

The Developing Alaska Salmon Shark Fishery

Brian C. Paust,
Extension Agent
Alaska Marine Advisory Program
P.O. Box 1329
Petersburg, Alaska 99833

Abstract: The salmon shark (Lamna ditropis) is a large, highly mobile predator associated with the inshore and oceanic waters of the temperate North Pacific Ocean. The species is an apex predator known to feed on a variety of marine species, the most notable being Pacific salmon.

Salmon shark, as well as other lamnid sharks, are of biological interest due to their ability to thermo-compensate. The Salmon Shark may gain considerable predatory advantage over various prey species due to this thermo-compensatory ability.

The salmon shark is of economic importance due to the comparatively high value of its flesh in developing domestic markets and for the value of its fins in Asian markets. Other byproducts from this shark may prove to be of significant economic value as well.

This paper reviews the basic natural history of the salmon shark and provides a prospectus of its potential economic importance as a developing commercial fishery in Alaska. Also reviewed is the reference volume titled **The Development of a Commercial Shark Fishery: The Salmon Shark (Lamna ditropis) of the North Pacific Ocean.**

Introduction

The salmon shark (Lamna ditropis) is a large, free-ranging, epipelagic shark occupying vast expanses of the North Pacific Ocean. It is a member of the lamnid family of sharks and is related to a number of other well-known predatory species including the white shark (Carcharodon carcharias) and shortfin mako shark (Isurus oxyrinchus). The distribution of the salmon shark lies in the range of 40-60° north latitude, with both north and south coastal extensions far beyond this range. On the Pacific Coast of the U.S., the salmon shark is distributed to at least the latitude of San Diego, California, in the south and unofficially to the latitude of St. Lawrence Island in the north. The species occupies the entire breadth of the North Pacific and is considered to be one of the most numerous species within the epipelagic community residing within these cold northern waters.

Biology and Behavior

The biology and natural history of salmon shark populations occupying the eastern portion of the species' range are poorly known. Practical aspects of the natural history of this large oceanic predator are best known among the fleets of U.S. and Canadian fishermen targeting on various Pacific salmon species (genus Oncorhynchus). The ranges of this shark and Pacific salmon broadly overlap, as do those of other shark species, including the blue (Prionace glauca) and white sharks. The salmon shark undergoes marked seasonal migrations that closely parallel that of certain prey species, one of the most notable being sockeye salmon (O. nerka).

The salmon shark is known to attain lengths of at least 3.1 m (10 feet) with corresponding weight of 363 Kg (800 pounds). Unofficial reports suggest that salmon shark may reach lengths in excess of 3.7 m (12 feet) and weights of 454 Kg (1000 pounds) or more. In terms of general anatomy, this species is similar to most aspects of the general shark body plan. One important exception is that the salmon shark, along with other lamnid sharks, has become partially warm-blooded. The salmon shark and its allies have counter-current heat exchangers that permit the effective conservation of metabolic heat. This adaptation is reflected in various aspects of the behavior and physiology of this species. It also allows the movements of salmon shark to be relatively independent of water temperature and incurs a significant predatory advantage. The presence of warm body temperatures, however, presents the prospective shark fisherman with an important quality control problem. This shark must be rapidly cooled in order to retain meat quality.

The salmon shark is a euryphagous feeder, not specializing on any one prey species or species group. However, this species is best known as a predator of fish and squid. It is a major predator of sockeye, pink (O. gorbuscha), chum salmon (O. keta). As mentioned, the migratory patterns of this shark seasonally paralleled those of sockeye salmon over major portions of its range. Although the distribution of this shark is directly related to the distribution of its major prey species, water temperature may exert indirect effects. This effect may be limited to the influence of water temperature on the distribution of prey species. The salmon shark is known to occur within a temperature range of 2-3° C (36-74° F). Surface aggregations of salmon shark in coastal waters begin to appear when sea surface temperatures increase to 10-11° C (50-52° F). It is interesting to note that silver salmon (O. kisutch), an important prey species, begin to appear in coastal waters at approximately this same surface temperature.

Several questions persist concerning the reproductive biology of this species. Most lamnid sharks exhibit the ovoviviparous mode of reproduction. These sharks employ internal fertilization, retention of energy-rich eggs without the development of placental structures, and live-bearing. Some researchers have suggested that the salmon shark may be viviparous. Viviparity is marked by the formation of a placental or pseudo-placental link between the embryo and the maternal body. The maximum fecundity of the salmon

shark is four pups over a reproductive cycle of 12 months. Some evidence suggests an even more extended reproductive cycle. This limited reproductive capacity suggests that this species may be easily affected by fishing mortality. Additional research is necessary, with particular attention directed at the reproductive capacity of discrete salmon shark populations.

Within the Gulf of Alaska, the identity of the salmon shark has frequently been confused with that of a related Atlantic species, the porbeagle shark (*Lamna nasus*). In fact, many veteran Pacific Coast salmon fishermen persist in calling this shark the "porbeagle shark." Some confusion has also occurred in differentiating between the salmon shark and white shark. The distribution of these two sharks overlap over significant portions of their ranges in northern regions. If the salmon shark is to become an important commercial species, it is important that the species gain its own identity. Also, the salmon shark, unlike related lamnid sharks, is not believed to be dangerous to humans. No attacks have been officially documented, although unofficial reports indicate close, non-lethal encounters of various types.

Salmon sharks are traditionally known to form seasonal aggregations at certain points along the Alaskan coastline. These areas include Aleutian Island passes, Kodiak Island bays, Valdez Narrows, the Copper River Delta, and many locations in Southeast Alaska. Surface occurrence tends to coincide with the 10-11° C (50-52° F) isotherm in the Gulf of Alaska. In the surface waters of Southeast Alaska the salmon shark is known to occur from May to November. The species is most common during the period June to September in this region. In these same waters, surface temperatures in excess of 11° C (52° F) increase the probability of the simultaneous occurrence of the blue shark with salmon shark.

In the western Pacific, salmon shark concentrations are often associated with oceanic frontal structures. The Oyashio Front in the northwestern Pacific is most notable in this regard. The eastern Pacific lacks similar major oceanic structures found to the west. Smaller, less conspicuous oceanographic structures will need to be used to indicate shark concentrations in Alaskan waters.

