24.50	41.00	13.50	10.43	21.30	35.65	11.74
118.00	13.30	25.50	44.00	13.50	11.27	21.61	37.29	11.44
120.00	14.00	26.50	45.00	15.50	11.67	22.08	37.50	12.92
122.00	15.00	26.00	46.00	15.50	12.30	21.31	37.70	12.70
127.00	14.00	27.20	47.00	16.00	11.02	21.42	37.01	12.60
121.00	13.50	26.00	44.00	15.00	11.16	21.49	36.36	12.40
130.50	15.50	28.00	47.00	16.50	11.88	21.46	36.02	12.64
131.00	15.30	28.20	47.00	16.60	11.68	21.53	35.88	12.67
129.00	15.00	28.00	26.20	16.10	11.63	21.71	20.31	12.48
150.00	16.20	33.60	53.00	20.00	10.80	22.40	35.33	13.33
155.00	16.50	34.50	53.00	20.00	10.65	22.26	34.19	12.90
152.00	16.50	34.00	53.00	19.50	10.86	22.37	34.87	12.83
158.00	17.00	35.50	55.00	20.50	10.76	22.47	34.81	12.97
135.00	16.00	29.30	48.00	17.00	11.85	21.70	35.56	12.59
126.00	14.00	28.20	46.00	16.50	11.11	22.38	36.51	13.10
122.00	14.50	28.00	45.00	16.00	11.89	22.95	36.89	13.11
123.00	14.50	28.90	45.00	16.00	11.79	23.50	36.59	13.01
176.00	21.00	41.00	62.00	25.00	11.93	23.30	35.23	14.20
171.00	21.00	41.00	62.00	25.00	12.28	23.98	36.26	14.62
161.00	18.80	37.00	58.80	24.50	11.68	22.98	36.52	15.22
166.00	19.00	37.00	58.00	24.10	11.45	22.29	34.94	14.52
173.00	21.00	40.00	62.00	25.30	12.14	23.12	35.84	14.62
116.20	12.50	23.60	41.00	13.30	10.76	20.31	35.28	11.45
119.00	13.50	24.00	44.60	13.50	11.34	20.17	37.48	11.34
125.50	14.00	27.00	47.00	16.60	11.16	21.51	37.45	13.23
175.50	21.00	41.00	62.00	24.00	11.97	23.36	35.33	13.68
109.00	12.20	23.00	40.00	13.00	11.19	21.10	36.70	11.93
118.00	13.00	24.00	45.00	13.50	11.02	20.34	38.14	11.44
129.00	16.00	33.50	49.00	20.20	12.40	25.97	37.98	15.66
142.00	16.00	33.00	51.00	20.00	11.27	23.24	35.92	14.08

P L	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
133.50	15.00	31.00	48.00	18.00	11.24	23.22	35.96	13.48
144.00	16.50	34.00	52.00	20.00	11.46	23.61	36.11	13.89
116.50	13.00	25.00	42.00	14.00	11.16	21.46	36.05	12.02
122.00	13.00	28.00	47.00	16.00	10.66	22.95	38.52	13.11
112.00	12.00	23.00	43.00	13.50	10.71	20.54	38.39	12.05
141.00	15.00	31.00	52.00	18.50	10.64	21.99	36.88	13.12
100.00	10.00	20.00	38.00	12.00	10.00	20.00	38.00	12.00
109.00	10.30	21.00	40.00	12.60	9.45	19.27	36.70	11.56
115.00	11.50	23.00	41.00	12.60	10.00	20.00	35.65	10.96
120.00	13.80	24.00	42.00	13.00	11.50	20.00	35.00	10.83
117.00	11.60	22.00	41.00	12.60	9.91	18.80	35.04	10.77
102.00	10.00	20.00	38.00	12.00	9.80	19.61	37.25	11.76
104.00	10.60	20.50	38.00	12.00	10.19	19.71	36.54	11.54
103.00	10.50	21.00	38.00	12.50	10.19	20.39	36.89	12.14
111.20	11.00	21.00	39.00	13.00	9.89	18.88	35.07	11.69
AVERAGE:								
117.52	12.85	24.68	42.05	14.49	10.94	20.86	35.89	12.22
Standard Deviation:								
19.47	2.46	5.82	7.06	3.59	1.09	2.38	3.22	1.48

Regression Output to Predict (PL):

Constant		20.503		
Std Err of Y Est		5.6616		
R Squared		0.9168		
No. of Observations		249		
Degrees of Freedom		244		
X Coefficient(s)	2.829	0.1779	0.8647	1.3741
Std Err of Coef.	0.5178	0.3136	0.1714	0.4429

Regression Output to Predict (D):

Constant	-1.121
Std Err of Y Est	0.8424

Constant	-8.278
R Squared	0.8835
No. of Observations	249
Degrees of Freedom	247

X Coefficient(s)	0.1189
Std Err of Coef.	0.0027

Regression Output to Predict (P):

Constant	-8.278
Std Err of Y Est	2.0148
R Squared	0.8806
No. of Observations	249
Degrees of Freedom	247

X Coefficient(s)	0.2805
Std Err of Coef.	0.0066

Regression Output to Predict (T):

Constant	2.1903
Std Err of Y Est	2.5052
R Squared	0.8747
No. of Observations	249
Degrees of Freedom	247

X Coefficient(s)	0.3392
Std Err of Coef.	0.0082

Regression Output to Predict (LL):

Constant	-5.806
Std Err of Y Est	1.2518
R Squared	0.8787
No. of Observations	249
Degrees of Freedom	247

X Coefficient(s)	0.1727
Std Err of Coef.	0.0041

Appendix 7. Data collections at Muttrah Souq and regression outputs on the relationship between body size and fin sizes for the hammerhead shark.

PL : Precaudal Length (cm)

D Fin : Dorsal Fin Length (cm)

P Fin : Pectoral Fin Length (cm)

L L : Lower Lobe of Tail (cm)

PL	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
114.50	23.00	21.00	54.00	18.50	20.09	18.34	47.16	16.16
129.00	24.60	23.00	57.80	20.80	19.07	17.83	44.81	16.12
133.00	24.60	21.70	57.00	19.80	18.50	16.32	42.86	14.89
121.00	23.00	20.00	52.00	17.00	19.01	16.53	42.98	14.05
121.00	23.00	20.00	52.00	17.00	19.01	16.53	42.98	14.05
127.00	24.00	21.40	58.00	18.00	18.90	16.85	45.67	14.17
188.00	31.00	30.50	77.00	26.00	16.49	16.22	40.96	13.83
162.00	31.00	28.50	74.00	25.00	19.14	17.59	45.68	15.43
146.00	27.20	25.00	63.00	21.00	18.63	17.12	43.15	14.38
128.00	22.00	20.00	53.50	18.60	17.19	15.63	41.80	14.53
277.00	62.50	52.00	94.00	39.00	22.56	18.77	33.94	14.08
112.00	21.00	18.50	49.00	17.70	18.75	16.52	43.75	15.80
144.50	28.00	25.50	65.00	22.70	19.38	17.65	44.98	15.71
140.50	27.40	24.00	61.00	22.00	19.50	17.08	43.42	15.66
105.00	21.00	17.90	46.80	16.10	20.00	17.05	44.57	15.33
120.50	22.00	20.00	53.00	18.00	18.26	16.60	43.98	14.94
112.00	21.00	18.80	50.00	16.80	18.75	16.79	44.64	15.00
90.50	16.30	14.30	38.50	12.30	18.01	15.80	42.54	13.59
120.50	21.20	19.20	50.00	17.30	17.59	15.93	41.49	14.36
98.50	18.50	15.50	44.00	13.50	18.78	15.74	44.67	13.71
107.50	20.20	17.30	46.50	14.90	18.79	16.09	43.26	13.86
93.00	17.00	15.00	41.40	13.40	18.28	16.13	44.52	14.41
103.50	19.00	17.00	46.00	14.20	18.36	16.43	44.44	13.72
128.00	24.70	23.30	57.70	19.70	19.30	18.20	45.08	15.39
128.40	24.00	21.70	58.20	18.00	18.69	16.90	45.33	14.02
139.00	23.60	22.50	60.50	20.00	16.98	16.19	43.53	14.39
105.00	20.50	17.50	54.00	15.00	19.52	16.67	51.43	14.29
154.20	29.00	29.00	70.50	24.50	18.81	18.81	45.72	15.89
154.70	29.00	30.50	70.20	24.00	18.75	19.72	45.38	15.51
164.50	38.00	32.00	74.20	26.60	23.10	19.45	45.11	16.17
110.00	21.50	20.00	52.00	17.00	19.55	18.18	47.27	15.45
157.00	32.00	28.00	62.00	21.50	20.38	17.83	39.49	13.69
116.00	23.00	21.00	52.00	17.00	19.83	18.10	44.83	14.66
141.00	29.00	26.00	60.00	20.00	20.57	18.44	42.55	14.18
147.00	30.00	27.00	60.00	20.00	20.41	18.37	40.82	13.61
150.00	31.00	28.00	61.00	21.00	20.67	18.67	40.67	14.00
193.00	50.00	43.00	84.00	32.00	25.91	22.28	43.52	16.58
127.00	24.50	23.50	57.50	20.00	19.29	18.50	45.28	15.75
107.00	20.00	17.30	44.50	14.50	18.69	16.17	41.59	13.55

