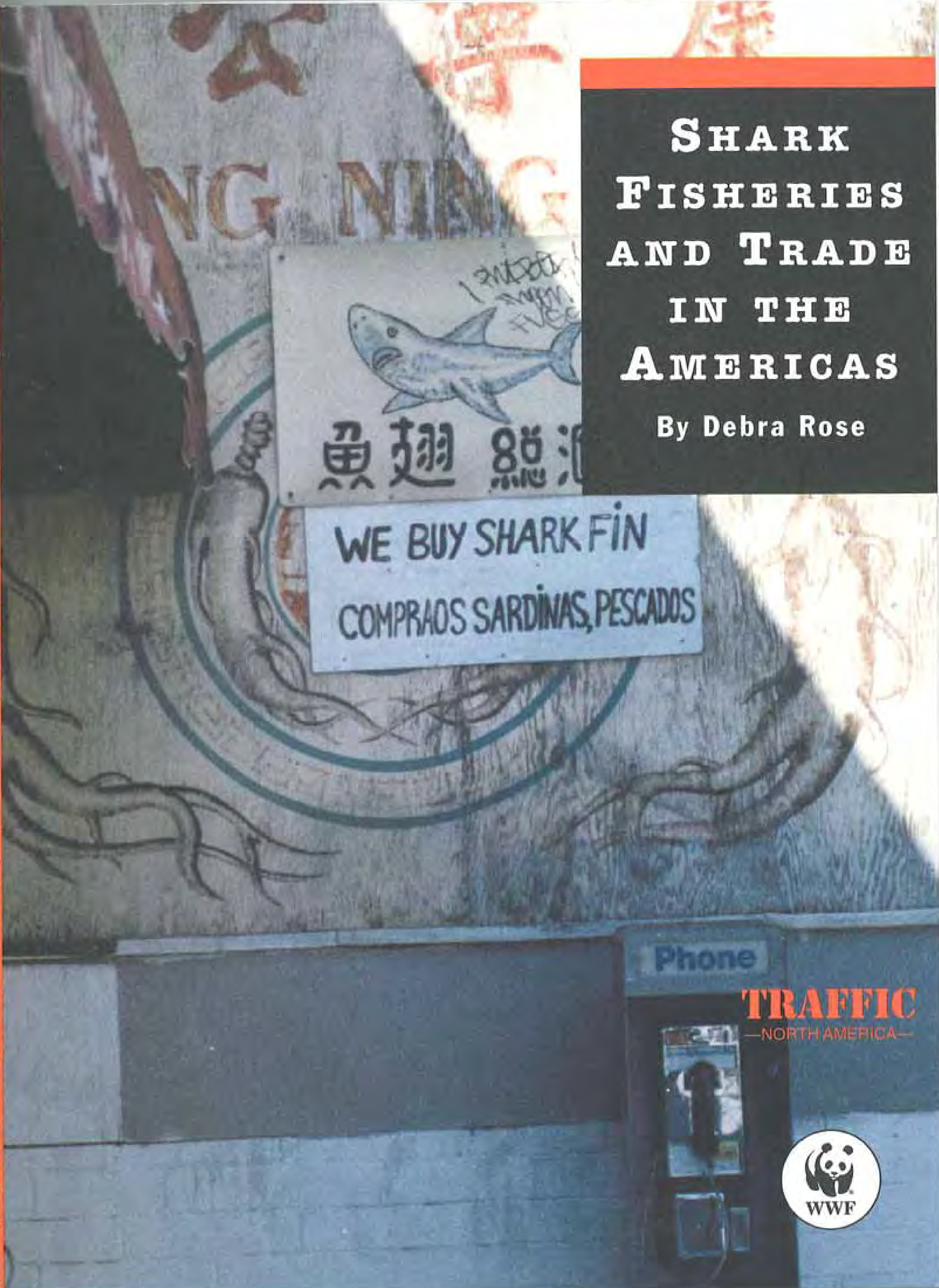
Shark Fisheries and Trade in the Americas

By Debra Rose



TRAFFIC
—NORTH AMERICA—

WWF

Published by TRAFFIC North America,
Washington, D.C., USA

Front cover photograph: North American street advertisement for shark fin

Photo credit: A. Lacklan, TRAFFIC North America

Printed on recycled paper.

SHARK FISHERIES AND TRADE IN THE AMERICAS

VOLUME I:

North America

by

Debra A. Rose

March 1998

PREFACE

Because of poor information and lack of documentation on fisheries and trade of sharks, skates, rays, and chimaeras--collectively referred to as "sharks" in this report--the world conservation community was not aware of the rapidly increasing and expanding demand for these taxa until the mid 1990s. A few international conservation organizations took action.