The migratory behavior of the salmon shark in the northeastern Pacific is poorly known. Much additional research is needed to understand the population structure of salmon shark in this broad region. It is believed that this species is distributed in an array of principal and accessory populations in a manner similar to that of other sharks. The proper management of this species will require precise knowledge of migratory behavior and population structure. The possibility exists that coastal salmon shark populations are not highly migratory, but may use deep thermal refuge areas in close proximity to the summer range. A major concern is that commercial fisheries targeting on salmon shark may drive small local populations to the point of extinction. The rapid demise of regional shark fisheries has been a chronic problem in many parts of the world.

The Emerging Fishery

Most people are not aware that the cold waters of the North Pacific harbor relatively large populations of epipelagic sharks. Salmon shark have become known primarily via their incidental capture in various salmon fisheries and observation of their predation on Pacific salmon. In this regard, salmon shark and similar predators, primarily blue shark, have been considered as major nuisances by commercial fishermen. The salmon shark has been implicated in the loss of trolling gear, severe damage to seines and gillnets, and the loss of hooked or netted salmon. For the most part incidentally captured shark have been discarded at sea. Prior to 1983 most fishermen and processors in Alaska were not aware of the commercial value of shark meat and byproducts. Even the valuable fins were not retained from incidentally captured salmon shark. The rate of incidental capture has been very high in certain offshore fisheries. The Japanese high seas salmon gillnet fishery in the general areas of the central Aleutian Islands incidentally harvests 25,000 salmon shark per year. The incidental capture of salmon shark in Alaskan coastal salmon fisheries is much lower, perhaps through mutual avoidance.

Prior to 1983 directed salmon shark fisheries have only existed in Japan. This fishery takes place in the vicinity of the Oyashio Front off the northeastern coast of Japan. However since 1983, a number of Alaskan fishermen and processors (Kodiak, Seward, Yakutat, Petersburg, and Sitka) have engaged in experimental shark fisheries. For the most part, these efforts have been successful in both harvesting and marketing salmon shark meat and selected byproducts (primarily fins). It is anticipated that a mature shark fishery will eventually develop from these pioneering efforts. Jim Parker, formerly an Alaska Department of Fish and Game biologist stationed at Sitka, is believed to have attempted the first pre-commercial shark harvesting experiments in Alaska. Parker participated in a productive test fishery in the Cross Sound (northern Southeast Alaska) area during the early 1960's.

Current work on the development of an Alaskan salmon shark fishery commenced with the "Southeast Alaska Salmon Shark Project." This project was financed by the Alaska Office of Commercial Fisheries Development and conducted by researchers from the Alaska Marine Advisory Program and the University of Alaska/Fairbanks.

The initial effort took place in Stephens Passage, a portion of the Inland Passage north of Petersburg, during the summer of 1983. The project was timed to intercept salmon shark migrations known to pass through this waterway during the July-August period. Surface aggregations of this species traditionally form at several locations along the eastern shore of Stephens Passage when sea surface temperatures approximate 10-11° C (50-52° F). Unfortunately, this research effort was beset by an environmental problem that ultimately proved to be insurmountable. The summer of 1983 throughout most of the eastern Pacific was marked by anomalous oceanographic conditions associated with the El Nino warm water phenomenon. Surface temperatures throughout Southeast Alaska were unusually high. The migratory patterns of

many forage and predatory species, including the salmon shark, were altered by these conditions. During the research period, surface temperatures in the Stephens Passage area were in the range 11-13° C (52-55° F). Salmon shark and associated schools of Pacific salmon were distributed throughout the area rather than being concentrated in a limited number of traditional fishing locations. As a result of these conditions, the researchers were able to intercept very few shark.

Gear

The researchers made use of a hybrid floating longline system similar to that used in the experimental California blue shark fishery. The mainline was floated at preset distances from the surface through the use of buoy bags. The mainline consisted of segments of both standard halibut "groundline" of 7 mm (9/32 inch) diameter nylon and galvanized steel cable of 2.4 mm diameter (3/32 inch). Stainless steel gangions of 0.9-1.1 m (3.0-3.5 foot) lengths were used, each terminating with a mustad 12/0 tuna hook. The gear performed well, indicating that similar gear could be used on most small commercial fishing boats operating in these waters. However, the short length of the gangions and the weak mainline attachment provided by standard stainless steel snaps caused a high loss rate. The short fishing period resulted in the capture of one 173 Kg (385 pound), 1.8 m (6 foot) female. Based on the occurrence of straightened hooks and lost gangions, it is believed that an additional 27 sharks were hooked but not retained. An earlier researcher (Parker) estimated that a small commercial fishing operation could expect to capture 20 shark per day using floating longlines.

Marketing

The shark meat harvested and processed as part of this project was test-marketed in the Seattle area. The meat received positive reviews in this marketing area. Test results encouraged other fishermen to initiate similar experimental fisheries, the earliest beginning in the late summer of 1983. During 1984 and 1985, thousands of pounds of salmon shark meat have been marketed along the Pacific Coast. Southern California has served as a major market. Again the product has been well received. Salmon shark meat from the Copper River Delta was evaluated along with the meat from a wide variety of other commercially important sharks as part of this Sea Grant Shark Conference. Salmon shark and the Pacific angel shark (Squatina californica) received the highest reviews.

The development of a salmon shark fishery in Alaska will be based on the marketing of a number of products. These products include: meat (ex-vessel value expected to be approximately \$1 per pound during the early part of the 1986 season), selected fins (value of the dried fins, excluding pectorals, is expected to exceed \$8 per pound), hides (limited marketing efforts expected), blood serum (limited marketing opportunities present), and jaw sets (tourist trade). Marketing opportunities for salmon shark meat and fins appear to be particularly strong.

Conclusions

It is expected that a limited salmon shark fishery will develop in the Gulf of Alaska. Much of the catch will probably originate from incidentally caught shark that are retained by the Pacific salmon fleet. A significant and growing portion of the harvest will come from a small group of harvesters planning to target on salmon shark. A major difficulty facing these harvesters and marketers is that the shark fishery will take place simultaneously with Pacific salmon fisheries. Onshore processing and freezing facilities will be severely limited during this time. Limited processing capacity during certain seasons may curtail the development of a major salmon shark fishery in Alaska. A number of small floating catcher/freezer processors are now planning to commence operations during the summer of 1986.