PL	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
134.00	25.50	24.50	58.00	20.00	19.03	18.28	43.28	14.93
132.00	24.60	23.00	58.00	19.80	18.64	17.42	43.94	15.00
118.00	23.00	22.00	52.00	17.00	19.49	18.64	44.07	14.41
119.00	22.00	21.50	53.00	17.20	18.49	18.07	44.54	14.45
199.50	49.40	43.00	86.00	32.00	24.76	21.55	43.11	16.04
126.00	25.00	24.00	57.00	19.50	19.84	19.05	45.24	15.48
121.80	22.50	19.50	53.00	18.20	18.47	16.01	43.51	14.94
122.00	22.40	20.00	52.80	18.20	18.36	16.39	43.28	14.92
122.50	23.00	22.50	54.00	17.50	18.78	18.37	44.08	14.29
145.00	29.00	26.00	60.00	20.50	20.00	17.93	41.38	14.14
180.50	40.00	35.00	77.00	28.80	22.16	19.39	42.66	15.96
130.00	24.50	22.50	57.20	21.00	18.85	17.31	44.00	16.15
131.00	26.00	24.70	60.00	21.30	19.85	18.85	45.80	16.26
130.00	24.20	24.00	58.00	21.50	18.62	18.46	44.62	16.54
124.40	21.00	20.00	51.00	18.00	16.88	16.08	41.00	14.47
121.60	24.50	22.40	57.00	19.50	20.15	18.42	46.88	16.04
136.00	27.50	24.80	59.00	19.50	20.22	18.24	43.38	14.34
152.00	27.60	24.70	65.50	21.80	18.16	16.25	43.09	14.34
144.00	28.40	24.60	64.80	22.80	19.72	17.08	45.00	15.83
129.00	25.00	23.30	58.00	20.00	19.38	18.06	44.96	15.50
137.00	27.00	25.00	61.00	21.40	19.71	18.25	44.53	15.62
150.50	28.80	28.80	70.00	24.00	19.14	19.14	46.51	15.95
103.50	19.50	16.50	44.80	14.70	18.84	15.94	43.29	14.20
Average:								
134.28	26.27	23.85	58.53	20.07	19.37	17.60	43.84	14.91
Standard Deviation:								
29.27	7.80	6.64	10.63	4.67	1.61	1.36	2.28	0.87

Regression Output to Predict (PL):

Constant	12.95
Std Err of Y Est	6.8653
R Squared	0.9486
No. of Observations	62
Degrees of Freedom	57

X Coefficient(s)	1.3804	0.356	0.6527	1.9117
Std Err of Coef.	0.6473	1.0189	0.4053	1.0959

Regression Output to Predict (D):

Constant	-7.901
Std Err of Y Est	2.3203
R Squared	0.9129
No. of Observations	62
Degrees of Freedom	60

X Coefficient(s)	0.2545
Std Err of Coef.	0.0101

Regression Output to Predict (P):

Constant	-5.557
Std Err of Y Est	1.7497
R Squared	0.9317
No. of Observations	62
Degrees of Freedom	60

X Coefficient(s)	0.219
Std Err of Coef.	0.0077

Regression Output to Predict (T):

Constant	12.182
Std Err of Y Est	3.3322
R Squared	0.9034
No. of Observations	62
Degrees of Freedom	60

X Coefficient(s)	0.3452
Std Err of Coef.	0.0146

Regression Output to Predict (LL):

Constant	-0.583
Std Err of Y Est	1.2461
R Squared	0.93
No. of Observations	62

Degrees of Freedom	60
X Coefficient(s)	0.1538
Std Err of Coef.	0.0055

Appendix 8. Data collections At Muttrah Souq and regression outputs on the relationship between body size and fin sizes for the spinner shark.

PL : Precaudal Length (cm)

D Fin : Dorsal Fin Length (cm)

P Fin : Pectoral Fin Length (cm)

L L : Lower Lobe of Tail (cm)

PL	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
158.50	18.00	29.00	51.50	20.00	11.36	18.30	32.49	12.62
148.50	16.00	26.60	50.50	17.00	10.77	17.91	34.01	11.45
153.00	16.00	29.50	51.50	20.00	10.46	19.28	33.66	13.07
103.00	12.40	22.00	34.20	13.30	12.04	21.36	33.20	12.91
167.00	17.90	30.20	58.00	20.00	10.72	18.08	34.73	11.98
141.00	17.00	25.50	48.00	17.50	12.06	18.09	34.04	12.41
138.00	16.00	26.00	48.60	17.70	11.59	18.84	35.22	12.83
126.00	13.00	20.00	38.00	14.00	10.32	15.87	30.16	11.11
146.00	17.00	27.40	51.00	19.50	11.64	18.77	34.93	13.36
116.50	16.50	20.00	42.00	11.50	14.16	17.17	36.05	9.87
153.00	19.00	29.00	53.00	20.50	12.42	18.95	34.64	13.40
150.30	17.40	29.00	51.60	20.00	11.58	19.29	34.33	13.31
148.70	17.10	28.00	50.20	19.50	11.50	18.83	33.76	13.11
155.80	19.30	31.00	53.50	21.00	12.39	19.90	34.34	13.48
151.00	17.50	29.00	51.70	20.00	11.59	19.21	34.24	13.25
152.00	17.60	29.20	51.90	20.00	11.58	19.21	34.14	13.16
176.50	20.00	33.30	60.50	22.00	11.33	18.87	34.28	12.46
170.00	20.00	33.00	60.00	22.00	11.76	19.41	35.29	12.94
153.20	18.10	27.60	53.00	19.30	11.81	18.02	34.60	12.60
155.00	18.50	28.00	53.30	20.00	11.94	18.06	34.39	12.90
150.00	17.70	27.60	51.50	19.90	11.80	18.40	34.33	13.27
108.00	12.40	20.00	37.50	14.00	11.48	18.52	34.72	12.96
120.00	12.50	20.00	37.50	14.00	10.42	16.67	31.25	11.67
110.50	12.80	20.50	39.00	15.00	11.58	18.55	35.29	13.57
154.50	18.00	29.50	53.30	21.50	11.65	19.09	34.50	13.92
150.00	16.60	27.50	52.10	20.20	11.07	18.33	34.73	13.47
155.50	17.50	29.00	51.00	21.50	11.25	18.65	32.80	13.83
114.00	12.50	20.00	39.20	13.50	10.96	17.54	34.39	11.84
107.70	13.40	20.00	37.50	13.00	12.44	18.57	34.82	12.07
99.00	11.00	17.80	34.40	11.60	11.11	17.98	34.75	11.72
107.00	13.00	20.40	34.70	14.50	12.15	19.07	32.43	13.55
106.00	12.00	18.80	37.40	13.60	11.32	17.74	35.28	12.83
116.00	12.60	21.00	40.00	15.00	10.86	18.10	34.48	12.93
106.00	12.70	17.80	37.30	13.20	11.98	16.79	35.19	12.45
114.50	13.30	21.50	41.00	16.00	11.62	18.78	35.81	13.97
110.00	13.00	20.00	38.00	13.00	11.82	18.18	34.55	11.82
114.00	13.20	21.50	41.00	16.00	11.58	18.86	35.96	14.04
101.00	12.00	18.40	34.50	13.00	11.88	18.22	34.16	12.87
102.00	12.00	18.50	34.50	13.00	11.76	18.14	33.82	12.75

PL	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
99.00	12.00	18.20	34.40	12.80	12.12	18.38	34.75	12.93
176.50	20.00	34.80	58.00	23.00	11.33	19.72	32.86	13.03
153.70	19.20	30.80	54.50	20.30	12.49	20.04	35.46	13.21
161.50	18.50	33.40	57.00	23.70	11.46	20.68	35.29	14.67
139.50	16.00	25.30	50.80	18.00	11.47	18.14	36.42	12.90
99.50	10.80	17.00	35.00	11.80	10.85	17.09	35.18	11.86
113.00	12.60	20.50	39.50	15.00	11.15	18.14	34.96	13.27
117.50	13.00	21.50	40.20	15.20	11.06	18.30	34.21	12.94
100.00	12.70	19.00	36.40	14.00	12.70	19.00	36.40	14.00
109.10	13.70	20.00	38.00	14.40	12.56	18.33	34.83	13.20
101.00	12.70	19.10	36.50	14.00	12.57	18.91	36.14	13.86
105.50	13.40	19.80	37.90	13.80	12.70	18.77	35.92	13.08
97.80	10.60	17.70	34.50	11.50	10.84	18.10	35.28	11.76
110.80	13.00	19.20	39.00	14.20	11.73	17.33	35.20	12.82
109.00	13.40	20.00	39.80	14.70	12.29	18.35	36.51	13.49
113.00	12.90	20.50	39.50	14.70	11.42	18.14	34.96	13.01
105.00	12.90	19.90	39.40	14.40	12.29	18.95	37.52	13.71
111.30	12.90	20.80	39.00	14.60	11.59	18.69	35.04	13.12
105.50	11.00	18.40	37.00	13.80	10.43	17.44	35.07	13.08
145.50	16.00	29.50	50.50	20.20	11.00	20.27	34.71	13.88
149.00	17.50	28.90	50.70	19.50	11.74	19.40	34.03	13.09
112.20	13.70	20.50	40.90	14.40	12.21	18.27	36.45	12.83
108.00	13.50	20.20	37.50	14.00	12.50	18.70	34.72	12.96
185.00	21.30	38.80	58.50	25.00	11.51	20.97	31.62	13.51
144.50	17.50	27.50	50.60	18.80	12.11	19.03	35.02	13.01
114.00	12.70	20.80	40.00	15.00	11.14	18.25	35.09	13.16
172.00	19.50	32.50	59.10	23.80	11.34	18.90	34.36	13.84
174.00	20.20	33.30	57.00	22.50	11.61	19.14	32.76	12.93
140.00	16.90	29.50	52.00	20.00	12.07	21.07	37.14	14.29
172.00	20.00	33.50	54.00	22.40	11.63	19.48	31.40	13.02
112.00	13.20	20.00	38.00	15.00	11.79	17.86	33.93	13.39
164.00	19.60	32.00	55.00	21.00	11.95	19.51	33.54	12.80
152.00	17.80	30.30	52.00	20.50	11.71	19.93	34.21	13.49
109.80	13.00	20.50	38.00	12.50	11.84	18.67	34.61	11.38
113.00	13.50	20.80	39.00	12.60	11.95	18.41	34.51	11.15
110.00	13.30	20.40	39.00	13.00	12.09	18.55	35.45	11.82
108.00	12.90	20.00	38.00	13.00	11.94	18.52	35.19	12.04
134.00	14.50	23.50	45.00	15.50	10.82	17.54	33.58	11.57
166.00	18.80	30.50	58.00	20.90	11.33	18.37	34.94	12.59