The TRAFFIC Network began to address this issue by compiling and publishing a series of regional overviews documenting markets and trade of sharks and other related species and the implication of that trade on shark management and conservation. This Volume I on North America is part of that series. Volume II on the South American shark fisheries and trade in Argentina and Uruguay will be published later this year.

In 1994, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) made an unprecedented move in its more than 20-year history by requesting a review of the trade of these species, although none were listed on its appendices. That review began in 1995 and culminated in June 1997 in a report to the CITES parties summarizing the known data and information on shark trade and management. This report was based upon TRAFFIC and IUCN research, information provided by intergovenrmental agencies, and by the CITES parties themselves. The report made recommendations to various agencies, organizations, and the CITES parties, and requested further information and data that were lacking in the analysis.

One CITES recommendation requested the expertise of the United Nations Food and Agriculture Organization (FAO) to assist CITES in its initiative. In late April 1998, the FAO will convene a meeting of world shark experts in Tokyo to discuss world shark fisheries and make recommendations that will be reviewed by FAO parties in Rome in October 1998. Those deliberations and decisions will again be reviewed by CITES in late 1999 when the parties meet in their biennial meeting.

The TRAFFIC Network has made two essential conclusions based upon its research. The first is that there is a basic lack of specific and consistent data to monitor the catch, landings, and trade of sharks. The second is that a scientifically-based global endeavor should be instituted to ensure sustainable offtake of sharks for the future. It is hoped that the two FAO shark meetings to be held in 1998 will provide the recommendations to address these needs and inspire the often lacking political will to implement them.

ANDREA L. GASKI
Director of Research

ACKNOWLEDGEMENTS

This TRAFFIC North America report is based on secondary and field research on shark fisheries, trade, and management in North America conducted from 1994 to 1996, as part of the ongoing work program of the TRAFFIC Network. During the course of the project, many individuals contributed their time, data, experience, and insights, without which this study would not have been possible. Countless representatives of the fishing industry and trade, members of the IUCN/SSC Shark Specialist Group, and officials of state, provincial, and federal management agencies received requests for information. These were nearly always cheerfully received and granted. The author is much indebted to each of these individuals and assumes responsibility for any errors of interpretation.

The author would also like to thank Andrea Gaski, Christopher Robbins, and Holly Reed of TRAFFIC North America for their assistance and support during the research, writing, and editing of this report. The U.S. market research also benefited greatly from collaboration and information sharing with other TRAFFIC Network researchers, particularly Glenn Sant of TRAFFIC Oceania, Rob Parry-Jones of TRAFFIC East Asia, and Elizabeth Fleming of TRAFFIC Europe.

TRAFFIC North America also gratefully acknowledges the assistance of World Wildlife Fund-US, the WWF Endangered Seas Campaign, the WWF-US Marine Leadership Council, and TRAFFIC International. The author also thanks the University of Florida for its support of this study in the form of a postdoctoral research assistantship granted to the author during 1995.

EXECUTIVE SUMMARY

As many of the world's important fisheries continue to decline, cartilaginous fisheries increasingly appear on lists of "underexploited species." Such fisheries are identified by national and international fisheries agencies throughout the world to offer fishermen alternative opportunities for exploitation, usually when the primary source of their catch becomes scarce or commercially unexploitable.

The importance of cartilaginous fishes to local, national, and international fisheries--and to local or national economics dependent on them--is heightened by the fact that the fisheries are seldom regulated locally, nationally, or internationally. Cartilaginous fishes are therefore instantly available to fishermen when other species are depleted, restricted, or seasonally unavailable, and, as a result, are often subjected to intense exploitation. Sharks, skates, rays, and chimaeras--the cartilaginous fisheries or elasmobranchs known herein as sharks--have become the versatile and "salvation" fisheries resource of the 1990s in the face of worldwide fisheries production decline.

At the same time, information on the volume and species composition of shark catches and landings, and on the species themselves, remains sparse or nonexistent. Prior to the 1990s, shark fisheries historically represented a minor and relative low value contribution of most nations. Sharks rarely had a high commercial or international value, and often were fully or partially utilized only in subsistence or artesanal fisheries. This was due to high costs of production and low market value of products such as oil and cartilage, and shark meat was considered unpalatable and of low value by many western markets. Overall, most sharks landed as bycatch in other valuable fisheries, such as tuna or swordfish, were usually dumped over the side of the ship by western fishermen as "trash" fish.

