CHAPTER 14. SHARK UTILIZATION

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14.1 INTRODUCTION

Sharks and their relatives may provide a multitude of usable products including but not restricted to: meat, fins, liver, skin, cartilage, and jaws and teeth. Unfortunately, tens of millions of sharks taken in fisheries each year have their fins removed and their carcasses discarded overboard (Fowler and Musick, 2002). This practice, called finning, represents a considerable waste as the fins on average make up only about 5% of the total weight of a shark (Vannuccini, 1999). Such waste is contrary to the United Nations Food and Agricultural Organization (FAO) Code of Conduct for Responsible Fisheries (Article 7.2.2 (g)) which stresses the importance of avoiding waste and discards in fisheries. In addition, the FAO International Plan of Action for the Conservation and Management of Sharks (IPOA- Sharks) encourages full use of dead sharks and retention of sharks from which fins have been removed (paragraph 22). Therefore, this chapter will briefly review the wide spectrum of uses that may be afforded by elasmobranchs in order to encourage their more complete and effective use. For a more comprehensive review see Vannuccini (1999) wherein an entire volume (470 pages) is devoted to the subject. A strong word of caution is necessary here: full utilization of shark carcasses should not be used as a pretext to fish unsustainably (Camhi, 2002). The goal of this manual is to provide information necessary to lead to sustainable elasmobranch fisheries.

14.2 CONSUMPTIVE UTILIZATION OF ELASMOBRANCHS

14.2.1 Meat

Shark meat has been used as food in coastal regions for over 5,000 years (Vannuccini, 1999). Most historical use of shark meat was local because the meat does not travel well without refrigeration. Sharks retain urea in their blood and tissues as part of their osmoregulatory physiology (Musick and McMillan, 2002). After a shark dies the urea breaks down into ammonia which imparts a strong smell and odor to the meat and which may be toxic in high concentrations. This problem may be avoided easily by rapid bleeding of the freshly caught animal, and thorough washing of the carcass with seawater. Usually the head, fins, gills and viscera are removed from larger sharks at sea, or in some artisanal fisheries immediately upon landing. Subsequent soaking of the meat in a weak acid solution (citrus juice or vinegar) may remove up to 90% of the urea (Gordievskaya, 1973). Various species have different concentrations of urea, spiny dogfish (*Squalus acanthias*) having the lowest and hammerheads (Sphyrnidae) having the highest concentrations of several species measured (Gordievskaya, 1973). In addition, elasmobranchs captured in brackish estuaries should have lower urea concentrations than those taken in full seawater (Evans et al., 2004).

After bleeding and soaking, carcasses should be iced or frozen to prevent enzymatic and bacterial breakdown. Small species with naturally low urea content like spiny dogfish (which also occurs in cold water (<12°C)) may be landed whole to be processed onshore (Kreuzer and Ahmed, 1978). Small sharks are preferred for meat in many markets because they usually have lower concentrations of urea and mercury, which is naturally absorbed from sea water and through dietary uptake may reach high concentrations in larger, older sharks (Forrester et al., 1972, Walker, 1980). However, in some markets such as Hong Kong larger sharks are preferred (Parry-Jones, 1996).

Shark fillets also may be salted and diced or smoked. In Germany, the belly flaps of spiny dogfish are smoked as *Schillerlocken*, an expensive gourmet item. Meat from blue sharks (*Prionace glauca)* which is not used directly for food in most places may be processed into *surimi* and subsequently used in a variety of seafood recipes (Nakano, 1999), shark paste or *happen,* (Kiyono, 1996).

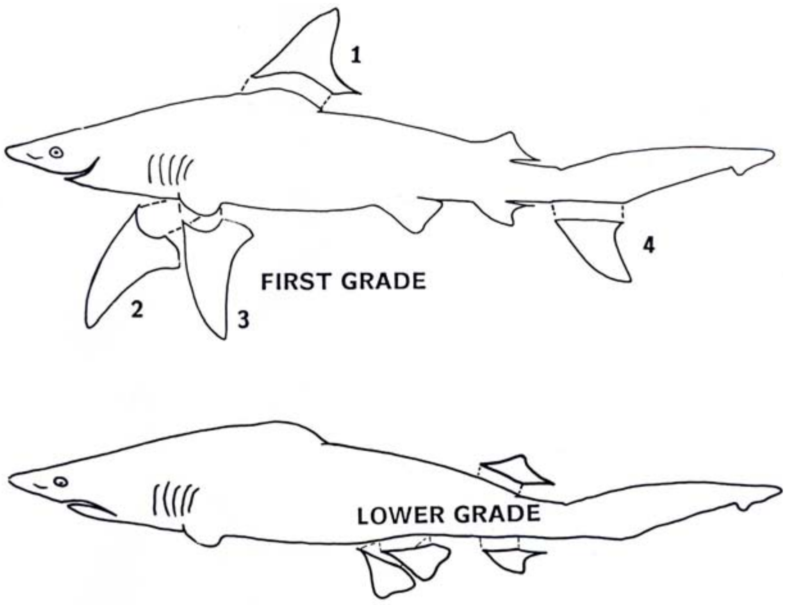
Batoid meat is also used widely throughout the world. In many areas batoid landings may approach those of sharks (Shotton, 1999) and in some places there are directed batoid fisheries (Agnew et al., 1999; Kulka and Mowbray, 1999; Pawson and Vince, 1999).