PL	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
165.00	19.50	33.00	57.00	22.00	11.82	20.00	34.55	13.33
137.00	15.50	25.00	45.80	16.00	11.31	18.25	33.43	11.68
125.00	15.00	24.60	44.40	15.70	12.00	19.68	35.52	12.56
112.00	13.20	21.00	41.00	13.60	11.79	18.75	36.61	12.14
106.00	12.00	18.50	37.20	12.50	11.32	17.45	35.09	11.79
115.00	13.00	23.00	38.00	14.70	11.30	20.00	33.04	12.78
114.00	12.30	21.00	38.50	13.40	10.79	18.42	33.77	11.75
175.70	22.60	14.00	68.50	27.00	12.86	7.97	38.99	15.37
108.00	12.50	21.00	38.00	14.00	11.57	19.44	35.19	12.96
107.00	12.40	21.00	38.00	13.50	11.59	19.63	35.51	12.62
106.00	12.10	18.60	37.10	12.40	11.42	17.55	35.00	11.70
109.00	12.60	21.40	38.20	14.00	11.56	19.63	35.05	12.84
162.50	18.20	32.00	55.70	20.80	11.20	19.69	34.28	12.80
156.00	17.70	31.00	52.20	20.00	11.35	19.87	33.46	12.82
136.50	15.80	24.00	44.00	16.20	11.58	17.58	32.23	11.87
194.00	22.50	40.00	63.00	25.00	11.60	20.62	32.47	12.89
197.00	23.70	40.90	65.10	25.00	12.03	20.76	33.05	12.69
128.00	15.00	23.00	43.00	15.20	11.72	17.97	33.59	11.88
117.00	11.70	19.50	40.00	13.50	10.00	16.67	34.19	11.54
114.00	13.00	21.00	40.60	14.50	11.40	18.42	35.61	12.72
149.00	16.40	28.00	56.00	19.00	11.01	18.79	37.58	12.75
109.50	13.00	20.50	39.00	13.40	11.87	18.72	35.62	12.24
110.50	13.00	20.60	39.00	13.50	11.76	18.64	35.29	12.22
113.00	13.10	21.00	40.00	13.50	11.59	18.58	35.40	11.95
197.50	24.20	41.40	64.50	26.00	12.25	20.96	32.66	13.16
154.00	18.40	30.00	53.00	22.00	11.95	19.48	34.42	14.29
145.00	15.70	28.00	49.00	17.00	10.83	19.31	33.79	11.72
141.00	15.50	28.00	49.00	17.00	10.99	19.86	34.75	12.06
138.00	15.20	27.70	48.80	16.80	11.01	20.07	35.36	12.17
148.00	16.60	28.10	49.00	17.00	11.22	18.99	33.11	11.49
161.00	21.40	34.00	61.00	22.50	13.29	21.12	37.89	13.98
150.00	18.20	29.70	52.00	22.00	12.13	19.80	34.67	14.67
142.00	15.30	28.00	49.00	17.20	10.77	19.72	34.51	12.11
176.30	21.70	34.30	58.50	22.20	12.31	19.46	33.18	12.59
117.00	13.00	21.50	42.00	14.40	11.11	18.38	35.90	12.31
112.00	12.10	19.50	37.70	14.40	10.80	17.41	33.66	12.86
119.20	13.80	21.00	37.00	14.70	11.58	17.62	31.04	12.33
109.00	13.00	20.50	37.00	13.60	11.93	18.81	33.94	12.48
113.00	12.50	19.50	40.00	14.00	11.06	17.26	35.40	12.39

PL	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
114.00	12.40	19.50	40.00	14.00	10.88	17.11	35.09	12.28
108.00	12.20	19.50	37.00	13.50	11.30	18.06	34.26	12.50
112.50	12.00	19.50	37.50	13.60	10.67	17.33	33.33	12.09
113.40	13.50	21.00	38.00	13.70	11.90	18.52	33.51	12.08
134.00	15.00	27.00	44.00	15.30	11.19	20.15	32.84	11.42
116.00	12.40	20.50	40.00	13.60	10.69	17.67	34.48	11.72
112.00	12.90	20.00	39.00	14.20	11.52	17.86	34.82	12.68
116.00	13.00	20.30	38.00	13.20	11.21	17.50	32.76	11.38
203.00	21.50	37.00	58.00	23.30	10.59	18.23	28.57	11.48
97.50	12.40	19.50	37.70	12.70	12.72	20.00	38.67	13.03
153.00	18.50	30.00	52.20	22.20	12.09	19.61	34.12	14.51
196.50	22.50	39.00	57.00	24.20	11.45	19.85	29.01	12.32
153.00	17.00	29.00	53.50	19.00	11.11	18.95	34.97	12.42
150.00	16.50	28.40	53.00	18.50	11.00	18.93	35.33	12.33
144.00	16.80	28.00	52.00	18.00	11.67	19.44	36.11	12.50
105.00	12.20	21.00	38.00	13.30	11.62	20.00	36.19	12.67
104.00	12.00	18.80	37.50	13.00	11.54	18.08	36.06	12.50
146.50	16.80	28.00	52.00	18.00	11.47	19.11	35.49	12.29
150.00	16.80	28.00	52.00	18.00	11.20	18.67	34.67	12.00
112.00	13.50	20.50	38.80	13.00	12.05	18.30	34.64	11.61
106.00	12.90	20.00	38.00	14.00	12.17	18.87	35.85	13.21
108.00	12.20	19.50	37.00	13.50	11.30	18.06	34.26	12.50
100.50	11.00	17.90	35.00	11.90	10.95	17.81	34.83	11.84
103.00	12.80	19.00	36.50	13.60	12.43	18.45	35.44	13.20
148.00	16.50	28.00	53.00	18.20	11.15	18.92	35.81	12.30
110.00	13.50	20.40	38.00	13.00	12.27	18.55	34.55	11.82
124.00	15.00	23.00	43.00	15.00	12.10	18.55	34.68	12.10
139.00	15.60	28.00	50.00	17.30	11.22	20.14	35.97	12.45
163.00	18.80	34.30	58.00	22.00	11.53	21.04	35.58	13.50
197.00	23.50	42.80	61.50	26.00	11.93	21.73	31.22	13.20
134.00	16.00	26.60	46.00	18.50	11.94	19.85	34.33	13.81
165.00	19.50	32.00	58.50	21.50	11.82	19.39	35.45	13.03
111.00	13.00	20.50	38.50	13.00	11.71	18.47	34.68	11.71
108.00	13.00	20.00	38.00	13.00	12.04	18.52	35.19	12.04
110.00	12.00	21.00	38.00	13.00	10.91	19.09	34.55	11.82
138.00	16.00	26.00	45.00	18.00	11.59	18.84	32.61	13.04
106.00	13.50	20.00	38.00	13.00	12.74	18.87	35.85	12.26
109.00	13.00	20.00	37.50	14.00	11.93	18.35	34.40	12.84
114.00	13.30	20.40	38.00	14.00	11.67	17.89	33.33	12.28

PL	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
117.00	13.00	20.00	39.00	14.00	11.11	17.09	33.33	11.97
113.00	13.00	20.00	38.00	14.00	11.50	17.70	33.63	12.39
138.00	17.00	27.50	51.00	17.00	12.32	19.93	36.96	12.32
103.00	12.00	19.00	36.60	13.50	11.65	18.45	35.53	13.11
146.00	17.50	29.00	54.00	18.00	11.99	19.86	36.99	12.33
107.00	12.50	20.00	37.00	12.50	11.68	18.69	34.58	11.68
133.00	16.00	25.00	49.00	17.00	12.03	18.80	36.84	12.78
137.00	16.00	26.00	50.00	17.00	11.68	18.98	36.50	12.41
202.00	24.00	39.00	65.00	25.50	11.88	19.31	32.18	12.62
171.00	20.50	34.00	59.00	22.50	11.99	19.88	34.50	13.16
152.00	16.80	29.00	54.00	19.00	11.05	19.08	35.53	12.50
106.00	13.00	20.00	38.00	14.00	12.26	18.87	35.85	13.21
157.00	17.50	30.00	55.00	19.50	11.15	19.11	35.03	12.42
175.00	23.00	36.00	61.30	22.00	13.14	20.57	35.03	12.57
142.00	16.50	27.00	52.00	18.20	11.62	19.01	36.62	12.82
144.00	16.50	27.20	52.20	18.00	11.46	18.89	36.25	12.50
110.00	13.50	20.40	38.50	13.00	12.27	18.55	35.00	11.82
145.00	16.50	27.00	53.00	19.00	11.38	18.62	36.55	13.10
110.00	13.10	20.30	38.40	13.50	11.91	18.45	34.91	12.27
105.00	12.80	20.00	38.00	14.00	12.19	19.05	36.19	13.33
103.00	12.00	19.00	37.00	13.00	11.65	18.45	35.92	12.62
108.00	13.00	20.00	38.00	13.50	12.04	18.52	35.19	12.50
99.00	12.30	19.60	38.00	12.50	12.42	19.80	38.38	12.63
137.50	16.60	27.50	51.00	17.00	12.07	20.00	37.09	12.36
148.00	17.00	28.00	52.00	18.00	11.49	18.92	35.14	12.16
165.00	18.50	35.00	61.00	23.00	11.21	21.21	36.97	13.94
150.00	17.00	31.00	57.00	22.00	11.33	20.67	38.00	14.67
132.00	17.00	29.00	55.00	18.20	12.88	21.97	41.67	13.79
107.00	13.00	20.00	36.00	12.20	12.15	18.69	33.64	11.40
194.00	22.50	37.00	64.00	24.00	11.60	19.07	32.99	12.37
152.00	17.00	31.00	57.00	22.00	11.18	20.39	37.50	14.47
194.00	22.00	40.00	65.00	25.00	11.34	20.62	33.51	12.89
137.00	17.00	29.00	54.00	18.00	12.41	21.17	39.42	13.14
140.00	18.00	29.00	54.00	18.00	12.86	20.71	38.57	12.86
167.00	22.50	36.00	53.00	20.00	13.47	21.56	31.74	11.98
165.00	22.00	35.00	53.00	20.00	13.33	21.21	32.12	12.12
114.00	13.00	21.00	39.00	13.00	11.40	18.42	34.21	11.40
106.00	12.50	20.00	38.00	12.50	11.79	18.87	35.85	11.79
100.50	12.00	18.00	35.00	12.00	11.94	17.91	34.83	11.94