That trend changed sometime in the late 1980s, when the growing economic buying power of consumers in Asia and the opening of fisheries markets in China increased demand for and trade in shark fin--now considered to be one of the most valuable fisheries products in the world. Another valuable shark product is cartilage, found in manufactured health food remedies in the growing western herbal market. The demand for moderate-value, high-quality sharkskin leathers fluctuates with western fashion demand.

Most shark species are extremely susceptible to overexploitation because they have life histories similar to those of higher animals, rather than their fellow fishes. They are long-lived, reproduce later than most comparable bony fish, and have low reproductive rates. These biological factors all limit the rate of sustainable harvest of these fish. Also, little is known of stock structure in most coastal waters--let alone in deep water--and there is little information on the abundance of individual species or populations, or even their most basic biological requirements for reproduction and growth. It is difficult to thoroughly speculate on the management and conservation implications of the rising demand for shark products, such as meat, fins, and cartilage, because of a number of factors pertaining to management and biology. These include lack of historical information on most aspects of these fisheries and local and international demand and use, poor or no reporting of fisheries products in trade, and lack of species-specific catch.

In 1994 FAO reported that notable increases of shark catches occurred in the central western Pacific Ocean, Indian Ocean, and the Northwestern Atlantic Ocean regions. These catches accounted for nearly 57 percent of the world's shark catches for that year. The three countries of North America--the United States, Canada, and Mexico --figured prominently, not only because of the proximity of their borders and fleets to these areas, but also because of the extent of their catches. Mexico and the United States together landed more than 100,000 metric tons of sharks in 1994 and, as a result, were considered two of nineteen top shark fishing nations in the world at that time.

Canada has historically been a minor shark fishing nation with landings in the mid 1990s at just over 1,000 metric tons. Canadian exports and imports of shark products are poorly documented by the government. Based on TRAFFIC's analysis, a large portion of fresh and frozen shark moves across the U.S.-Canadian border. International trade statistics suggest a low level of trade in shark meat and fins. Most catches in Canadian Atlantic waters have been bycatch in tuna and swordfish fisheries. Until recently research and management measures have been extremely limited. A research program was initiated in 1993 and, in 1995, a management plan with quotas of three species of sharks was put into place in the Atlantic.

Mexico's artesanal fisheries for sharks have been an important national marine resource with shark meat serving as an important source of protein to subsistence users and lower income urban households. An indicator of this is the fairly constant annual catch and landings of sharks from 1982 through 1993--about 33,500 metric tons. And, unlike in other North American countries, many parts of the shark are processed for consumer markets--oil for local and national vitamin supplements, fins to Asia, sharkskins for national tanneries and international luxury exotic leather markets, and cartilage for international health food remedies.

Mexico's fisheries agencies have instituted long-term reporting of state catches and landings, analysis of fisheries production, and monitoring of fisheries vessel composition. Still, more detailed data and information is lacking on the trade of shark products which would greatly assist efforts to monitor and analyze trends. Since 1992, the National Fisheries Institute sponsored a national research program and has also initiated a joint research effort with the United States. This new and improved data and information will eventually be used to establish management regimens.

Any shark management measures proposed in Mexico, however, will have to take into consideration not only the shark fisheries themselves, but also the local economics and humans that depend on them. In particular, these measures should carefully evaluate the constraints already faced by small-scale fishermen, the growing importance of Mexico's longline fleets, and the full or near-full utilization of sharks in Mexico waters. The measures should also review the value of shark bycatch in other fisheries, which often is utilized as human food, rather than discarded and wasted as happens in the United States and Canada.

The United States is one of the 19 top shark fishing based upon 1994 FAO data, and one of the top trading countries of shark products based upon international statistics.

It is also probably the best compiler of data and information on shark fisheries and trade in the world, although much of this still lacks the specificity needed for shark monitoring and management.

Directed Atlantic shark fisheries began to develop in the early 1980s and rapidly increased after 1984. This undoubtedly resulted from increasing demand and value for shark products and declining stocks of tuna and swordfish. U.S. shark catch and landings are dominated by spiny dogfish and skates. Dogfish landings increased almost by about 250 percent and other sharks by almost 300 percent at the end of the period from 1985 to 1994. Rising concern over the landings resulted in the implementation of a controversial 1993 shark management plans in the Atlantic, and covered 39 of the 74 species that were known to occur there.

There were no comparable increases in U.S. Pacific shark fisheries from 1985 to 1994. Landings fluctuated around 5,000 metric tons and consisted primarily of spiny dogfish. However, 1993 records saw the first evidence of large shark landings in Hawaii and U.S. Pacific territories. These landings were registered at about 1,800 metric tons, and consisted mostly of three pelagic species caught as bycatch of the tuna and swordfish fleets relocating from the Atlantic. There is no national shark management plan in place in the Pacific.