Some batoids such as the guitarfishes (Rhinobatidae) and sawfishes (Pristidae) are very shark-like in their morphology and their meat is processed similarly to that of sharks. However, in more typical batoids such as the skates (Rajidae), stingrays (Dasyatidae) and eagle rays (Myliobatidae) the body is dominated by the wing-like pectoral fins which, unlike those of sharks, are thick and muscular. These "wings" are cut from the body, then the dorsal and ventral meat is filleted away from the cartilage framework and usually skinned. Depending on the taxonomic group, the meat may vary from very delicate and white (Rajidae) to thick and dark (Myliobatidae). Batoids should be bled upon capture and the meat soaked as in sharks. Batoid wings do not contain the "needles" so valuable in shark fins (see below), but sawfish, guitarfish, and wedgefish dorsal fins contain needles and are some of the preferred fins in the market.

14.2.2 Fins

Shark fins are used to make a traditional shark fin soup in the Chinese culture, and are among the most valuable fish products in the world (Camhi et al., 1998). Only the fine collagenous fibers called "needles" which support the fin margin are used in the soup. In most sharks the first dorsal, pectorals and lower lobe of the caudal fin are the most valuable and these are usually sold as a set from each shark. The lower lobe of the caudal is used because it contains the collagenous needles whereas the upper lobe is supported by the vertebral column and has no needles. The smaller second dorsal and pelvic fins ("chips"), also are taken but are of much lower value and lots are mixed from several sharks. Because the base of the fin contains large cartilaginous supporting elements called radials and muscle not used in soup, the fin is removed with a semi-circular cut (Fig 14.1) to eliminate some of these materials at the base of the fin (Trachet et al., 1990). Any meat left adhering to the base of the fin will spoil during drying thus lowering the quality or even destroying the value of the fin. The greater care taken in removing fins the greater their value (Vannuccini, 1999).

Figure 14.1 Method for cutting shark fins (after Trachet et al., 1990).



Fins are traded virtually during all stages of processing. These include:

1) Wet fins; fresh, iced or frozen

2) Dried "raw" fins; with skin (including denticles) and some radial elements intact. Fins salted before drying are usually of lower value because they retain more moisture. Fins are sun-dried, and turned frequently to facilitate drying to prevent curling. Fins should be kept out of the rain and dew and away from insects. Drying may take 7-14 days to produce an acceptable product (18% moisture content (Vannucinni, 1999)). Dried fin sets are usually packed in 25 kg sacks and dried "chips" in 50 kg sacks.

3) Semi-processed or "cooked" fins; with the denticles and radials removed, but needle fan intact. In this presentation fins are soaked in water for 8-10 hours (wet fins) or 16-24 hours (dry fins), then further soaked in water pre-heated to 80-90°C until the scales and skin be come loose. Then softened fins are placed into chilled water and scales and skin removed with a wire brush. After washing again, any remaining meat and the cartilaginous radials are removed. The pre-processed fins are then dried on bamboo mats for 4-6 days.

4) Fully processed; with the needle fans separated into individual strands. Semi-processed fins may be further processed to separate the needle bundles by soaking in water for up to 12 hours then boiling for 5-10 minutes. The needles may then be easily separated from the surrounding membrane in cold water. Fin needles may be traded as wet fin needles or pro cessed into fin nets.

5) Fin nets; usually from smaller fins, the fin needles have been boiled, separated, re-dried and packaged in loose clumps.

6) Ready to eat products; canned or instant shark fin soup.

Most fins are traded as dried fins and imported for further processing in Hong Kong, Singapore or Taiwan for domestic use or subsequent re-export.