Although it appears to be inevitable that a shark fishery will develop, a number of major management concerns persist. The population dynamics of the salmon shark need to be better understood before rational management strategies can be put into operation. Areas requiring additional research include population size, discrete ranges, migratory patterns, and reproductive capacity.

A comprehensive report, **The Development of a Commercial Shark Fishery: The Salmon Shark (*Lamna ditropis*) of the North Pacific Ocean**, is available dealing with the biology of the salmon shark and the development of shark fisheries in Alaska and along the Pacific West Coast. Sections in this "salmon shark manual" include the description of the natural history of the species, fishing strategies, quality control requirements, and marketing conditions. The manual provides a very thorough treatment of these various topics. This volume is available through the Alaska Sea Grant Program, Fairbanks, Alaska.

Synopsis¹

Development of Gulf Coast Shark Fisheries

Gary Graham
Texas Sea Grant Program
Route 2 Armory Building
Angleton, Texas 77515

The development of markets for shark in Texas has been different than in other parts of the United States. The market is characterized by a fairly strong sensitivity to oversupply and has required the Texas A & M University Sea Grant Program to put more effort into its development than others have devoted to similar fisheries in other parts of the country.

Awareness of shark resources in Texas waters is a direct result of the swordfish (Xiphias gladius) longline fishery. Sharks have often been taken as incidental catch in this fishery over the years. Some of the incidental shark species, such as shortfin mako (Isurus oxyrinchus) and the bigeye thresher shark (Alopias superciliosus), have always found ready markets. However, little effort was applied to developing these other species because it has been difficult to induce fishermen to target on shark when they could earn as much as \$800 per fish for swordfish. In fact, gear was rigged specifically to allow sharks to break free until the past few years. It was a common view of fishermen that this saved a lot of time and trouble in wrestling with fish for which there was no ready market. Often up to 20% of the 300-400 hooks set on swordfish longlines would be bitten off by sharks.

Small markets did develop for the incidental shark catch in 1980, especially in Mexico. On occasion swordfish boats landed up to 21,700 kg (48,000 pounds) of dressed shark for which ex-vessel prices ranged from \$0.77-\$1.11/kg (\$0.35-\$0.50/pound). This price did not encourage targeting on sharks, but it did help pay the fuel bills of the vessels. One of the limiting factors in developing a consistent market for Texas shark in Mexico has been the fluctuation of the value of the peso. In 1980, the exchange rate was 12.5 pesos to the dollar. By late 1985, the peso had fallen to an exchange rate of 380 pesos per dollar.

Interest in sharks as a directed fishery resource in Texas increased about five years ago (1980) because of the decline of swordfish and bottomfish. Many types of sharks are considered recruitible to this fishery

¹ This paper was summarized by Sid Cook from a tape recording of Mr. Graham's presentation at the conference.

with the exception of hammerheads (Sphyrna sp.) and tiger sharks (Galeocerdo cuvieri), which have not been retained because their darker flesh and somewhat higher urea content makes them more difficult to handle and market successfully.

The test rigs used by Texas Sea Grant consisted of 226 kg (500 pound) test leader topped with 0.67-1.0 m (2-3 feet) of stainless steel wire. The gear was tested by commercial longline vessels.

Sharks taken with the gear are routinely shot to subdue them (the heart continues to beat for up to 20 minutes afterward, allowing the animal to be bled). The animal is then gaffed, brought on board, and the tail removed for bleeding. Then the shark is eviscerated, the head removed, and the fins recovered.

When fishing is good, cleaned carcasses are often left on deck rather than placed in the ice hold. This is a poor practice. The Texas fishery is sub-tropical. It is characterized by warm water temperatures and hot days, which greatly accelerate the deterioration of the shark if it is not properly cooled. This can be avoided by limiting the number of animals brought on board. Although it goes against a fisherman's grain, often it is best to cut loose excess sharks and let them swim away rather than to bring aboard more shark than can be handled in an efficient manner. Usually a vessel can handle about 1360-1810 kg (3000-4000 pounds) of dressed shark without any problem. Amounts over that figure are difficult to field dress rapidly and will tend to oversupply the market and be difficult to sell. A Texas Sea Grant researchers landed 2630 kg (5800 pounds) of dressed silky shark (Carcharinus falciformis) on a demonstration trip and had difficulty finding a market for it.

After a shark has been thoroughly cleaned, it should be cooled with some ice from the ice hold before being placed in refrigeration. Placing a warm carcass on ice without cooling it first will cause an air pocket to form around the fish and it will not maintain its quality. This is especially important because Texas boats often have to run 80 or more km (60 or more miles) from their home ports to fish for shark and trips of 5-6 days are the rule. On swordfish boats that intend to keep incidental sharks, the sharks are only retained for the last five days of the trip.

Many persons believe that the belly flaps should be removed from the shark during field dressing to prevent spoilage. There is some concern that removal of the belly flaps might increase the chance of contamination by increasing the cut surfaces. However, buyers will often insist that sharks have the flaps removed, and in such cases, the fisherman is left little choice but to comply with buyer specifications to be able to market the product.

There are no problems marketing the fins from Texas sharks as long as they are properly cleaned in the field (all meat removed with crescent cut). They should be hung on lines rather than left sitting on top of the wheelhouse or on hatch covers; experience indicates that they lighten considerably during frying and will blow away in brisk winds.

Another consideration in the development of Texas shark fisheries is that blacktip sharks (Carcharinus limbatus) often will congregate around shrimp trawlers. This very marketable shark could add to the revenue of the vessel if fished during times when the shrimp gear is not deployed. In tests by Texas Sea Grant, 317-361 kg (700-800 pounds) of dressed shark can be taken in as little as 40 minutes with jury-rigged longline gear.

The potential conflict between the shark fishery and the billfish fishery can be minimized by fishing for shark in the morning and swordfish in the evening. To discourage swordfish from taking shark baits, the bait is cut in half before being placed on the hooks. Shark will be attracted to this bait, but billfish will not.