TRAFFIC recommends two essential specific issues be addressed for the conservation and management of sharks in North America and the world. These are the development and compilation of specific and consistent data to monitor the catch, landings, and trade of sharks, and the establishment of a scientifically-based global endeavor to ensure sustainable offtake of these species for the future.

INTRODUCTION

Sharks, skates, rays, and chimaeras, the cartilaginous fishes--or elasmobranchs--are versatile fisheries resources. Not only the meat and fins, but also the skin and internal organs, are used for human consumption. The skins may be tanned to produce a high-quality leather or used as an abrasive, while shark liver oil is used in the textile and tanning industries and in the manufacture of lubricants, cosmetics, vitamins, and pharmaceutical products. Shark cartilage may be used in the manufacture of fishmeal, and is increasingly marketed as a treatment for cancer. Additional research is underway to test its efficacy in treating a wide variety of additional ailments. Shark teeth and jaws--byproducts of growing commercial fisheries--are widely offered for sale as tourist curios. Live specimens are increasingly appearing in both public and private aquaria, and sharks and rays have become an important attraction to scuba divers and recreational fishers.

Elasmobranchs are also valuable fisheries resources. Shark fins--highly appreciated in Chinese cuisine--are among the world's most expensive fisheries commodities; their value has risen sharply in the last decade. Long considered trash fish, or entirely unpalatable, the meat of sharks, skates, rays, and chimaeras is becoming increasingly popular in both domestic markets and export markets. New markets for shark cartilage offer the opportunity to utilize a fisheries byproduct that would otherwise be discarded or used in low-value fishmeal production. The social and economic importance of elasmobranchs is heightened by the fact that fisheries for sharks, skates, and rays are seldom regulated, and therefore are readily available when other species are depleted, restricted, or seasonally unavailable. As many of the world's important fisheries decline, elasmobranchs increasingly appear on the list of "underexploited species," thereby offering new opportunities for fisheries development.

Generally speaking, however, elasmobranch species are also extremely vulnerable to overexploitation (Compagno, 1990; Bonfil, 1995). Long life cycles, delayed sexual maturation, and low fecundity rates severely limit the rate of sustainable harvest for these fishes. For most species, little is known of stock structure, abundance, or reproductive behavior. This lack of information hinders effective management, and, with many species being highly migratory, the task of fisheries management is further complicated. However, elasmobranch fisheries have historically represented only a minor and relatively low-value contribution to the overall fisheries production of most nations, and are often a minor and/or seasonal component of multispecies fisheries, which include such high-profile species as tuna and swordfish. As a consequence, information on both the volume and species composition of elasmobranch catches and landings, and on the species themselves, is sparse or nonexistent. Difficulties in species identification for the approximately 380 described species of sharks and more than 470 species of rays (McEachran, 1990) further limits the quality of information available for status assessments.

A paucity of historical information on elasmobranch fisheries and uses, poor reporting of production and trade of elasmobranch products, and lack of species-specific catch, landing, production, and trade statistics have hindered efforts to assess the impacts of fisheries and use on elasmobranch stocks. It is therefore difficult to predict the management and conservation implications of rising demand for shark products such as meat, fins, and cartilage. In 1994, the TRAFFIC Network, the wildlife trade monitoring program of World Wildlife Fund (WWF) and the World Conservation Union (IUCN), began to address these informational needs by initiating a study of global shark fisheries and trade. TRAFFIC offices in the United States, Europe, India, Southern Africa, Southeast Asia, East Asia, and Oceania undertook regional in-depth research on the exploitation of elasmobranchs, examining available information on shark fisheries, utilization of shark products, domestic markets and trade, and management and conservation measures, and, in many cases, conducting original research on fisheries and/or markets. Each of these reports is published separately by the regional TRAFFIC offices. In addition, the report An Overview of World Trade in Sharks and other Cartilaginous Fishes (Rose, 1996) was published by TRAFFIC International and WWF International in late 1996 and provides a global overview of world markets and trade for sharks and other elasmobranch species and the implications for management and conservation.

The present overview summarizes and analyzes the findings of a regional study conducted by TRAFFIC North America from 1994 to 1996, and includes includes detailed country studies for the United States, Canada, and Mexico. The study was developed through a combination of secondary and original research focused on published and government sources; interviews with fisheries managers and representatives of the fishing industry; market investigations; analysis of customs and other trade data; and review of existing management, research, and regulatory measures. Due to the greater availability of both published and unpublished information sources in the United States, research efforts were more extensive and a wider variety of methods were employed to supplement published sources. In all cases, in response to concerns relating to the publication of proprietary or other sensitive information, the names of individuals and companies interviewed during the course of market research kept strictly confidential and are not cited in the text or in the list of references.