PL	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
116.00	14.00	21.00	40.00	13.00	12.07	18.10	34.48	11.21
135.00	16.00	23.00	42.00	17.00	11.85	17.04	31.11	12.59
141.00	16.00	23.00	48.00	18.00	11.35	16.31	34.04	12.77
135.00	15.50	24.00	46.00	18.00	11.48	17.78	34.07	13.33
155.00	17.50	30.00	52.00	19.00	11.29	19.35	33.55	12.26
159.00	18.50	31.00	52.50	20.00	11.64	19.50	33.02	12.58
137.00	16.00	24.00	47.00	18.00	11.68	17.52	34.31	13.14
152.00	17.00	30.00	51.00	19.00	11.18	19.74	33.55	12.50
190.50	23.00	42.00	58.00	21.00	12.07	22.05	30.45	11.02
116.00	13.00	21.00	40.00	13.00	11.21	18.10	34.48	11.21
109.00	12.00	20.50	38.00	11.80	11.01	18.81	34.86	10.83
148.00	17.00	28.00	50.00	18.50	11.49	18.92	33.78	12.50
120.00	13.30	22.00	43.00	14.50	11.08	18.33	35.83	12.08
115.00	13.00	21.00	40.00	13.00	11.30	18.26	34.78	11.30
136.00	16.00	24.00	46.00	18.00	11.76	17.65	33.82	13.24
141.00	16.00	26.00	50.00	18.00	11.35	18.44	35.46	12.77
115.00	13.50	21.00	38.00	15.00	11.74	18.26	33.04	13.04
112.00	13.30	20.60	38.50	14.00	11.88	18.39	34.38	12.50
140.00	17.00	28.00	52.50	18.20	12.14	20.00	37.50	13.00
136.00	17.00	27.10	51.00	17.00	12.50	19.93	37.50	12.50
115.00	13.00	21.00	41.50	14.00	11.30	18.26	36.09	12.17
125.50	14.00	26.00	47.00	15.00	11.16	20.72	37.45	11.95
153.00	16.50	29.00	53.50	19.20	10.78	18.95	34.97	12.55
135.00	15.00	22.50	42.00	17.00	11.11	16.67	31.11	12.59
110.00	13.00	20.00	38.00	13.10	11.82	18.18	34.55	11.91
162.00	17.50	30.00	55.00	20.00	10.80	18.52	33.95	12.35
119.00	14.00	21.00	39.00	13.50	11.76	17.65	32.77	11.34
140.50	16.00	28.40	51.50	17.70	11.39	20.21	36.65	12.60
117.00	13.00	22.00	42.50	14.40	11.11	18.80	36.32	12.31
149.00	17.00	28.80	52.50	18.00	11.41	19.33	35.23	12.08
113.00	13.00	21.00	41.00	14.00	11.50	18.58	36.28	12.39
126.00	15.00	23.00	42.00	15.00	11.90	18.25	33.33	11.90
118.00	12.80	22.00	42.00	14.50	10.85	18.64	35.59	12.29
160.00	19.00	32.00	55.00	20.00	11.88	20.00	34.38	12.50
177.50	23.00	36.00	61.50	22.00	12.96	20.28	34.65	12.39
135.00	15.50	27.00	51.00	17.50	11.48	20.00	37.78	12.96
Average:								
133.08	15.50	25.19	46.09	16.84	11.65	18.84	34.73	12.62

PL	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
Standard Deviation								
25.88	3.14	5.90	8.43	3.68	0.59	1.29	1.69	0.78

Regression Output to Predict (PL):

Constant		7.90		
Std Err of Y Est		4.71		
R Squared		0.97		
No. of Observations		231.00		
Degrees of Freedom		226.00		
X Coefficient(s)	2.50	1.10	0.64	1.73
Std Err of Coef.	0.37	0.15	0.14	0.31

Regression Output to Predict (D):

Constant		-0.12
Std Err of Y Est		0.81
R Squared		0.93
No. of Observations		231.00
Degrees of Freedom		229.00
X Coefficient(s)	0.12	
Std Err of Coef.	0.00	

Regression Output to Predict (P):

Constant		-3.55
Std Err of Y Est		1.88
R Squared		0.90
No. of Observations		231.00
Degrees of Freedom		229.00
X Coefficient(s)	0.22	
Std Err of Coef.	0.00	

Regression Output to Predict (T):

Constant	4.47
Std Err of Y Est	2.38
R Squared	0.92
No. of Observations	231.00
Degrees of Freedom	229.00

X Coefficient(s)	0.31
Std Err of Coef.	0.01

Regression Output to Predict (LL):

Constant	-1.28
Std Err of Y Est	1.05
R Squared	0.92
No. of Observations	231.00
Degrees of Freedom	229.00

X Coefficient(s)	0.14
Std Err of Coef.	0.00

Appendix 9. Data collections from Muttrah Souq and regression outputs on the relationship between body size and fin sizes for the black-tip shark.

PL : Precaudal Length (cm)

D Fin : Dorsal Fin Length (cm)

P Fin : Pectoral Fin Length (cm)

L L : Lower Lobe of Tail (cm)

P L	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
177.00	32.00	37.00	63.00	26.00	18.08	20.90	35.59	14.69
144.00	23.00	34.00	57.00	23.00	15.97	23.61	39.58	15.97
150.00	23.50	35.00	55.00	22.00	15.67	23.33	36.67	14.67
130.00	22.00	30.00	49.00	18.00	16.92	23.08	37.69	13.85
160.00	26.00	37.00	57.00	23.30	16.25	23.13	35.63	14.56
137.00	23.00	31.00	49.00	18.50	16.79	22.63	35.77	13.50
125.00	23.00	31.00	55.00	21.00	18.40	24.80	44.00	16.80
148.00	24.00	36.00	58.00	23.30	16.22	24.32	39.19	15.74
175.00	31.00	37.00	62.00	26.00	17.71	21.14	35.43	14.86
150.50	23.00	35.00	57.00	23.00	15.28	23.26	37.87	15.28
139.00	23.00	33.50	49.00	20.50	16.55	24.10	35.25	14.75
170.50	27.60	38.00	61.00	25.00	16.19	22.29	35.78	14.66
159.00	24.00	36.00	58.00	23.00	15.09	22.64	36.48	14.47
128.00	22.00	30.00	49.00	18.00	17.19	23.44	38.28	14.06
160.00	27.00	38.00	60.00	23.00	16.88	23.75	37.50	14.38
150.50	24.00	35.00	54.00	21.00	15.95	23.26	35.88	13.95
170.50	29.00	39.00	61.00	24.00	17.01	22.87	35.78	14.08
172.00	31.00	39.00	61.00	24.00	18.02	22.67	35.47	13.95
175.00	27.00	40.00	61.00	25.50	15.43	22.86	34.86	14.57
197.00	31.00	45.00	66.00	27.00	15.74	22.84	33.50	13.71
136.00	22.00	31.00	50.00	18.50	16.18	22.79	36.76	13.60
139.00	22.50	32.00	48.00	20.00	16.19	23.02	34.53	14.39
165.00	28.50	41.00	58.00	24.00	17.27	24.85	35.15	14.55
150.50	22.70	33.00	55.00	20.00	15.08	21.93	36.54	13.29
167.00	27.00	37.00	59.00	25.00	16.17	22.16	35.33	14.97
148.00	24.50	34.00	57.00	23.00	16.55	22.97	38.51	15.54
150.00	23.00	34.00	55.50	21.50	15.33	22.67	37.00	14.33
155.00	25.00	35.00	57.50	23.50	16.13	22.58	37.10	15.16
131.00	22.00	30.00	49.00	18.00	16.79	22.90	37.40	13.74
148.00	23.00	33.60	55.00	21.20	15.54	22.70	37.16	14.32
153.00	28.00	36.00	58.50	24.00	18.30	23.53	38.24	15.69
141.00	25.00	32.00	57.00	22.00	17.73	22.70	40.43	15.60
155.00	28.00	37.00	59.00	25.00	18.06	23.87	38.06	16.13
165.00	26.80	37.00	59.00	25.00	16.24	22.42	35.76	15.15
157.00	25.00	35.00	58.00	23.00	15.92	22.29	36.94	14.65
134.00	23.00	31.00	51.00	19.00	17.16	23.13	38.06	14.18
129.00	22.00	30.00	50.00	18.50	17.05	23.26	38.76	14.34
135.20	20.60	31.50	50.00	20.00	15.24	23.30	36.98	14.79
184.00	29.00	40.00	58.80	24.20	15.76	21.74	31.96	13.15

P L	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
137.80	23.00	32.00	52.00	21.00	16.69	23.22	37.74	15.24
162.50	27.00	39.00	58.80	24.00	16.62	24.00	36.18	14.77
138.00	22.60	34.00	44.50	19.00	16.38	24.64	32.25	13.77
129.00	20.60	30.00	49.00	17.00	15.97	23.26	37.98	13.18
202.00	32.00	43.50	66.00	26.00	15.84	21.53	32.67	12.87
122.00	19.00	28.50	44.50	17.00	15.57	23.36	36.48	13.93
121.00	19.00	28.00	44.00	17.00	15.70	23.14	36.36	14.05
Average:								
151.59	24.93	34.82	55.35	21.99	16.45	23.02	36.66	14.52
Standard Deviation:								
19.10	3.37	3.89	5.53	2.80	0.89	0.84	2.10	0.84

Regression Output to Predict (PL):

Constant		-17.51		
Std Err of Y Est		5.04		
R Squared		0.94		
No. of Observations		46.00		
Degrees of Freedom		41.00		
X Coefficient(s)	1.46	3.06	0.68	-0.51
Std Err of Coef.	0.55	0.48	0.44	0.94

Regression Output to Predict (D):

Constant	0.55
Std Err of Y Est	1.39
R Squared	0.83
No. of Observations	46.00
Degrees of Freedom	44.00
X Coefficient(s)	0.16
Std Err of Coef.	0.01

Regression Output to Predict (P):

Constant	5.39
Std Err of Y Est	1.19
R Squared	0.91
No. of Observations	46.00
Degrees of Freedom	44.00

X Coefficient(s)	0.19
Std Err of Coef.	0.01

Regression Output to Predict (T):

Constant	16.07
Std Err of Y Est	2.50
R Squared	0.80
No. of Observations	46.00
Degrees of Freedom	44.00

X Coefficient(s)	0.26
Std Err of Coef.	0.02

Regression Output to Predict (LL):

Constant	2.05
Std Err of Y Est	1.26
R Squared	0.80
No. of Observations	46.00
Degrees of Freedom	44.00

X Coefficient(s)	0.13
Std Err of Coef.	0.01

Appendix 10. Data collections at Muttrah Souq and regression outputs on the relationship between body size and fin sizes for the sandbar shark.