Anyone entering this fishery must be aware that sharks can move considerable distances in short periods of time. You aren't likely to find large numbers of sharks in the same place they were located on your last trip. And in the case of silky sharks, the larger individuals are inshore (averaging 43 kg) and the smaller ones are offshore (averaging 13.5 kg). This is the opposite of most shark species.

In conclusion, let me emphasize that product quality is the overriding limiting factor in the development of this fishery. Efforts must be made at all points in the processing and distribution of shark to maintain both a high quality product and to avoid oversupplying the market.

Post-Catch Handling and Quality Control of Shark

Virginia L. Slosser
Fishery Marketing Specialist
National Marine Fisheries Service
9450 Koger Boulevard
St. Petersburg, Florida 33702

Abstract: All shark to be used as human food and to receive optimum benefits from its by-products must be taken care of immediately. The key to greater consumer acceptance will be quality. Because of its unique characteristics, shark must be handled with greater care. Fishermen are learning proper bleeding and refrigerating techniques which will result in larger and more dependable markets.

Shark will become popular throughout the United States when the food industry and public gain complete confidence in its quality. Inconsistent quality has been a major marketing problem in the past. Unlike red meat, if the consumer receives a low quality shark product he usually won't try it again. Especially if it's served in a restaurant. Consumers will not spend entertainment dollars on a seafood dinner of which they are not sure.

Shark meat has wonderful flavor. Unfortunately, it can be quickly and irretrievably lost when fish are mishandled at the time of capture. West coast fishermen and dealers learned this lesson many years ago. The Gulf and South Atlantic industry has been on the learning curve for the past five years. In my region today, successful shark fishermen are observing proper handling techniques scrupulously, and careless fishermen are having their catches rejected. Occasionally some bad shark meat finds its way into the market. But, generally, our quality control efforts are working.

The opportunity to make serious money fishing for shark has been a boon for many struggling fishermen in my region. So there is keen interest in developing this fishery and markets by producing training aids for fishermen and point-of-sale materials for purveyors.

In the old days it was believed that shark had limited food potential because it developed off odor and flavor too rapidly. We know now that shark meat has excellent shelf-life when it is handled properly. It is the high concentration of urea and TMAO in the blood of sharks that make proper handling so critical.

TMAO is a handy acronym for trimethylamine oxide. It is a substance, similar to ammonia, that causes the flesh of many marine animals such as sharks to deteriorate rapidly after death.

Urea is a substance produced in sharks as a by-product of protein metabolism. While urea itself is odorless, tasteless, and nearly non-toxic, it does provide a nutrient source for surface bacteria on the meat. The by-product (metabolite) of this use by the bacteria is ammonia. It is the ammonia derived from not removing as much urea and retarding bacterial action by preserving, freezing or refrigerating that ruins the flavor and odor of shark. For fishermen and processors experienced with bony fish, this has not been a quality control problem, as bony fish primarily rid themselves of nitrogenous wastes by the excretion of ammonia. Rapid bleeding of sharks in the field will greatly reduce urea levels.

It has been suggested in articles and cookbooks that mildly ammoniated shark meat can be restored to good taste by washing it in water and soaking it overnight in lemon juice, tomato juice or vinegar. However, be warned, this treatment is not always effective. Even if it was, first time consumers would not be inclined to buy shark a second time if they had to go through those steps to make it edible. And the industry should not expect them to do so.

On the other hand, good cooks don't mind doing things that make a good product even better. And marinating high quality shark meat in citrus juice or milk actually does enhance flavor.

Shark fishing is hard work and extremely dangerous. The snapping jaws and razor sharp teeth of sharks are capable of inflicting serious injury, and injuries have actually been sustained after the fish have died. So most fishermen learn quickly to work cautiously around sharks and how to preserve them to obtain the best possible price at the dock. Here's how they do it.

Fishermen work as fast as they can to "board" and butcher sharks while the fish are still alive and kicking, because they know that spoilage will occur rapidly after death. Efficient crews are able to "board" sharks and get them butchered and refrigerated in less than 15 minutes.

While it would seem prudent to shoot large sharks to render them less dangerous, (and indeed some small boat fishermen use this technique) few fishermen use this method. A loaded firearm can be more dangerous than a shark when one is trying to aim and fire it on a rolling, slippery deck. Most often, sharks are hoisted alongside and partially immobilized by hitting them on their snouts with a heavy wooden or rubber mallet. On occasion, they will hit them squarely on top of the head.

Bleeding and evisceration is done while the fish is hanging over the side, stunned but still alive. The caudal fin is severed, which enables the heart to pump most of the animal's blood through caudal arteries in about 3 minutes. Care is taken as the valuable lower lobe of the tail must be retained. When the blood flow stops, the fish is eviscerated and hauled aboard and deposited on the deck, preferably a safe distance from where the crew are hauling in new fish.

A crewman carefully straddles the shark, then cuts off its head. This severs the spinal cord. The belly flaps, valuable in small sharks but high-spoilage areas in large fish, are then removed. The carcass and belly cavity are cleansed of blood and visceral matter, usually by inserting a hose into the main artery and then thoroughly hosing down the carcass.

At some point during this operation the crewman removes the valuable dorsal and pectoral fins. Considerable care is taken to cut off the fins just above the meaty portion where they are attached to the body. If this is not done the meat remaining on the fins will spoil as the fins are drying, causing a tremendously offensive odor and attracting insects.

Remaining now is a headless, tailless, finless and eviscerated product that fisherman call a log, tube, loin or trunk. The butchering process, efficiently executed, requires only a few minutes.

The logs must be lowered to a cool temperature quickly. This is done by placing them in an ice/saltwater solution or brine tank. The solution is emptied and replaced frequently to avoid contamination. If fishing is good or the vessel plans to stay at sea for some time, the logs will be transferred to the hold when time permits. There they are placed belly down in clean ice, and ice is packed into the belly cavity.

This completes the steps that are necessary to preserve shark meat in pristine quality at sea.

As with any other seafood product, shark has an edible life of only a few days when it is held in the fresh state. Therefore, careful attention must be paid to sanitation and to storage temperatures as shark passes through the distribution chain. Shark does not require unusual care, however.