Before beginning the country studies, this report offers a general overview of global and regional shark fisheries, trade, and management in order to place these research results in a broader context. The overview provided in the following section is abstracted from the TRAFFIC Network's Overview of World Trade in Sharks and other Cartilaginous Fishes. Unless otherwise referenced, summary information on information on shark fisheries and trade in the United States, Canada, and Mexico is taken from the country studies that follow. Also included in the overview are conclusions and recommendations drawn from the global study of shark fisheries and trade, which will, in many but not all instances, echo those drawn from the country studies.

It is the wish of the author and of TRAFFIC North America that, by enhancing available information on international trade in these species, this work will assist a number of efforts currently underway at national and international levels.

Sources of Information

The review of U.S. shark fisheries and trade is based upon the following sources:

- Review of published and unpublished research results relating to shark biology, status of stocks, directed and incidental commercial fisheries, recreational fisheries, and commercial use

- Review of fisheries and management information pertaining to the various federal, regional, and state shark fishery management programs underway in the United States

- Analysis of available federal statistics on commercial and recreational catches and landings

- Analysis of U.S. customs data, supplemented by additional information from customs statistics of other countries

- Market surveys of restaurants and herbal, pharmaceutical, seafood, and other retail outlets conducted in major ethnic centers in New York, San Francisco, and Los Angeles during 1994-1996, supplemented in some instances by additional market surveys conducted by the author in Mexico, Argentina, Chile, and Malaysia

- Interviews with federal and state fisheries biologists, managers, and economists

- Industry interviews. A total of 45 fishermen and/or representatives of fishermen's associations; processors; wholesalers; manufacturers, and importers/exporters were interviewed by telephone or in person, and/or observed, during 1994-1996.

Research methods for the chapter on Canadian shark fisheries and trade were as follows:

- Compilation of available data on shark catches and landings

- Analysis of Canadian customs data

- Interviews with federal fisheries biologists and managers

Research methods for the chapter on Mexican shark fisheries and trade were as follows:

- Compilation of published and unpublished research results

- Interviews with federal and state fisheries biologists and managers

- Market surveys conducted in 1991-1992 and in 1995 in Mexico City, Baja California, Quintana Roo, Yucatan, and Campeche

- Interviews with fishermen, wholesalers, and exporters during 1991-1992 and 1995 in Mexico City, Baja California, Quintana Roo, Yucatan, and Campeche

OVERVIEW: NORTH AMERICA IN CONTEXT[1]

The Food and Agriculture Organization of the United Nations (FAO), through its Yearbook of Fisheries Statistics: Catches and Landings and Yearbook of Fisheries Statistics: Production, provides the most comprehensive data available on world fisheries production and is the only published sources of such data on a global scale. According to FAO published data, world elasmobranch catches have risen steadily since the 1940s (Compagno 1984; Bonfil 1994). Total reported world elasmobranch catches averaged 678,249 metric tons (mt) per year from 1985 to 1994, with an upward trend from 622,908 mt in 1985 to 730,784 mt in 1994 (Anon., 1995a; Anon, 1996).

The most notable increases in nominal catches during this period occurred in the Northwest Atlantic, the Indian Ocean, and the Western Central Pacific, with declining trends notable in the Mediterranean and Black Sea and the Northeast and Southeast Pacific. In 1994, the Western Indian Ocean (FAO Area 51), Eastern Indian Ocean (FAO Area 57), Northwest Pacific (FAO Area 61), and Western Central Pacific (FAO Area 71) reported the highest nominal catches of chondrichthyans, together accounting for nearly 57 percent of world nominal catches (Anon., 1995a; Anon.,1996). In that year, major chondrichthyan fishing nations of the world (those reporting nominal catches of 10,000 mt or more annually) included Argentina, Brazil, France, India, Indonesia, Italy, Japan, Malaysia, Maldives, Mexico, New Zealand, Pakistan, Portugal, South Korea, Spain, Sri Lanka, Taiwan, United Kingdom, and the United States. Other important chondrichthyan fishing nations included Australia, Canada, Nigeria, Norway, Philippines, Thailand, and Venezuela (Anon., 1996).

Because chondrichthyan fisheries have historically made a relatively minor contribution to overall fisheries production, little emphasis has been placed on gathering data on these species or their exploitation. As a result, data on the volume and species composition of chondrichthyan catches is often sparse or nonexistent. National agencies often 1) do not report chondrichthyan catches at all; 2) report them as a single category or as "sharks" and "skates and rays;" or 3) report sharks but not related species. National reporting by species is rare and generally occurs only in the few cases where chondrichthyans are included in existing management plans. Of the total elasmobranch fishes reported in landings by the FAO in 1994, approximately 182,000 mt were identified as sharks; 197,000 mt identified as skates and rays; 5,000 mt as chimaeras; and 347,000 mt as unidentified chondrichthyan species (Anon., 1996). The largest increases in landings are reported as unidentified elasmobranchs (Anon., 1994).