14.2.3 Skin

14.2.3.1 Skin as Food

Shark skin may be consumed as food in several countries including the Maldives, Japan, Taiwan, and the Solomon Islands (Vannuccini, 1999). Preparation involves drying, removing the denticles, bleaching, then drying again (Chen et al., 1996). Skin from dusky, thresher and whale sharks as well as skin from the giant guitarfish (*Rhynchobatus djiddensis*) is eaten in Taiwan. Shark skin is processed into the gelatinous food *nikigori* in Japan (Kiyono, 1996). In Singapore and Malaysia, after processing, cooked shark skin is marketed as "shark lips" or "fish lips." In the Solomon Islands shark skin is salted and then sun dried or smoked after which it is boiled and the denticles are removed. The resulting product is then made into soup with coconut milk (Matthew, 1996).

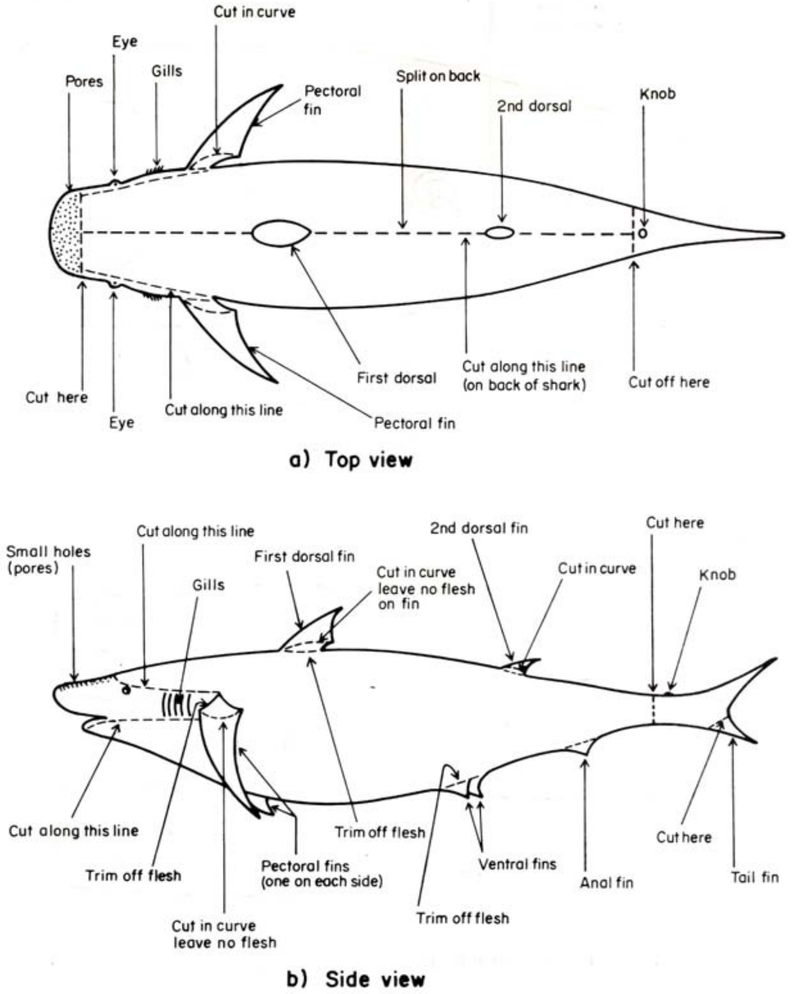
14.2.3.2 Shark skin leather

Untanned shark skin, with the rough denticles attached is called shagreen and has been used as sandpaper in woodworking and other industries for centuries. It has also been used to cover sword hilts (providing a slip-free grip) and as a striking surface for matches (Kuang, 1999). The greatest use for shark skin has been for leather. Shark skin is tanned much in the same way as are the skins of other animals (Tanikawa, 1985). Shark leather may be used to make a variety of products including furniture, bookbinding, shoes and handbags. Historically, the major markets for shark leather products have been in the USA, Germany, France and Japan with tanneries located in several countries. Today, because of environmental restrictions on the tanning industry and problems with a steady supply of raw skin, most tanned leather is produced in Mexico (Kuang, 1999). Top quality skins usually come from larger sharks which must be carefully skinned soon after capture. Skin from shark carcasses used for meat and frozen or stored on ice are usually damaged to the point that they are useless for making leather.

Most shark leather products have had the denticles removed. However, some products such as the expensive Boroso leather made from small Moroccan shark hides retain their denticles which are polished to a high gloss (Kuang, 1999). Recently stingray skin has been used in luxury leather products in the USA (Boncompagni, 2003).