Cleanliness when handling shark or any other fresh seafood is extremely important because bacteria multiply at unbelievable speed in an unclean environment. In four hours it is possible for bacteria to multiply 4,000 times on products that are poorly handled.

Air-cooling of shark will not match the effectiveness of ice. The melting action of ice:

- removes heat from shark rapidly;
- lowers product temperature to near 0° C (32°F);
- creates a low-oxygen environment around products that slows down bacterial and enzymatic action, oxidation and deterioration; and
- washes away blood and other spoilage material.

Air cooling, on the other hand tends to dehydrate and oxidize fresh products rapidly.

As with any fresh seafood:

- keep your ice supply covered to prevent dirt and other contaminants in the air from settling upon the ice;
- cover containers of iced shark for the same reason;
- when storing logs [shark carcass minus head, fins, and internal organs], place them in ice (belly down) and completely cover them with ice;
- wrap processed shark products such as fillets and steaks before burying them in ice to prevent their juices from leaching out; and
- put receiving dates on all shark products that you keep in refrigerated storage. This will insure that the oldest products are used first.

Some people believe that frozen shark meat is tastier and less chewy than fresh; however, market demand is strongest for fresh. Frozen shark has the normal storage life of other marginally lean fish. Never allow it to warm above -18°C (0°F). Store it at -23°C (-10°F) or lower for longest storage life.

To summarize, shark is unusually vulnerable to quality loss at sea if it is not bled and refrigerated quickly. Most fishermen have learned this lesson and quality reliability is improving. The normal care given other seafoods is adequate for shark as it passes along the distribution chain.

Consistent quality will be very important as new markets develop for shark around the country. One must remember that quality can not be improved from its present state and that quality lost can never be retrieved. People are trying shark for the first time and will form good or bad impressions that could last a lifetime.

Synopsis¹

Shoreside Processing of Shark

Harlon Pearce
Harlon's Old New Orleans Fish Company
126 Airline Highway
Metairie, Louisiana 70001

People tend to put processors in an unrealistic light that makes us seem to be more than we are. But ultimately, we are still fish peddlers. And one of our chief concerns is the marketability of the products we handle, for that determines what processing techniques we will apply. We must continually ask ourselves who will be purchasing our product. Will it go to institutions? School systems? Local or distant markets? High-end restaurants? The object of an efficient fishery is to land high quality fish that the consumer will buy at a price that will satisfy both the producer and the processor. These factors must operate in balance for a fishery to succeed. We will look at all aspects of production from catch to processing to end user.

Louisiana's estuaries accounts for about 25% of the total estuarine area of the United States. It is within this area that the Louisiana shark fishery has developed. The estuaries cover all of our coast, but are the most concentrated on the west and east approaches to the Mississippi River delta for a distance of about 170 km (100 miles). There are three principal areas in the local shark fishery: 1) inshore (comprising bays, bayous and estuaries) where waters are 1-3 m (3-10 feet) deep; 2) sounds (outer edges of estuaries) where the water is 3-7 m (10-20 feet) deep; and 3) deeper water (beyond the barrier islands) where waters are deeper than 7 m (20 feet). The largest and best developed fishery lies in the inshore area with relatively little development of the sounds and deeper water areas. Inshore development has occurred because production has been sufficient to provide for the needs of the fishing community and there has not been a pressing need to develop other shark resources.

The Inshore Fishery. This fishery principally produces small bull sharks (Carcharinus leucas) comprising 95-98% of the summer catch. Large bull sharks tend to have somewhat tougher meat than small individuals due to a fibrous membrane that is striated through the muscle. The best bull sharks are those in the 13.6-18.1 kg (30-40 pound) size class; they are euphemistically called "veal of the sea" to enhance their market appeal.

¹ This paper was summarized by Sid Cook from a tape recording of Mr. Pearce's presentation at the conference.

The Sound Fishery. When you get into the outer estuary where the water is deeper than 4 m (12 feet), a completely separate fishery begins to develop. The principal species in this fishery are blacktip (Carcharinus limbatus) and spinner (C. brevipinna) sharks. These species are found in large numbers around the barrier islands also.

The Deeper-Waters Fishery. This fishery is nearly undeveloped, but includes large sharks such as the mako (Isurus oxyrinchus).

The Gear. Small vessels with shallow drafts are used in the shallow waters of the inshore fishery. They are usually 5-7 m (16-20 feet) aluminum, flat bottom boats, or 7-9 m (20-30 feet) beach skiffs with semi-flat bottoms. The fishery developed secondarily to the estuarine fishery for sea trout (Cynoscion sp.) and redbfish (Sciaenops ocellatus). Both shark and gar (Lepisosteus sp.) are taken with damaged nets recycled from other fisheries. This is usually 7.6-10.1 cm (3-4 inch) mesh gillnet, which has proved to be good gear. "Salt tides" bring in large numbers of sharks during the summer months but tend to cause a decline in fishing for other species.

Most boats go out once or twice a day since the grounds are not more than one hour from the dock (usually less than 20 minutes away).

Field Dressing. The key to a successful shark fishery lies in the fishermen. Sharks have to be handled quickly on the boat. There is no way to recover bad fish once they have been delivered to the dock. First, the shark has to be headed and gutted on the boat. (The head is removed behind the pectoral fins.) Then the fish is thoroughly cleaned, leaving the belly flaps on the carcass. They can be removed later without damage to the shark. All offage (offal) is retained by the fisherman and taken back to the dock for disposal. Discarding offage in the water has caused a dramatic decline in the fishery in that area for some time. Next the fish is placed in a saltwater-ice slush to begin cooling it down. In this particular fishery, the shark usually is delivered to the dock within 20-60 minutes of the time it is killed.

Dockside Receiving. At the dock the shark is immediately transferred from the boat into another saltwater-ice slush. "Slushing" is important in maintaining a high-quality product. The use of ice alone does not sufficiently cool the fish quickly enough. In recent years, more boats in the inshore fishery have been equipped with refrigeration and water circulating pumps.

The fish is transferred to a truck as gently as possible to avoid mechanical damage and bruising. The method found to work best is to place a layer of ice, then a layer of shark, then a layer of ice, etc. It is important to keep the shark below 4.5°C (40°F). Temperatures above this will cause bacterial action on the meat to skyrocket.