In the United States, chondrichthyan landings are dominated by spiny dogfish and skates. Spiny dogfish landings rose rapidly from 8,812 mt in 1982 to 21,242 mt in 1994. Landings of skates also increased to more than 10,000 mt annually during the early

[1] This overview is excerpted from Rose (1996) published by TRAFFIC International.

1990s. After 1985, directed commercial fisheries for sharks on the Atlantic coast developed as a result of rising prices for shark fins, growing popularity of shark fillets and steaks for domestic consumption, and declining stocks of tuna and swordfish. Total landings of sharks other than dogfish rose from 2,554 mt in 1985 to 7,436 mt in 1994. Recreational shark fisheries are also popular in the United States, with recreational landings in the Atlantic and Gulf of Mexico averaging 2.5 million sharks annually from 1978 to 1988.

Rising concern over the status of shark stocks due to the rapid increase in landings led to the establishment of catch quotas and other regulatory measures, such as the federal Fishery Management Plan for Sharks of the Atlantic Ocean, which was implemented in 1993 and increased state regulation in the Pacific. The Fishery Management Plan for Sharks of the Atlantic Ocean (FMP) applies to 73 species of shark, although only 39 species are actively managed through the establishment of quotas. The FMP established annual permit requirements for vessels wishing to sell shark and set commercial quotas for species included in large coastal and pelagic species management units. In addition, the FMP prohibits the practice of finning and stipulates that total fin landings may not exceed five percent of landed carcass weights. Finally, mandatory vessel logbook reporting requires not only the reporting of catch, but also the destination of catch (whether retained, discarded dead, or discarded alive). Despite mandatory reporting of shark catches, some 68 percent of reported shark catches remain unidentified to species.

On the Atlantic coast of the United States, common species in landings include the blacktip shark *(Carcharhinus limbatus)*, sandbar shark *(C. plumbeus)*, bull shark *(C. leucas)*, spinner shark *(C. brevipinna)*, blacknose shark *(C. acronotus)*, finetooth shark *(C. isodon)*, copper shark *(C. brachyurus)*, smalltail shark *(C. porosus)*, oceanic whitetip shark *(C. longimanus)*, silky shark *(C. falciformis)*, lemon shark *(Negaprion brevirostris)*, sand tiger shark *(C. taurus)*, hammerhead shark (Sphyrnidae), bonnethead shark *(Sphyrna tiburo)*, tiger shark *(Galeocerdo cuvier)*, nurse shark *(Ginglymostoma cirratum)*, Atlantic sharpnose shark *(Rhizoprionodon terraenovae)*, longfin mako shark *(Isurus paucus)*, shortfin mako shark *(I. oxyrinchus)*, porbeagle shark *(Lamna nasus)*, thresher shark *(Alopias vulpinus)*, pelagic thresher *(A. pelagicus)*, and blue shark *(Prionace glauca)*.

Landings on the Pacific coast are much lower, fluctuating around some 5,000 mt annually during the late 1980s and early 1990s, consisting largely of spiny dogfish (Squalus acanthias). Other principal species in landings include thresher sharks *(Alopias* spp)., Pacific angelshark *(Squatina californica)*, tope shark *(Galeorhinus galeus)*, and shortfin mako, with minor landings of salmon shark *(Lamna ditropis)*, broadnose sevengill shark *(Notorynchus cepedianus)*, and leopard shark *(Triakis semifasciata)*. Reported shark landings in Hawaii and American territories in the Western Pacific (Guam, American Samoa, and the Northern Marianas) were minimal until 1993, when shark landings of 1,180 mt were registered by Hawaii, consisting almost entirely of pelagic sharks (blue, thresher, and shortfin mako sharks) caught as bycatch by tuna and swordfish vessels relocating from the Atlantic.

Historically, Canada has been a minor shark fishing nation. Total commercial shark landings averaged only slightly over 3,000 mt annually during the 1980s, with most commercial landings consisting of spiny dogfish. Landings of sharks other than dogfish occur mostly on the Atlantic and have consistently reached 100 mt per year since the early 1990s. A directed fishery emerged on the Atlantic coast in 1991 targeting primarily porbeagle, shortfin mako, and blue sharks, and landings of sharks other than dogfish reached 1,890 mt in 1994. In that year, a federal management plan for Atlantic sharks established a number of precautionary management measures. The management plan is similar to that implemented in the United States for Atlantic sharks but applies only to porbeagle, blue, and shortfin mako sharks. The management plan establishes precautionary species-specific quotas for experimental fisheries for these species and prohibits the practice of finning. Vessel reporting of catches of covered species is also required. Neither the U.S. nor Canadian management plan applies to spiny dogfish, which is by far the most important species by volume in Atlantic landings in North America.