Shark skin is thick and tough and may be difficult for a novice to remove properly. However, with practice, experienced shark skinners can efficiently remove a shark's hide in a matter of minutes. A diagram of the skinning process is provided in Fig. 14.2 (after Kreuzer and Ahmed, 1978).

Figure 14.2 Method for skinning sharks for leather (after Kreuzer and Ahmed, 1978).



14.2.4 Cartilage

14.2.4.1 Shark cartilage as food

Shark cartilage is used as food in China and Japan where it is boiled, cleaned of meat, and sun dried for later cooking. Cartilage utilized includes fin radials (left over from fin processing), pieces of jaw and chondrocranium, and most importantly the vertebral column. The latter is usually marketed dry as a cyclindrical rod about one meter long with the vertebral processes removed (Vannuccini, 1999).

14.2.4.2 Dried cartilage pills

Shark cartilage has been dried and pulverized into a powder that can be delivered in pills or capsules. The market for shark cartilage pills expanded dramatically after the publication of a book (Lane and Comac, 1992) that purported to show that sharks do not get cancer (an assertion shown to be incorrect, Musick and McMillan, 2002), and that claimed that shark cartilage pills could cure human cancers. The use of shark cartilage pills ingested orally subsequently has been found to be worthless in the treatment of cancer in humans (Horsman et al., 1998; Leitner et al., 1998; Miller et al., 1998). These results were not surprising as the digestive system would breakdown any biologically active proteins in cartilage into constituent amino acids before absorption through the gut lining (Kava, 1995). However, cartilage in general is a good source of chonrdroitin and glucosomine sulfate, and shark cartilage is no exception. These compounds have been found to be useful in treating various forms of arthritis, and to that end, shark cartilage capsules are marketed today.

14.2.4.3 Shark cartilage extracts

It has been known for many years that tumors require the development of blood vessels (angiogenesis) in order to grow, and that some substances in cartilage could inhibit angiogenesis and retard tumor growth. Recently, Aeterna Laboratories, a pharmaceutical company based in Toronto, Canada, http://www.aeterna.com/, has developed a unique proprietary process to extract biologically active molecules contained in cartilage. Aeterna uses shark cartilage as raw material because cartilage makes up to 6% of a shark's body weight and shark cartilage has been a readily available by-product of shark fisheries for which fins and/or meat are the principal targets. The resulting product from Aeterna's process, called Neovastat, has been shown to have multiple mechanisms of antiangiogenesis action, and to be effective in treating cancers of many types as well as other diseases where angiogenesis is a mitigating factor. Neovastat is in the final stages of clinical trials at this writing, but should be available for use shortly.

14.2.5 Liver

14.2.5.1 Liver as food

Shark liver has been eaten as food in China and the Solomon Islands and elsewhere (Vannuccinni, 1999). The liver may be cooked fresh or salted for later preparation.

14.2.5.2 Liver extracts

Shark liver is rich in various hydrocarbons, and oils extracted from livers have been used in the farming and textile industries, as lubricants, in cosmetics, as lamp fuel, as a wood preservative on boat hulls, and in the pharmaceutical industry (Kuang, 1999). The pharmaceutical use of shark oil products holds most present interest and future promise.

14.2.5.2.1 Vitamin A

Shark liver is high in vitamin A and target fisheries for shark livers developed in the 1940s. These fisheries were short-lived because of the development of synthetic vitamin A (Kreuzer and Ahmed, 1978). Even so, the short but intense fishery for the soupfin shark (*Galeorhinus galeus*) off the west coast of the United States led to rapid stock collapse (Ripley, 1946) that has lasted for several decades (Camhi et al., 1998).

14.2.5.2.2 Squalene

Squalene is a highly unsaturated aliphatic hydrocarbon found primarily in the livers of deep-sea dogfishes (Squaliformes). This low density (0.86 s.d.) compound provides buoyancy to the sharks (Thorson, 1990). Squalene has been used as a fine lubricant because it is stable over a wide temperature range (-75ºC to 330ºC) (Kuang, 1999). Its most widespread use appears to be in skin creams to soften skin, and as a moisturizer, to speed up wound healing, and as a bactericide. It is often hydrogenated to the more stable form Squalane before use (Anonymous, 1996; Kuang, 1999). The problem in developing further markets for squalene is that the squaloid sharks from which it comes are among the slowest growing, latest maturing sharks known. Thus, these species may be very quickly overfished if harvesting is not controlled at some low level (Musick et al., 2000).