PL : Precaudal Length (cm)

D Fin : Dorsal Fin Length (cm)

P Fin : Pectoral Fin Length (cm)

L L : Lower Lobe of Tail (cm)

P L	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
147.00	30.50	42.00	52.50	16.00	20.75	28.57	35.71	10.88
143.00	29.00	38.00	50.00	19.00	20.28	26.57	34.97	13.29
133.00	25.00	35.00	48.00	16.50	18.80	26.32	36.09	12.41
98.00	13.00	22.00	32.00	12.40	13.27	22.45	32.65	12.65
114.00	14.00	23.50	33.00	13.00	12.28	20.61	28.95	11.40
116.00	23.00	31.00	42.00	17.50	19.83	26.72	36.21	15.09
103.00	21.00	27.00	39.00	13.50	20.39	26.21	37.86	13.11
101.00	20.60	26.80	38.50	13.30	20.40	26.53	38.12	13.17
122.00	26.00	36.00	43.00	16.00	21.31	29.51	35.25	13.11
122.00	24.60	34.00	46.00	18.50	20.16	27.87	37.70	15.16
135.00	29.40	37.50	47.60	18.80	21.78	27.78	35.26	13.93
130.00	28.80	36.50	48.50	19.20	22.15	28.08	37.31	14.77
144.00	34.00	38.50	54.00	21.60	23.61	26.74	37.50	15.00
87.40	12.50	22.00	30.50	11.00	14.30	25.17	34.90	12.59
88.00	12.60	22.00	30.50	11.10	14.32	25.00	34.66	12.61
89.00	12.60	22.20	30.10	11.10	14.16	24.94	33.82	12.47
93.00	13.30	9.00	31.00	11.50	14.30	9.68	33.33	12.37
140.00	29.00	38.00	53.00	20.20	20.71	27.14	37.86	14.43
135.00	28.30	38.80	49.00	19.70	20.96	28.74	36.30	14.59
100.00	21.00	26.00	39.00	13.70	21.00	26.00	39.00	13.70
128.50	31.50	37.50	52.00	18.00	24.51	29.18	40.47	14.01
130.50	26.50	36.50	44.00	16.50	20.31	27.97	33.72	12.64
83.00	12.00	20.00	30.00	11.50	14.46	24.10	36.14	13.86
122.00	24.20	34.00	46.50	16.60	19.84	27.87	38.11	13.61
117.40	24.20	6.00	45.60	16.80	20.61	5.11	38.84	14.31
108.00	22.20	31.00	38.00	15.50	20.56	28.70	35.19	14.35
128.50	26.00	34.50	48.00	17.00	20.23	26.85	37.35	13.23
125.20	26.50	35.50	45.20	17.20	21.17	28.35	36.10	13.74
134.00	27.00	37.60	49.50	18.00	20.15	28.06	36.94	13.43
118.00	24.00	31.50	44.00	15.40	20.34	26.69	37.29	13.05
125.00	27.20	34.40	47.00	17.20	21.76	27.52	37.60	13.76
92.00	12.80	21.50	31.00	12.00	13.91	23.37	33.70	13.04
84.00	11.80	20.50	30.00	11.50	14.05	24.40	35.71	13.69
119.00	23.00	31.50	43.50	17.70	19.33	26.47	36.55	14.87
93.00	18.50	23.70	35.00	11.30	19.89	25.48	37.63	12.15
128.00	26.00	34.40	48.00	18.00	20.31	26.88	37.50	14.06
127.00	29.00	37.50	48.00	19.50	22.83	29.53	37.80	15.35
121.00	29.00	37.00	48.00	19.10	23.97	30.58	39.67	15.79

P L	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
Average:								
116.43	22.88	30.27	42.38	15.85	19.29	25.73	36.31	13.57
Standard Deviation:								
18.60	6.53	8.41	7.71	3.09	3.28	4.85	2.17	1.10

Regression Output to Predict (PL):

Constant		15.89		
Std Err of Y Est		5.80		
R Squared		0.91		
No. of Observations		38.00		
Degrees of Freedom		33.00		
X Coefficient(s)	-0.63	0.61	1.97	0.79
Std Err of Coef.	0.71	0.39	0.62	0.87

Regression Output to Predict (D):

Constant		-14.94
Std Err of Y Est		2.52
R Squared		0.86
No. of Observations		38.00
Degrees of Freedom		36.00
X Coefficient(s)	0.32	
Std Err of Coef.	0.02	

Regression Output to Predict (P):

Constant		-11.36
Std Err of Y Est		3.00
R Squared		0.84
No. of Observations		38.00
Degrees of Freedom		36.00
X Coefficient(s)	0.36	
Std Err of Coef.	0.03	

Regression Output to Predict (T):

Constant	-3.52
Std Err of Y Est	2.43
R Squared	0.90
No. of Observations	38.00
Degrees of Freedom	36.00
X Coefficient(s)	0.39
Std Err of Coef.	0.02

Regression Output to Predict (LL):

Constant	-1.61
Std Err of Y Est	1.34
R Squared	0.82
No. of Observations	38.00
Degrees of Freedom	36.00
X Coefficient(s)	0.15
Std Err of Coef.	0.01

Appendix 11. Data collections at Muttrah Souq and regression outputs on the relationship between body size and fin sizes for the spottail shark.

PL : Precaudal Length (cm)

D Fin : Dorsal Fin Length (cm)

P Fin : Pectoral Fin Length (cm)

L L : Lower Lobe of Tail (cm)

P L	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
98.00	13.00	19.00	36.00	11.50	13.27	19.39	36.73	11.73
100.00	13.00	21.00	38.00	13.30	13.00	21.00	38.00	13.30
98.00	12.00	20.50	37.00	12.00	12.24	20.92	37.76	12.24
106.00	14.00	21.00	38.00	13.50	13.21	19.81	35.85	12.74
110.00	14.20	23.00	39.00	14.00	12.91	20.91	35.45	12.73
100.00	13.00	21.00	37.50	13.00	13.00	21.00	37.50	13.00
105.00	12.60	20.50	37.00	12.50	12.00	19.52	35.24	11.90
122.00	16.00	26.00	41.40	16.50	13.11	21.31	33.93	13.52
88.00	11.00	17.00	33.00	10.00	12.50	19.32	37.50	11.36
96.00	13.00	19.00	36.00	12.00	13.54	19.79	37.50	12.50
102.00	13.00	19.00	36.00	12.20	12.75	18.63	35.29	11.96
104.00	14.00	22.00	38.00	13.20	13.46	21.15	36.54	12.69
100.00	12.00	21.60	34.00	13.00	12.00	21.60	34.00	13.00
98.00	12.00	21.00	35.00	13.00	12.24	21.43	35.71	13.27
99.00	13.00	21.00	37.00	13.00	13.13	21.21	37.37	13.13
83.00	11.50	18.00	34.00	12.00	13.86	21.69	40.96	14.46
85.00	12.00	18.00	34.00	12.00	14.12	21.18	40.00	14.12
104.00	14.00	20.00	37.40	13.00	13.46	19.23	35.96	12.50
101.00	13.00	19.00	37.00	13.00	12.87	18.81	36.63	12.87
98.00	12.60	18.00	36.00	12.00	12.86	18.37	36.73	12.24
109.00	14.00	20.50	37.00	13.00	12.84	18.81	33.94	11.93
101.00	13.20	19.00	36.80	13.00	13.07	18.81	36.44	12.87
104.00	14.00	20.00	37.00	13.00	13.46	19.23	35.58	12.50
105.00	14.00	20.00	37.00	13.00	13.33	19.05	35.24	12.38
98.00	12.70	18.50	36.00	11.60	12.96	18.88	36.73	11.84
100.00	12.10	19.60	37.00	12.60	12.10	19.60	37.00	12.60
98.50	12.00	19.50	37.00	12.60	12.18	19.80	37.56	12.79
87.00	11.00	18.50	34.00	11.80	12.64	21.26	39.08	13.56
84.50	10.20	17.00	32.50	11.50	12.07	20.12	38.46	13.61
106.00	12.80	21.00	38.50	16.00	12.08	19.81	36.32	15.09
104.00	12.70	21.00	38.00	15.50	12.21	20.19	36.54	14.90
106.00	12.80	21.20	39.00	15.50	12.08	20.00	36.79	14.62
102.00	12.20	20.50	40.00	13.00	11.96	20.10	39.22	12.75
106.00	13.50	22.00	38.00	14.00	12.74	20.75	35.85	13.21
95.30	13.20	19.50	36.00	12.00	13.85	20.46	37.78	12.59
106.00	13.50	22.00	37.00	14.50	12.74	20.75	34.91	13.68
83.00	10.20	18.00	33.50	10.50	12.29	21.69	40.36	12.65
106.00	14.10	22.00	38.60	13.30	13.30	20.75	36.42	12.55
96.00	12.30	18.60	38.00	11.20	12.81	19.38	39.58	11.67