The Quality Control Process. There are five quality control checks made on shark being brought in to Harlon's Old New Orleans Fish Company: 1) at dockside, the shark is assessed for odor and appearance; 2) the fish is checked for odor again before being unloaded at the plant; 3) each fish is handled and inspected as it is unloaded at the plant for mechanical damage and odor; 4) it is inspected for odor and smell as it enters the processing line; and 5) during post-processing/packaging, the fish is inspected for miscuts, ragged edges, and any other condition that might render quality fish unsightly. This is important, since the consumer generally buys fish by appearance over any other consideration.

Filleting. Any remaining fins are removed from the cleaned and cooled carcass. A normal filleting process is then used. Beginning at the end nearest the head, a cut is made toward the tail along the backbone. A second cut is made along the cartilage material at the edge of the belly cavity (skeletal septum, see figure 1). With this process 60-63% of the dressed carcass can be recovered as edible meat--a good yield for small-bodied sharks.

One of the most important steps in processing is the removal of the heavy "bloodline." It is unsightly and reduces the quality of the fillet dramatically. Several skinning machines have been tested for suitability for skinning sharks. Most machines of recent design and construction are not suited to use with shark as they tend to cut too thinly to remove the skin properly. Such machines don't even come close to removing the bloodline from the fish. At the Old New Orleans Fish Company, a Baader 50 skinning machine has been found to work the best. This machine employs a rotating blade and has a variable blade height adjustment. The cut can be adjusted to leave a suitably thick portion of flesh on the skin to completely remove the bloodline. All the sharks we handle are machine-skinned. This is much easier than hand-skinning due to the coarseness of the meat and toughness of the hide. The Baader 50 is also a conveyor-fed machine, which provides greater safety for employees over hand-fed machines.

The importance of proper market development cannot be overemphasized. Product preparation and packaging are determined by the how the buyer will use the fish. Portion control is important to institutional and restaurant users more than it is to retailers. Quantity is important to school lunch programs. There is no blanket method for marketing shark that I know. Each individual market and customer needs to be dealt with in a slightly different manner to assure that his or her needs are met. It is the responsibility of the processor to maintain good market efficiency. Since there is a seasonality to shark fisheries as with other types of fishes, backup supplies must be developed.

Market development should be geared to making the best use of all shark that is landed for two reasons. First, we need to build solid working

relationships between the fisherman and the processor in order to keep a steady supply of fish. It is difficult to tell a fisherman you can only purchase 45 kg (100 pounds) of fish from him because you don't have enough developed markets to handle all of the fish he delivers. It is the job of the fisherman to obtain the fish and get it to the processor in the best possible condition, and it is the job of the processor to develop a reasonable market base in which to distribute it. Second, we have to practice resource conservation; that is, we cannot waste a potentially salable resource by poor market effort.

School lunch programs are an example of an institutional market in which shark can be used. Schools will often request 70-85 g (2.5-3.0 ounce) controlled portions of shark because it is boneless and in quantity can be nearly as economical as bony fish fillets. The role of the processor in this setting is to be able to provide large quantities of frozen shark on the order of 13,600-18,100 kg (30,000-40,000 pound) lots. If the school district likes your samples, you must be able to deliver lots of this size on short notice. This will require careful planning and close working cooperation between the fishermen and processor. Shark for this market can be either blast frozen or mechanically frozen with little difference in the final product, except that there is a higher moisture loss in the mechanical freezing process.

In closing let me say that shark markets may expand more slowly than those for some exotic bony fishes; however, the U.S. consumer is primed to purchase shark and other new seafood products at the present time. So with prudent planning and perseverance, the processor and the fisherman will prevail.

Specialty Product Development Using Frozen Shark

Michael G. Haby¹, Valerie Z. Roach²
and Russell J. Miget¹

Abstract: Information is presented about the activities undertaken in support of the introduction and adoption of hot-smoked portions and shelf-stable snack jerky manufactured from shark meat. Once the products were developed and refined, a proforma analysis of the economics of producing, processing and marketing the snack jerky determines whether adequate margins exist throughout the marketing channel so that the product can be "pushed" through the system. Next, the results of a survey of seafood smokehouse operators are presented along with the results of several taste tests conducted at various trade shows. These findings demonstrate that even though hot smoked shark and smoked snack jerky are prototype products, the responses are quite positive, and many participants express genuine interest in utilizing these specialty foods. Additionally, the current posture of regulatory groups concerning product labeling, product integrity, and processing of seafoods in Federally inspected meat plants is outlined. This may be important in seafood producing states such as Texas which have a large, diversified, specialty meat smoking infrastructure but lack a similar industry oriented to seafood. The paper concludes with a discussion of the different techniques which can be used to move the product into commercialization.

Introduction

Historically slow moving inventory, low ex-vessel prices and sporadic seasonal production (which reduces the opportunity for fresh meat sales) have been limitations in the development of a continual, directed fishery for sharks in the Western Gulf of Mexico. Because of these limitations, utilization of frozen (seasonally produced) shark in convenience and gourmet food products was evaluated as a means of increasing its value, thus partially removing it from the commodity-oriented level of competition. This paper

¹ Michael G. Haby, Seafood Marketing Specialist, and Russell J. Miget, Marine Fisheries Specialist are employed by the Texas Agricultural Extension Service/Sea Grant College Program at Texas A&M University.

² Valerie Z. Roach, Research Associate, is employed by the Seafood Technology Section/Texas A&M Agricultural Experiment Station at Corpus Christi.

outlines the various functions completed to date and suggests tasks which could make the production and sale of convenience snack jerky products manufactured from shark a reality.

The Jerky Manufacturing Process & Prototype Development

Butchering

Silky and dusky sharks (Carcharhinus falciformis and C. obscurus respectively), blast frozen as boneless, skinless slabs and held at approximately -27°C (-16°F) for five months, were removed from frozen storage, partially defrosted and sliced (transverse section) into 6.4 mm (1/4 inch) thick portions. Using this cutting method, the muscle striation runs through the strip with the length of the muscle fibers being determined by the thickness of the slice. Because of unavoidable hand contact with the raw slices, strips were rinsed with a shower spray.