Sharks have long served as an important resource for artesanal fisheries in Mexico where reported shark catches have remained relatively constant over the past several years, averaging some 33,500 mt annually from 1982 to 1993. Approximately two-thirds of reported landings are reported for the Pacific, with the remainder reported for the Gulf and Caribbean. Directed shark fisheries on the Gulf and Caribbean take nurse, shortfin mako, silky, bull, dusky *(Carcharhinus obscurus)*, blacktip, blacknose *(Carcharhinus acronotus)*, sandbar, Caribbean reef shark *(Carcharinus perezi)*, night shark *(C. signatus)*, tiger, lemon, Atlantic sharpnose, bonnethead, scalloped hammerhead *(Sphyrna lewini)*, great hammerhead *(S. mokarran)*, and smoothhound sharks (*Mustelus* spp). Rays are also frequently landed for human consumption, but no data are available on the volume or species composition of landings. The small Gulf of Mexico longline fleet targeting tuna, grouper, and snapper takes a utilized bycatch of sharks, including blacktip, oceanic whitetip, bull, tiger, blue, shortfin mako, longfin mako, thresher, bigeye thresher *(Alopias supercilisis)*, scalloped hammerhead, great hammerhead, and other requiem sharks. Shark bycatch by tuna vessels operating in the Pacific is reported to include many of the same species, excluding longfin mako, and including pelagic thresher.

Mexico's Ministry of Fisheries has reportedly suspended the issuance of new fishing permits for shark and, in 1992, initiated the national Shark Program for improved biological and fisheries research for the purpose of developing further management measures for shark fisheries.

Chondrichthyan Products in Trade

Utilization of chondrichthyans is often poorly understood; national fisheries statistics frequently do not report products such as skins and leather, jaws, fishmeal and fertilizer, liver oil, cartilage, or even fins. Artesanal fisheries, producing salted meat and other products for local consumption, may also be underreported in national data. Furthermore, production data available at the national level are often not included in published reports.

Chondrichthyan fisheries--directed as well as incidental--are often characterized by a great deal of waste due to the low commercial value of their flesh and the difficulty or economic infeasibility of obtaining all potential products from a single animal (Kreuzer and Ahmed, 1978; Nichols, 1993; Anon., 1993). Drying and salting of sharks and rays has traditionally been practiced in rural areas worldwide and allows for simultaneous removal of skins, cartilage, and other byproducts. However, drying is time consuming and dried meat commands low prices with limited possibilities for export. Shark meat contains high tissue levels of urea, and production of fresh, chilled, or frozen meat requires immediate processing to prevent spoilage, and, therefore, requires installation of costly refrigeration or freezing facilities. Smaller sharks are more easily marketed for human consumption due to their lower concentrations of mercury and urea, ease of processing, and size comparability with other fisheries species; large sharks are sought for dried fins and leather. Markets for skins are limited by the small number of facilities available for the tanning of shark leather, which requires a special chemical process for the removal of denticles from the skin. It is also difficult to simultaneously process sharks for meat and skins, as skins must be processed immediately to preserve their quality. As a result, shark fisheries historically have been undervalued and ignored except during boom-and-bust cycles for export products, such as liver oil and fins.

In the 1930s and 1940s, the use of shark liver oil as a lubricant and source of vitamin A prompted a boom in fisheries for tope shark--also known as soupfin or liveroil shark--and the spiny dogfish. The development of synthetic substitutes caused the shark liver oil market to collapse, although oil products continue to be used in small volumes in the manufacture of cosmetic and pharmaceutical products. Commercial production of shark meat began in the 1950s and 1960s, and fresh or frozen shark steaks and fillets have become increasingly popular in urban markets. In many regions, skates and rays have also become important to human consumption. The rapid rise of world prices for shark fin in the mid 1980s and again in the early 1990s stimulated trade in this luxury product, thereby stimulating shark fisheries and trade in some areas. Shark cartilage, obtained as a byproduct from commercial and artesanal fisheries, is increasingly marketed as a health supplement worldwide, but no information is available on the volume of production or trade.