P L	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
108.00	14.20	22.10	39.00	13.40	13.15	20.46	36.11	12.41
96.00	13.00	20.00	37.00	12.80	13.54	20.83	38.54	13.33
94.40	12.80	20.00	36.00	12.50	13.56	21.19	38.14	13.24
108.60	14.00	23.00	39.30	14.20	12.89	21.18	36.19	13.08
94.80	12.80	20.00	36.00	12.80	13.50	21.10	37.97	13.50
98.50	14.00	23.00	39.30	14.10	14.21	23.35	39.90	14.31
99.00	13.60	20.00	38.60	13.00	13.74	20.20	38.99	13.13
99.20	11.70	20.00	39.00	12.80	11.79	20.16	39.31	12.90
101.50	14.00	21.20	39.00	13.00	13.79	20.89	38.42	12.81
86.00	10.70	17.50	33.00	10.50	12.44	20.35	38.37	12.21
87.50	12.50	19.00	35.00	11.60	14.29	21.71	40.00	13.26
85.00	10.50	17.40	33.00	10.40	12.35	20.47	38.82	12.24
87.00	12.50	19.00	35.00	11.60	14.37	21.84	40.23	13.33
84.00	10.40	17.50	32.80	10.30	12.38	20.83	39.05	12.26
84.50	10.50	17.50	32.80	10.30	12.43	20.71	38.82	12.19
97.50	11.50	19.60	38.90	10.70	11.79	20.10	39.90	10.97
86.60	10.80	17.50	33.00	10.60	12.47	20.21	38.11	12.24
95.00	11.90	18.50	36.00	12.50	12.53	19.47	37.89	13.16
90.50	12.80	18.10	35.00	12.50	14.14	20.00	38.67	13.81
83.50	10.70	17.00	33.00	10.00	12.81	20.36	39.52	11.98
84.00	10.70	17.00	33.00	10.00	12.74	20.24	39.29	11.90
84.20	10.60	17.10	33.10	10.00	12.59	20.31	39.31	11.88
92.20	13.00	18.50	32.20	11.50	14.10	20.07	34.92	12.47
148.00	15.50	26.00	47.00	18.50	10.47	17.57	31.76	12.50
117.00	13.60	21.00	38.50	13.00	11.62	17.95	32.91	11.11
98.00	12.00	19.40	36.00	12.00	12.24	19.80	36.73	12.24
105.00	14.00	22.00	38.40	13.10	13.33	20.95	36.57	12.48
99.00	12.70	18.00	38.00	12.40	12.83	18.18	38.38	12.53
95.00	12.00	18.50	37.50	12.00	12.63	19.47	39.47	12.63
98.00	12.00	19.60	37.00	12.20	12.24	20.00	37.76	12.45
101.00	13.00	22.00	38.50	14.00	12.87	21.78	38.12	13.86
98.00	11.80	19.00	39.00	10.00	12.04	19.39	39.80	10.20
94.50	11.90	19.00	36.80	11.80	12.59	20.11	38.94	12.49
94.00	11.90	18.80	36.50	11.50	12.66	20.00	38.83	12.23
74.00	10.00	13.80	29.00	9.30	13.51	18.65	39.19	12.57
59.00	8.00	11.50	25.00	7.00	13.56	19.49	42.37	11.86
130.00	16.50	24.90	50.00	17.60	12.69	19.15	38.46	13.54
110.00	13.00	22.50	40.00	15.70	11.82	20.45	36.36	14.27
151.00	18.00	28.00	53.20	20.00	11.92	18.54	35.23	13.25

P L	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
89.00	10.60	15.70	33.50	11.20	11.91	17.64	37.64	12.58
90.30	10.60	15.90	33.70	11.20	11.74	17.61	37.32	12.40
91.30	10.70	15.90	33.70	11.20	11.72	17.42	36.91	12.27
88.30	16.60	15.60	33.50	11.10	18.80	17.67	37.94	12.57
155.00	17.50	30.00	52.00	16.60	11.29	19.35	33.55	10.71
104.00	12.30	20.00	39.80	13.00	11.83	19.23	38.27	12.50
92.00	11.80	17.30	36.00	11.30	12.83	18.80	39.13	12.28
91.40	12.00	17.00	36.00	11.20	13.13	18.60	39.39	12.25
87.00	11.30	17.00	35.60	11.50	12.99	19.54	40.92	13.22
89.00	12.00	17.00	35.50	11.60	13.48	19.10	39.89	13.03
83.00	11.00	17.00	33.00	10.00	13.25	20.48	39.76	12.05
88.00	11.00	17.00	33.10	10.00	12.50	19.32	37.61	11.36
106.00	14.00	23.00	38.00	13.30	13.21	21.70	35.85	12.55
102.00	14.00	23.00	37.00	13.00	13.73	22.55	36.27	12.75
99.80	12.50	20.00	38.00	12.50	12.53	20.04	38.08	12.53
87.00	11.00	17.00	35.50	11.00	12.64	19.54	40.80	12.64
Average:								
98.26	12.59	19.65	36.76	12.48	12.86	20.02	37.61	12.70
Standard Deviation:								
13.90	1.64	2.76	3.90	1.95	0.96	1.16	1.94	0.84

Regression Output to Predict (PL):

Constant		-17.08		
Std Err of Y Est		3.91		
R Squared		0.92		
No. of Observations		94.00		
Degrees of Freedom		89.00		
X Coefficient(s)	1.14	1.13	1.76	1.15
Std Err of Coef.	0.47	0.37	0.24	0.50

Regression Output to Predict (D):

Constant	2.78

Std Err of Y Est	0.87
R Squared	0.72
No. of Observations	94.00
Degrees of Freedom	92.00
X Coefficient(s)	0.10
Std Err of Coef.	0.01

Regression Output to Predict (P):

Constant	1.86
Std Err of Y Est	1.15
R Squared	0.83
No. of Observations	94.00
Degrees of Freedom	92.00
X Coefficient(s)	0.18
Std Err of Coef.	0.01

Regression Output to Predict (T):

Constant	10.90
Std Err of Y Est	1.36
R Squared	0.88
No. of Observations	94.00
Degrees of Freedom	92.00
X Coefficient(s)	0.26
Std Err of Coef.	0.01

Regression Output to Predict (LL):

Constant	0.11
Std Err of Y Est	0.87
R Squared	0.80
No. of Observations	94.00
Degrees of Freedom	92.00
X Coefficient(s)	0.13
Std Err of Coef.	0.01

Appendix 12. Data collections at Muttrah Souq and regression outputs on the relationship between body size and fin sizes for the pigeye shark.

PL : Precaudal Length (cm)

D Fin : Dorsal Fin Length (cm)

P Fin : Pectoral Fin Length (cm)

L L : Lower Lobe of Tail (cm)

P L	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
145.50	25.50	42.40	59.00	21.00	17.53	29.14	40.55	14.43
152.20	27.00	40.50	61.00	26.00	17.74	26.61	40.08	17.08
148.00	25.00	43.00	60.00	22.00	16.89	29.05	40.54	14.86
142.00	24.00	39.00	58.00	21.50	16.90	27.46	40.85	15.14
154.00	25.50	43.00	59.80	22.00	16.56	27.92	38.83	14.29
160.00	26.50	43.50	62.00	24.00	16.56	27.19	38.75	15.00
135.00	25.00	39.00	59.00	24.00	18.52	28.89	43.70	17.78
138.00	23.60	38.00	59.00	22.40	17.10	27.54	42.75	16.23
145.00	29.00	46.00	58.00	22.00	20.00	31.72	40.00	15.17
177.00	29.00	46.50	62.00	27.00	16.38	26.27	35.03	15.25
149.00	29.50	45.00	60.00	23.00	19.80	30.20	40.27	15.44
150.00	26.00	43.00	61.00	23.00	17.33	28.67	40.67	15.33
143.00	24.00	39.00	57.00	21.00	16.78	27.27	39.86	14.69
150.00	28.00	43.00	63.00	23.00	18.67	28.67	42.00	15.33
141.00	24.00	38.00	57.00	21.00	17.02	26.95	40.43	14.89
144.00	24.00	39.00	57.00	21.00	16.67	27.08	39.58	14.58
158.00	27.00	42.00	61.00	23.00	17.09	26.58	38.61	14.56
151.00	26.00	40.00	60.00	23.00	17.22	26.49	39.74	15.23
140.00	24.00	39.00	57.00	22.00	17.14	27.86	40.71	15.71
170.50	27.00	43.40	64.00	26.00	15.84	25.45	37.54	15.25
150.00	27.50	42.00	59.00	23.30	18.33	28.00	39.33	15.53
134.00	23.50	37.50	60.00	23.00	17.54	27.99	44.78	17.16
145.00	24.30	38.50	57.50	23.50	16.76	26.55	39.66	16.21
167.50	27.00	41.00	64.00	25.00	16.12	24.48	38.21	14.93
151.00	25.50	39.50	58.00	23.00	16.89	26.16	38.41	15.23
140.00	26.00	45.00	56.00	22.00	18.57	32.14	40.00	15.71
149.00	25.00	39.00	57.00	24.00	16.78	26.17	38.26	16.11
147.00	27.00	43.00	57.00	23.50	18.37	29.25	38.78	15.99
152.50	25.50	39.00	59.50	25.50	16.72	25.57	39.02	16.72
160.00	26.00	40.00	60.00	25.70	16.25	25.00	37.50	16.06
157.00	25.70	39.00	59.00	25.00	16.37	24.84	37.58	15.92
150.00	25.20	39.00	59.00	25.00	16.80	26.00	39.33	16.67
144.00	27.00	45.60	57.00	22.50	18.75	31.67	39.58	15.63
145.00	28.00	46.00	58.00	22.00	19.31	31.72	40.00	15.17
142.00	28.50	46.00	58.00	23.00	20.07	32.39	40.85	16.20
145.00	29.00	46.00	58.00	23.00	20.00	31.72	40.00	15.86
170.00	29.00	44.00	64.00	27.50	17.06	25.88	37.65	16.18
162.00	26.80	44.50	66.00	24.00	16.54	27.47	40.74	14.81
166.50	33.50	45.70	69.40	27.30	20.12	27.45	41.68	16.40

P L	D FIN	P FIN	TAIL	L L	% D	% P	% T	% L L
166.00	29.20	46.00	65.00	24.00	17.59	27.71	39.16	14.46
151.00	29.50	43.00	59.00	23.80	19.54	28.48	39.07	15.76
175.00	26.70	42.00	65.00	25.00	15.26	24.00	37.14	14.29
178.70	28.30	48.00	66.00	28.00	15.84	26.86	36.93	15.67
Average:								
152.13	26.59	42.13	60.14	23.64	17.52	27.78	39.63	15.56
Standard Deviation:								
11.36	2.08	2.94	3.06	1.63	1.29	2.14	1.79	0.81

Regression Output to Predict (PL):

Constant		-40.98		
Std Err of Y Est		5.73		
R Squared		0.77		
No. of Observations		43.00		
Degrees of Freedom		38.00		
X Coefficient(s)	-1.35	1.22	1.75	3.06
Std Err of Coef.	0.82	0.52	0.42	0.70

Regression Output to Predict (D):

Constant		12.23
Std Err of Y Est		1.80
R Squared		0.27
No. of Observations		43.00
Degrees of Freedom		41.00
X Coefficient(s)	0.09	
Std Err of Coef.	0.02	

Regression Output to Predict (P):

Constant	24.91
Std Err of Y Est	2.68

R Squared	0.19
No. of Observations	43.00
Degrees of Freedom	41.00
X Coefficient(s)	0.11
Std Err of Coef.	0.04

Regression Output to Predict (T):

Constant	27.35
Std Err of Y Est	1.86
R Squared	0.64
No. of Observations	43.00
Degrees of Freedom	41.00
X Coefficient(s)	0.22
Std Err of Coef.	0.03

Regression Output to Predict (LL):

Constant	4.64
Std Err of Y Est	1.17
R Squared	0.60
No. of Observations	43.00
Degrees of Freedom	41.00
X Coefficient(s)	0.12
Std Err of Coef.	0.02

Literature Cited for Appindices:

Bear, R.S. 1952. The structure of collagen fibrils. In "Advances in Protein Chemistry" Eds. Anson, M.L., Bailey, K. and Edsall, J.T. pp. 69-154. Academic Press Inc., NY.