Curing process

Several different cures were tried. The cure finally used was a 1:1 ratio of teriyaki sauce and water, 3% salt (NaCl), 0.4% onion juice and 0.4% garlic juice. The ratio of cure weight to product weight was 2:1. Shark strips were cured under refrigeration for approximately 16 hours. Once removed from the cure, each strip was lightly rinsed with fresh water and a medium grind black pepper was sparsely applied to each side. The pepper provided additional spiciness to the jerky and reduced the perception of saltiness. At this point the product was ready to be placed in the smokehouse.

Cooking schedule

Cured strips were placed in the smokehouse and air dried for 1/2 hour. This air drying step consisted of allowing the main blower to operate while the temperature was held at approximately 49°C (120°F), the smokehouse blower was activated, and the product was allowed to dry for 2 1/2 hours at 71°C (160°F). As a finishing step, the heat was turned off and the product was air dried for another 1/2 hour. At the end of the finishing stage, the product was removed from the smokehouse and allowed to cool on racks for approximately 45 minutes at which time it was vacuum packaged.

Laboratory analysis of shelf-stable jerky

A high-protein food marketed without refrigeration requires assurances that the product is microbiologically stable. The two major organisms which could represent a health hazard in shark jerky are Clostridium botulinum type E which is prevalent in the marine environment and Staphylococcus aureus which can result from human contamination during post-cook handling. Preparation of a shark jerky may provide the conditions necessary for the outgrowth of and toxin production by these organisms. These are:

- a) an environment suitable for C. botulinum growth;³
- b) lack of refrigeration which would ordinarily retard the growth of Staphylococcus aureus.

Adequate process controls need to be established to insure a safe product. Several controls exist. Heating the muscle to at least 66°C (150°F) will injure C. botulinum type E spores causing them to become less tolerant of salt. S. aureus generally tolerates higher salt concentrations than C. botulinum, thus a water phase salt percentage of 16%-18% is required to insure against postcook contamination problems⁴.

Following manufacture of the jerky, several samples were vacuum packaged, stored at both 4°C (30°F) and 30°C (86°F), and sampled periodically for approximately three months. Salt and moisture content of the finished jerky were 9.94% + .48% and 32.9% + 3.8% respectively, with a water phase salt concentration of 23.5% + 2.8%.

Both anaerobic and aerobic plate counts were conducted during the first 21 days of storage. Anaerobic agar, with and without 5% NaCl, was used for anaerobic counts. Standard methods agar (SMA) and SMA plus 5% NaCl were used for aerobic counts. After 10 days of storage, anaerobic counts had dropped to zero and remained so during subsequent sampling periods in the first three weeks. Therefore, anaerobic sampling was discontinued. With respect to the aerobic analysis, there was no significant difference in growth of colonies on media with and without 5% salt so the addition of salt to the media was also discontinued after the first three weeks of storage.

Aerobic plate counts were relatively stable over the 110 day storage period. Results, shown in Figure 1, are the average of two replicates.

Economics of Manufacture and Marketing

There are two questions which must be answered concerning the economics of manufacture and marketing:

- a. Can purchase, storage, manufacturing and marketing margins be calculated that leave enough production incentive for the fishermen?

³ An anaerobic environment can be created with vacuum packaging and/or through chemical reduction of the product surface as compounds from the smoke react with it.

⁴ Water phase salt is the percentage salt (NaCl) in the finished product as determined by the method described in sections 18.006, 18.009 and 18.010 of the Official Methods of Analysis of The Association of Agricultural Chemists, 10th edition, (1965) p. 273.

- b. Does the manufacturing process build in too high a cost to the subsequent marketers of this product when compared to the substitute products found in the marketplace?

These questions can be answered on a preliminary basis by considering the hypothetical costs of manufacturing and marketing. The information in Table 1 indicates hypothetical production costs (cooking yields, direct and overhead expenditures), selling prices and marketing margins associated with such a product.

Table 1: Computation of Hypothetical Cost per Pound
for Producing Shelf-Stable Jerky

Panel A: Proforma Processing Costs

Sales price	\$9.02
Product cost	2.11
Processing costs	2.00
Post-cook yield	60%
Direct cost	6.85
Overhead	.50
Total cost	7.35
Freight	.20
Total delivered cost	7.55
Pretax net return	\$1.47

Panel B: Margins and Product Costs
for Mid-level Handlers

Wholesale distribution	
Product cost	9.02
15% gross margin	1.59
Wholesale sales price	10.61
Retail interests	
Product cost	10.61
33% gross margin	5.23
Retail sales price	15.84

Shark jerky would compete against a beef counterpart which carries a standard of identity mandated by the Meat and Poultry Inspection Division of USDA regarding the ratio between residual moisture after cooking and protein. According to the labeling standard, beef jerky must be drier than a similar seafood product so there may be some economic advantage for the processor who produces a seafood (shark) product. As indicated in the cost comparison between inside beef rounds and boneless, skinless shark fillets in Table 2 below, even though the shark initially costs 37% more than the inside rounds, (as of October 1985), the required moisture loss for the beef products results in it being significantly more expensive to manufacture than the same type of product made from shark.

Table 2: Comparison of Direct Costs Per Pound to Produce Beef and Shark Jerky

	Beef inside rounds	Shark b/s fillets
incoming cost	\$1.50	\$2.05
yields	<u>98%</u>	<u>97%</u>
beginning cost	1.53	2.11
processing labor	2.00	2.00
post-cook yield	40%*	60%
direct cost	\$8.83	\$6.85

* Percentage yield deduced from the mandated moisture/protein requirements from USDA.

Marketing

Marketing Planning

Most products which successfully make it through the prototype stage are then analyzed for potential customers' attitudes toward the product, how well the proposed product stacks up against competition, and the gross margins available to the mid-level trade (which significantly contributes to reseller interest). When planning for the marketing of any product, several questions should be considered. Specifically, what is the anticipated market, what are the characteristics of this market, and what activities must be performed to enter this market successfully?

The convenience store market currently retails a wide range of shelf-stable snack meat products. Because of the impulse purchase nature of the snack food market, convenience stores should continue their sales dominance in this product class. Since shark jerky is a product adaptation, the convenience store would appear to be the logical outlet.