14.2.5.2.3 Squalamine

Squalamine is one of several aminosterols (steroids) found in shark liver (oore et al., 1993; Rao et al., 2000). This steroid has been found to be a broad spectrum antibiotic which exhibits potent bactericidal activity against both gram-negative and gram-positive bacteria. Also, squalamine induces osmotic lysis of protozoa and is fungicidal (Moore et al., 1993). In addition, squalamine has recently been shown to be an effective inhibitor of angiogenesis and directly blocks blood vessel cell activation, migration and proliferation by many growth factors (Sills et al., 1998). Genaera corporation (http://www.genaera.com/antiangiogenesis.htm) has recently synthesized squalamine and although its pharmaceutical potential is vast, the future demand for the compound directly from shark livers is probably minimal at best (as with vitamin A).

14.2.5.2.4 Other liver extracts

Shark liver contains many biologically active compounds some of which may remain to be discovered. Among known compounds alkoglycerols have been shown to have some benefit in the regression of tumor growth (Hallgren and Larsson, 1962; Brohult et al., 1986).

14.2.6 Miscellaneous Products

Rose (1996) has reviewed the use of peripheral shark products from various regions around the world. These include

1) Jaws and teeth as curios
2) Sawfish rostra as curios
3) Whole preserved small sharks as curios
4) Bait in pot or long-line fisheries
5) Fishmeal and fertilizer
6) Dogfish as dissection specimens in schools
7) Exhibition in public aquaria
8) Small specimens in private aquaria

14.3 NON-CONSUMPTIVE UTILIZATION OF ELASMOBRANCHS

14.3.1 Recreational diving

Recreational diving has been one of the fastest growing recreational activities worldwide for several years (Anderson, 2002). Estimates of the number of active recreational divers run to several million. Sharks and rays are always the major diving attraction wherever they occur (Anderson, 1999). Diving magazines regularly carry articles and advertisements concerning dive destinations where "shark watching" is offered (Murphy, 1993; Saunders, 1995). Shark diving destinations are widespread throughout the developing and developed world and include (among others) South Africa, Egypt and Sudan, the Maldives, Myanmar, throughout Southeast Asia, Australia, Palau, French Polynesia, California, and the Bahamas (Anderson, 2002). The shark diving industry generates hundreds of millions of dollars for local economies worldwide. Divers may pay from $75 to $200 for a single dive with sharks and rays, and recreational diving expeditions to cage dive with sharks may cost several thousand dollars (Anderson, 2002). Because many species of sharks may be residential at particular dive sites, and because individual sharks may live for at least a decade, an individual shark may be observed by a multitude of divers over time. Therefore, considering the cumulative input to the economy by shark divers, Anderson and Ahmed (1993) estimated that in 1992 a single gray reef shark (*Carcharhinus amblyrhynchus*) was worth US $33,500 per year at the most popular shark watching site in the Maldives. In contrast, a dead gray reef shark was calculated to have a one time value of US $32 to local fishermen (Anderson and Ahmed, 1993). Likewise, in the Bahamas where shark watching contributed about six million dollars a year in the early 1990s (Hall, 1994), a single Caribbean reef shark (*Carcharhinus perezi)* was calculated to be worth between $13,300-$40,000 annually (Amsler, 1997; Anderson, 2002), yet a dead Caribbean reef shark was estimated to have a one time value of US $50-60. Therefore in those areas where recreational diving may be a viable industry non-consumptive use of sharks may contribute several orders of magnitude more to the local economy than consumptive uses.

14.3.2 Recreational catch and release fishing

Recreational shark fishing has been popular in many areas at least since the mid-1970s when the motion picture film "Jaws" was released (King and Cailliet, 1992; Pepperell, 1992). In recent years an increasing number of recreational shark fishers have been choosing to release their catches often after tagging (Casey and Kohler, 1992; Hueter, 1996). The value of recreational fishing to local communities may be huge considering the costs to fishers of food, accommodation, bait, tackle, boat charter, etc.

Therefore, the value of an individual shark in a recreational fishery even where harvest is practiced is several fold greater than its value in a commercial fishery. Catch and release provides even greater value because individuals may be caught multiple times by several anglers, and even with some post-release mortality (Heuter, 1996; Skomal and Chase, 1996) catch and release fishing clearly contributes to the sustainability of the shark stocks. Post-release survivorship may be increased through the use of circle hooks, and care in handling the animals when landing and releasing.

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