FAO/WHO 1987. First draft of codex world-wide standard for shark-fins. (Prepared by the Republic of Cuba). Codes Alimentarius Commission, Joint FAO/WHO Food Standards Program, Document CX/LA 87/9. Rome. 8 pages.

Gilbert, S.G. 1973. "Pictorial Anatomy of the Dogfish". University of Washington Press. Seattle.

Ka-keong, E.L. 1983. Shark-fins - Processing and marketing in Hong Kong. Infofish Marketing Digest no. 5/83: 35-39. Malaysia.

Subasinghe, S. 1992. "Shark-Fin, Sea Cucumber and Jellyfish - A processor's Guide" Technical Handbook Series/INFOFISH. Malaysia

BIBLIOGRAPHY

Alexander R.McN. 1965. The lift produced by the heterocercal tails of Selachii. Journal of Experimental Biology 43: 131-138.

Alexander R.McN. 1975. "The Chordates." Columbia University Press, London.

Ambe, K.S. and Sohonie, K. 1957. A comparative study of the proteins of shark and skate and casein. Indian Journal of Fisheries 4(1): 130-133.

Anderson, I. 1987. Fast food for the hot-bellied shark. New Scientist No.1559: 31.

AOAC 1980. Association of Official Analytical Chemists. In "Official Methods of Analysis of the Association of Official Analytical Chemists" Ed. Horwitz, W. Washington D.C.

AOAC 1990. Association of Official Analytical Chemists. In "Official Methods of Analysis of the Association of Official Analytical Chemists" Ed. Horwitz, W., Washington D.C.

AOAC 1993. Association of Official Analytical Chemists. In "Official Methods of Analysis of the Association of Official Analytical Chemists" Ed. Horwitz, W., Washington D.C.

Applegate, S.P. 1967. A survey of shark hard parts. In "Sharks, Skates, and Rays" Ed. Gilbert, P.W., Mathewson, R.F, Rall, D.P. pp. 37-68. The Johns Hopkins Press. Maryland.

Applegate, S.P., Soltelo-Macias, F., Espinosa-Arrubarrena, L., 1993. An overview of Mexican shark fisheries, with suggestions for shark conservation in Mexico. In "Conservation Biology of Elasmobranchs" Ed. Branstetter, S. pp. 31-37. NOAA Technical Report NMFS 115, USA.

Balian, G. and Bowes, J.H. 1977. The structure and properties of collagen. In "The Science and Technology of Gelatin" Eds. Ward, A.G. and Courts, A. pp. 1-27. Academic Press, London.

Bartley, W., Birt, L.M., and Banks, P. 1968. "The Biochemistry of the Tissues." John Wiley & Sons Ltd., London.

Bear, R.S. 1952. The structure of collagen fibrils. In "Advances in Protein Chemistry," Eds. Anson, M.L., Bailey, K. and Edsall, J.T. pp. 69-154. Academic Press Inc., NY.

Blumenfeld, O.O., Mercedes, A.P., Gallop, P.M., and Seifter, S. 1963. The nature, quantity, and mode of attachment of hexoses in Ichthyocol. Journal of Biological Chemistry 238(12): 3835-3839.

Bond, C.E. 1979. "Biology of Fishes." Saunders Collage Publishing., Philadelphia.

Bone, Q. and Marshall, N.B. 1982. "Biology of Fishes." Blackie, London.

Bone, Q. and Roberts, B.L. 1969. The density of elasmobranchs. Journal of Marine Biological Associations, United Kingdom. 49: 913-937.

Boylan, J.W. 1967. Gill permeability in Squalus acanthias. In "Sharks, skates, and Rays," Eds. Gilbert, P.W., Mathewson, R.F. and Rall, D.P. pp. 197-206. The Johns Hopkins Press. Maryland.

Breder, C.M. 1962. The locomotion of fishes. Zoologica 4: 159-297.

Budker, P. 1971. "The Life of Sharks." Columbia University Press, London.

Caplan, A.I. 1984. Cartilage. Scientific America 251(4): 84-94.

Carey, F.G. and Teal, J.M. 1969. Mako and probeagle: Warm-bodied sharks. Comparative Biochemistry and Physiology 28: 199-204.

Carey, F.G., Teal, J.M., and Kleijn, K. 1972. Body temperatures of black-tip sharks (Carcharhinus limbatus). Deep Sea Research, England. 19: 179-181.

Castro, J.I. 1983. "The sharks of North American Waters." Texas A&M University Press, Texas.

Clucas, I.J. 1982. "Fish Handling, Preservation and Processing in the Tropics: Part 2." Tropical Development and Research, London.

Compagno, L.J.V. 1990. Shark exploitation and conservation. In "Elasmobranchs as Living Resources: Advances in the Biology, Ecology, Systematics, and the Status of the Fisheries.," Eds. Pratt Jr., H.L., Gruber, S.H. and Taniuchi, T. pp. 157-415. NOAA Technical Report NMFS 90, USA.

Corner, E.D.S., Denton, E.J., Foster, F.R.S., and Foster, G.R. 1969. On the buoyancy of some deep-sea sharks. Proceeding Royal Society. 171B: 415-429.

Corner, E.D.S., Denton, E.J., Foster, F.R.S., and Foster, G.R. 1969. On the buoyancy of some deep-sea sharks. Proceeding Royal Society. 171B: 415-429.

Craik, J.C.A. 1978. The lipid of six species of shark. Journal of Marine biology Association. UK 58: 913-921.

Damodaran, M., Sivaraman, C., and Dhavalikar, S. 1956. Amino açid composition of elastoidin. The Biochemical Journal 62: 621-625.

Davenport, S. and Stevens, J.D. 1988. Age and growth of two commercially important sharks (Carcharhinus tilstoni and Carcharhinus sorrah) from Northern Australia. Australian Journal of Marine and Freshwater Research. 39: 417-433.

Dayton, L. 1991. Save the sharks. New Scientist 1773: 35-38.

Domantay, J.S. 1958. Aquatic products of Zamboanga, Basilan and Sulu Archipelago. Journal of Philippine Fisheries 6: 31-33.

FAO/WHO 1987. First draft of codex world-wide standard for shark-fins. (Prepared by the Republic of Cuba). Codex Alimentarius Commission, Joint FAO/WHO Food Standards Program, Document CX/LA 87/9. Rome. 8 pages.

Fischer, W. and Bianchi, G. 1984. "FAO Species Identification Sheets for Fisheries Purposes; volume 5; Western Indian Ocean; Fishing Area 51." FAO, Rome.

Franks, F. 1988. "Characterization of Protein." Humana Press, NJ.

Fussman, C. 1991. Jaws: The final battle for the shark. Khaleej Times, Sharjah. no.1638: 1 page.

Gilbert, S.G. 1973. "Pictorial Anatomy of the Dogfish." University of Washington Press, Seatle.

Goldstein, L. 1967. Urea biosynthesis in elasmobranchs. In "Sharks, Skates, and Rays," Eds. Gilbert, P.W., Mathewson, R.F. and Rall, D.P. The Johns Hopkins Press, Maryland.

Goldstein, L. and Funkhouser, D. 1972. Biosynthesis of trimethylamine oxide in the nurse shark (Ginglymostoma cirratum). Comparative Biochemistry and Physiology. England. 42A: 51-57.

Goodrich, E.S. 1930. "Studies on the Structure and Development of Vertebrates." Macmillan and Company, London.

Gottschalk, A. 1972. "Glycoprotein, their Composition, Structure and Function." Elsevier Publishing Co., Amesterdam.

Gross, J. and Dumsha, B. 1958. Elastoidin: A two-component member of the collagen class. Biochimica et Biophysica Acta 28: 268-270.

Gross, J., Dumsha, B., and Glazer, N. 1958. Comparative biochemistry of collagen, some amino acids and carbohydrates. Biochimica et Biophysica Acta 30: 293-297.

Gustavson, K.H. 1964. Review and history on the chemistry of collagen. Federation Proceedings 23: 613-617.

Hardingham, T.E. and Muir, H. 1973. Binding of oligosaccharides of hyaluronic acid to proteoglycans. The Biochemical Journal 135: 905-908.

Harper, H.A. 1969. "Review of Physiological Chemistry." Lange Medical Publication, California.

Harper, H.A., Rodwell, V.W., and Mayes, P.A. 1979. "Review of Physiological Chemistry" 17th edition. Lange Medical Publication, California.

Harris, J.E. 1937. The mechanical significance of the position and movement of the paired fins in the Teleostii. Carnegie Institute of Washington Publication 475: 171-189.

Hazin, F.H.V., Lessa, R., Ishino, M., Otsuka, K., Kihara, K. 1991. Morphometric description of the blue shark, Prionace glauca, from the Southwestern Equatorial Atlantic. Journal of the Tokyo University of Fisheries 78(2): 137-144.

Heinegard, D., Paulsson, M., Inerot, S., and Carlstrom, C. 1981. A novel low-molecular-weight chondroitin sulphate proteoglycan isolated from cartilage. The Biochemical Journal 197: 355-366.

Heller, J.H., Heller, M.S., Springer, S., and Clark, E. 1957. Squalene content of various shark livers. Nature. London 179: 919-920.

Hickman Jr., C.P. and Trump, B.F. 1969. The kidney. In "Fish Physiology; Volume 1; Excretion, Ionic Regulation, and Metabolism," Eds. Hoar, W.S. and Randall, D.J. pp. 91-227. Academic Press., New York.

Hoenig, J.M. and Gruber, S.H. 1990. Life-history patterns in the elasmobranchs: Implications for fisheries management. In "Elasmobranchs as Living Resources: Advances in the Biology, Ecology, Systematics, and the Status of the Fisheries.," Ed. Branstetter, S. NOAA Scientific and Technical Publication, Varginia.

Hoffman, P. and Meyer, K. 1962. Structural studies of mucopolysaccharides of connective tissues. Federation Proceedings 21(4): 1064-1069.

Horn, H. and deBoer, F. 1986. Versatile seafood from shark meat in the Caribbean. Infofish Marketing Digest. no.3/86: 43-45.