Nationally, convenience stores are growing at an annual rate of approximately 20% with gasoline and ready to eat foods accounting for significant percentages of sales growth. Judging from the width and length of the ready-to-eat, shelf-stable snack meats line, the demand and the gross margin earned from the sale of this product line (both percentage and overall dollars) appear high⁵.

From the manufacturer's standpoint, this segment of the retail food industry has one significant characteristic which indicates the extent of access to the market: a low advertising to sales ratio. In a convenience outlet, product placement and limited point of purchase materials serve as promotion. Therefore almost any sized firm can participate since a large promotional budget is not a prerequisite.

At the manufacturer level, attention to package design as a point of sale tool and calculation of the net weights and prices is essential to be competitive in this venture.

Does This Product Have a Future?

As a surrogate to full test marketing, samples of smoked shark jerky were featured at the 47th Annual Texas Restaurant Association Convention and Trade Show held in San Antonio⁶. The jerky was served to trade show participants, and these testers were asked to rate the product in terms of flavor, texture and appearance. The appeal of the shark jerky was overwhelming!

Some 700 participants sampled the product. A ten point rating scale was used with 0 being least desirable and 10 being most desirable. Average scores

⁵With the price of substitute products quite high, good gross margins are obtainable. Reported gross margins on beef jerky are 33%. Estimated gross margins on shark jerky are about 50%, so this should induce prominent placement in the outlet which contributes to impulse sales.

⁶While not specifically positioned as an appetizer in food service, it is interesting to note that the persons providing these ratings were professionals in the food service industry and are perhaps more critical of new products than persons without such a tie to the food industry. Specifically, people sampling the jerky included restaurant owners/managers, wholesale distributors, food brokers, food processors, dieticians and private caterers.

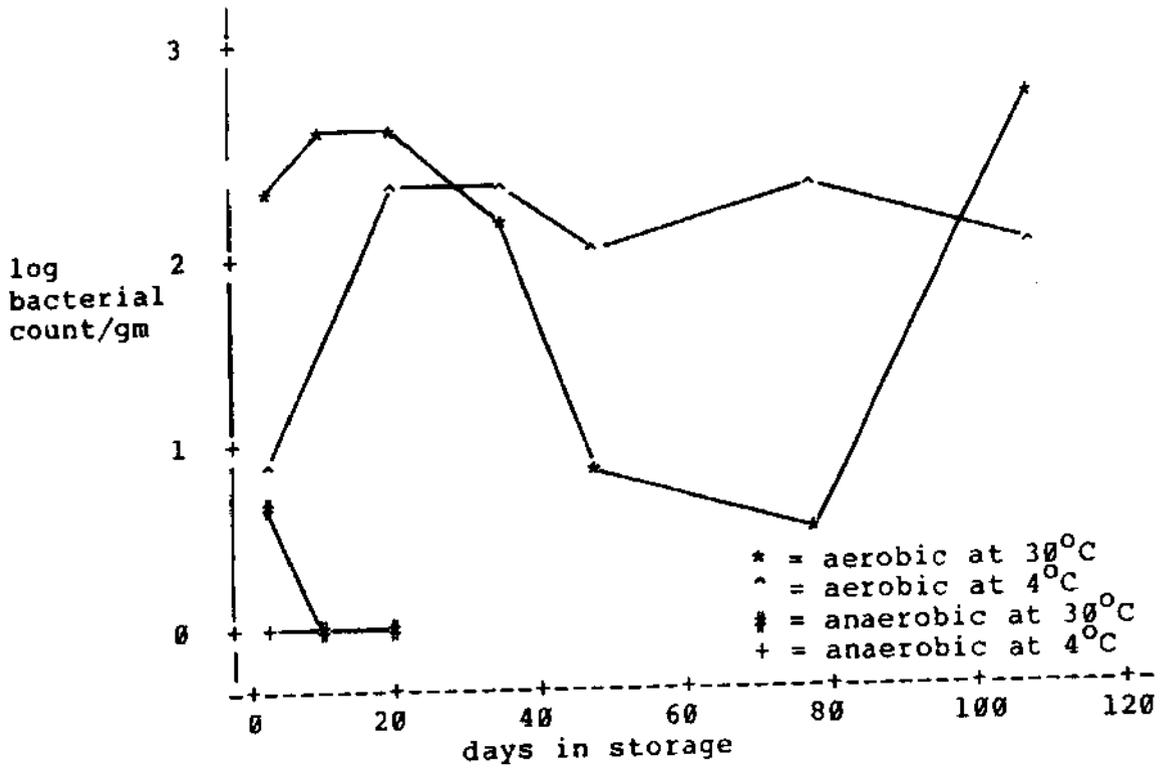
for appearance, flavor and texture were $8.91 + 1.16$, $8.86 + 1.47$ and $9.09 + 1.18$, respectively, or a total score of 26.86 (89.43%), indicating high overall acceptability. When asked whether the shark jerky would make a good happy hour-type snack, the response was a unanimous Yes!

The practice of predicting success or failure of new products is in essence conjecture. However, when evaluated in terms of manufacturing costs vis-a-vis' beef jerky, gross margins available to the marketing channel and preliminary consumer response, the opportunities for shark jerky appear promising. To date, no firm in Texas has committed to testing this idea, although several smokehouses have expressed interest in expanding their smoked meats line⁷. Whether this product is commercially produced will depend upon locating that processor who has the financial and marketing wherewithal to not only produce an acceptable product, but find the appropriate marketing techniques to place it next to checkout areas in the retail food industry's fastest growing sector.

⁷Currently there are no firms in Texas which smoke fish and seafood. In working with the beef processing industry, we have faced two recurring questions: "Is shark meat available in the quantity and quality which I will need?" and "What regulations exist about labeling standards, using seafood in inspected meat plants, etc?" Our work has centered around work with Federally inspected meat plants as well as some smaller state regulated firms. The contention of both regulatory groups is that running a seafood product through the plant is permissible so long as the operations are separable. Conceivably, we envision a processor running the shark jerky on a day when he would not be processing beef.

Figure 1

Bacteriological Stability of Vacuum Packaged
Shark Jerky stored at 30°C and 4°C



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