Howell, A.B. 1932. The architecture of the pectoral appendage of the dogfish. Journal of Morphology 54(2): 399-412.

INFOFISH Correspondance 1991.

INFOFISH International 1991. INFOFISH no. 2/91, Malaysia.

INFOFISH International 1994. INFOFISH no. 1/94, Malaysia.

INFOFISH Trade News 1983. INFOFISH no. 83/23, Malaysia.

INFOFISH Trade News 1983. INFOFISH no. 83/22, Malaysia.

INFOFISH Trade News 1987. INFOFISH no. 87/23, Malaysia.

INFOFISH Trade News 1990. INFOFISH no. 90/6, Malaysia.

INFOFISH Trade News 1990. INFOFISH no. 92/21, Malaysia.

INFOFISH Trade News 1990. INFOFISH no.90/19, Malaysia.

IS:5471 1969. "Indian Standard Specification for Dried Shark-Fins." Indian Standards Institution, New Delhi.

Jamieson, B.G.M. 1991. "Fish Evolution and Systematics: Evindence from Spermatozoa." Cambridge University Press, Cambridge.

Jayawardena, K.M. 1980. Improved chemical methods for extraction of fin rays from shark-fins. Bulletin of the Fisheries Research Station, Sri Lanka. 30: 41-51.

Jollie, M. 1962. "Chordate Morphology" Reinhold Publishing Corporation. NY.

Ka-keong, E.L. 1983. Sharkfins - processing and marketing in Hong Kong. Infofish Marketing Digest no. 5/83: 35-39.

Keeton, W.T. 1967. "Biological Science." W.W. Norton and Company Inc., NY.

Van Keulen, J. and Young, B. 1977. Evaluation of acid insoluble ash as a natural marker in ruminant digestibility studies. Journal of Animal Science 44: 282-287.

King, D., Leach, I., and Poulter, R.G. 1984. Utilization of sharks. Fisheries Newsletter. no.30: 21-28.

Kizevetter, I.V. 1973. "Chemistry and Technology of Pacific Fish." Israel Program for Scientific Translation, Jerusulam.

Kreuzer, R. and Ahmed, R. 1970. "Shark Utilization and Marketing" FAO/UNCTAD/GATT, Rome.

Leach, A.A. and Eastoe, J.E. 1977. The chemical examination of gelatins. In "The Science and Technology of Gelatin," Eds. Ward, A.G. and Courts, A. pp. 476-502. Academic Press, London.

Lehninger, L.A. 1970. "Biochemistry, Molecular Basis of Cell Structure and Function." Worth Publishers, Inc., NY.

Limpus, L.G. 1991. "Draft Code of Practice for the Full Utilization of Sharks." FAO Fish Circular no. 844. FAOUN, Rome.

LineaweaverIII, T.H. 1970. "The Natural History of Sharks." J.B. Lippincott Company, Philadelphia.

Lyle, J.M. 1984. Mercury concentrations in four Carcharhinid and three hammerhead sharks from coastal waters of the Northern territory. Australian Journal of Marine and Freshwater Research. 35: 441-451.

Madhavan, P. 1981. Production of shark-fin rays. In Proceeding Summer Institute on Non-Traditional Diversified Fish Products and By-Products. Central Institute of Fisheries Technology. India : 8 pages.

Maisy, J.G. 1987. Evolution of shark. In "Sharks," Ed. Stevens, J.D. pp. 14-16. Facts On File Publications, NY.

Marcovecchio, J.E., Moreno, V.J., and Perez, A. 1991. Metal accumulation in tissues of sharks from the Bahia Blanca estuary, Argentina. Marine Environement Research 31: 263-274.

Marshall, N.B. 1965. "The Life of Fishes." Weidenfeld and Nicolson, London.

Mathews, M.B. 1971. Comparative biochemistry of chondroitin sulphate-proteins of cartilage and notochord. The Biochemical Journal 125: 37-46.

McGilvery, R.W. 1979. "Biochemistry, A Functional Approach" 2nd edition. W. B. Saunders Co., Philadelphia.

Michelacci, Y.M. and Horton, D.S.P.Q. 1989. Proteoglycans from the cartilage of young hammerhead shark, Sphyrna lewini. Comparative Biochemistry and Physiology 92B(4): 651-658.

Morris, R.F. and Stouffer, J.R. 1975. New food products from sharks. New York Food and Life Science Quarterly. 8(2): 3-7.

Moyle, P.B. and Cech Jr., D. 1988. "Fishes; An Introduction to Ichthyology" 2nd edition. Prentice-Hall Inc., New Jeresy.

MPEDA and CIFT 1989. "Processing of Fish Maws, Shark-Fins, Fin Rays for Export." The Marine Products Export Development Authority & Central Institute of Fisheries Technology, India.

Murray, R.K., Granner, D.K., Mayes, P.A., and Rodwell, V. W. 1990. "Harper's Biochemistry" 22nd edition. A Lange Medical Book, California.

Nair, K.G.R. and Madhavan, P. 1974. Shark-fin rays technology of extraction. Fishery Technology XI(1): 60-63.

Neuman, R.E. 1949. The amino acid composition of gelatins, collagens and elastins from different sources. Archives Biochemistry 23: 289-298.

Norman, J.R. 1936. "The History of Fishes" Ernest Benn Limited. london

Oguri, M. 1990. A review of selected physiological characteristics unique to elasmobranchs. In "Elasmobranchs as Living Resources: Advances in the Biology, Ecology, Systematics, and the Status of the Fisheries," Eds. Pratt Jr., H.L., Gruber, S.H. and Taniuchi, T. pp. 49-54. NOAA Scientific and Technical Publication, Varginia.

Olsen, A.M. 1987. Using sharks. In "Sharks," Ed. Stevens, J.D. Facts On File Publications., New York.

OS - Omanian Standard 1986. Methods of test for animal feeds; part 1: Determination of essential composition. Ministry of Commerce and Industry, Directorate General for Specifications and Measurements. Oman.

Paulsson, M. and Heinegard, D. 1981. Purification and structural characterization of a cartilage matrix protein. The Biochemical Journal 197: 367-375.

Perlman, D.F. and Goldstein, L. 1988. Nitrogen metabolism. In "Physiology of Elasmobranch Fishes," Ed. Shuttleworth, T.J. Springer-Verlag Berlin Heidelberg. New York.

Piez, K.A. and Gross, J. 1960. The amino acid composition of some fish collagens: The relation between composition and structure. The Journal of biological Chemistry 235(4): 995-998.

Ramachandran, A. and Sankar, T.V. 1989. Fins and fin rays from whale shark (Rhiniodon typus smith). Research Centre of Central Institute of Fisheries Technology. India : 7 pages.

Ramachandran, L.K. 1962. Elastoidin - A mixture of three proteins. Biochemical and Biophysical Research Communications 6(6): 443-448.

Romer, A.S. 1970. "The Vertebrate Body" 4th edition. W. B. Saunders Company. Philadelphia.

Ronsivalli, L.J. 1978. Sharks and their utilization. Marine Fishery Review 40(2): 1-13.

Sastry, V.S. and Ramachandran, L.K. 1965. The protein components of elastoidin. Biochemica et Biophysica Acta. 97: 281-287.

Seymour, H.H. and Danberg, K.S. 1980. Shark. University of Delaware Sea Grant Collage Porgram. A Delaware Marine Advisory services Publication. 6 pages.

Sinclair, K. 1987. Shark as food: A traditional delicacy. In "Sharks" Ed. Stevens, J.D. Facts On File Publications, NY.

Spiro, R.G. 1972. Basement membranes and collagens. In "Glucoproteins, their Composition, Structure and Function," Ed. Gottschalk, A. Elsevier Publishing Co., Amsterdam.

Stevens, J.D. 1987. Shark biology. In "Sharks," Ed. Stevens, J.D. Facts On File Publications, New York.

Stryer, L. 1988. "Biochemistry" 3rd edition. W.H. Freeman and Company., New York.

Subasinghe, S. 1992. "Shark Fin, Sea Cucumber and Jellyfish - A Processor's Guide." Technical Handbook Series/INFOFISH, Malaysia.

Summers, G. and Wong, R. 1992. Cosmetic products from semi-refined shark liver oil. Infofish International no.2/92: 55-58.

Suzuki, S. 1960. Isolation of novel disaccharides from chondroitin sulfates. The Journal of Biological Chemistry 235(12): 3580-3588.

Thomson, K.S. and Simanek, D.E. 1977. Body form and locomotion in sharks. American Zoology 17: 343-354.

Trachet, N., Pelasio, M., and Gillett, R. 1990. "So You Want to Sell Some Shark-Fin? A Manual for Rural Fishermen." FAO/UNDP Regional Fishery Support, Fiji.

Tressler, D.K. and McwLemon, J. 1951. "Marine Products of Commerce" 2nd edition. Reinhold Publications Corporation, NY.

Vynios, D.H., Aletras, A., Tsiganos, C.P., Tsegenidis, C. A., Hjerpe, A., and Engfeldt, B. 1985. Proteogllycans from squid cranial cartilage: extraction and characterization. Comparative Biochemistry and Physiology 80B(4): 761-766.

Walford, L.A. 1931. California sharks and rays. California Department of Fish and Game. Fisheries Bulletin 45: 5-7.

Wetherbee, B.M., Gruber, S.H., and Cortes, E. 1990. Diet, feeding habits, digestion, and consumption in sharks, with special reference to the lemon shark, Negaprion brevirostris. In "Elasmobranchs as Living Resources: Advances in the Biology, Ecology, Systematics, and the Status of the Fisheries.," Ed. Branstetter, S. pp. 1-15. NOAA Scientific and Technical Publication, Varginia.

White, A., Handler, P., and Smith, E.L. 1973. "Principle of Biochemistry" 5th edition. A Blackiston Publication, NY.

White, A., Handler, P., Smith, E.L., and Stetten Jr., D. 1959. "Principle of Biochemistry" 2nd edition. A Blackiston Publication, NY.

Wood, C.C., Ketchen, K.S., and Beamish, R.J. 1979. Population dynamics of spiny dogfish (Squalus acanthias) in British Columbia waters. Journal of the Fisheries Research Board of Canada. 36(1): 647-656.

Yancey, P.H. and Somero, G.N. 1979. Counteraction of urea destabilization of protein structure by methylamine osmoregulatory compounds of elasmobranchs fishes. The Biochemical Journal. England. 183: 317-323.