Total world production of chondrichthyan products as reported by the FAO gives some indication of chondrichthyan exploitation. The data, however, are incomplete and may be misleading if used to derive the relative importance of trends for individual products. For example, reported production of shark liver oil totaled only 412 mt from 1984 to 1993, while production of other shark oil totaled 227 mt (Anon., 1995b). According to national data, Korea alone imports an average of 327 mt of shark liver oil annually. Worldwide human consumption of fresh meat also continues to be poorly reflected in FAO data. The FAO Yearbook reports average annual production of 4,972 mt of chilled or frozen shark fillets and 9,767 mt of dried salted meat of mixed sharks, skates, and rays from 1984 to 1993 (Anon., 1995b). A separate document (Anon., 1991), however, reports that EEC imports of shark totaled 35,400 mt in 1988 alone. On the other hand, although world production of dried shark fins is reported by FAO to have risen dramatically from 866 mt in 1984 to 6,012 mt in 1993, an examination of customs data by TRAFFIC Network offices suggests that much of this apparent increase is due to double-counting of fins shipped back and forth between China and Hong Kong.

Meat

Traditionally, shark meat has been consumed in dried, salted, and smoked forms in coastal communities worldwide. In most regions, large-scale commercial exploitation of sharks began only after World War I. During this era, it became popular in Germany to smoke the belly flaps of the spiny dogfish for human consumption. Shark meat was also introduced into the fish and chips trade in the United Kingdom. In 1925, the U.S.-based Ocean Leather Corporation was formed and commercial shark fisheries developed in the United States, Mexico, and Venezuela to provide hides to the tannery. Salted and dried meat obtained from these fisheries began to appear in local markets (Kreuzer and Ahmed, 1978).

In many countries, industry and/or government marketing campaigns and market development efforts were necessary to overcome consumer reluctance to accept sharks for human consumption. In Canada, for example, government assistance was provided to the fishing industry for a number of years to encourage the production and marketing of spiny dogfish (Ketchen, 1986). The FAO has also provided assistance in improved fishing techniques, processing, distribution, and marketing to a number of developing countries and has provided numerous technical publications (Kreuzer and Ahmed, 1978; Trachet et al., 1990; Anon., 1991). Sharks also often continue to be sold under market names designated to disguise their true identity in the marketplace. Nonetheless, sharks, rays, skates, and chimaeras have become increasingly important in recent years in domestic and international markets. In Europe, the United States, and South America, for example, fresh shark steaks and fillets are commonly offered in supermarkets. The United States has become an important importer of fresh and frozen shark and is a key exporter of dogfishes and skates to European consumers.

According to FAO data (Anon., 1996), reported world exports of fresh, chilled, and frozen shark meat rose from 22,203 mt in 1985 to 47,686 mt in 1994, while reported world imports increased from 33,838 mt in 1985 to 50,579 mt in 1994. The number of countries reported in trade also rose during this period, with exports reported from 18 countries in 1985 and 37 in 1994. Imports were reported from 12 countries in 1985 and 36 in 1994. Top countries in reported trade during this period are all located in Europe. Principal importers are Italy, France, the United Kingdom, Germany, and Denmark, while the main exporters are the United Kingdom, Norway, Ireland, Denmark, and Germany. Their importance as reflected in FAO data are likely due in part to their historic role in shark, and specifically dogfish trade, and also to more complete reporting of trade. For example, the United States is among the world's most important traders of shark meat, but does not appear in the above list because, until 1989, trade in shark meat was not reported under a separate customs classification.

Reported trade in shark fillets remains much lower in volume, with exports peaking at 4,698 mt in 1988. World trade in fresh, chilled, and frozen skates appears to remain significantly underreported, with imports reported only for New Zealand and Norway, and exports only for the United Kingdom, Iceland, and Norway. An average of 1,780 mt of unidentified sharks, rays, skates, and chimaeras were reported as exported annually from 1985 to 1994, with an average of 6,077 mt of unidentified species imported annually from 1990 to 1994.

Shark species preferred for human consumption vary by country and region according to species availability and customary processing and preparation techniques. Generally speaking, a number of species are widely recognized for their high quality flesh. Shortfin mako is considered the world's finest quality shark and is used for sashimi in Asia and sold in high-value fresh seafood markets in the United States and Europe, where it is sometimes comparable in price to swordfish. Other high-value shark species are thresher and porbeagle sharks--pelagic species caught in high numbers in both directed fisheries and as bycatch in tuna and swordfish fisheries. These species are widely sold by dealers of sashimi-grade tuna and swordfish, and the quality of their meat is compared to swordfish. Pelagic thresher and bigeye thresher are considered inferior to thresher, but are also widely marketed. These species are often marketed in the same form as swordfish--as steaks, logs, or clippers--and, in the United States, are often consumed as broiled or grilled steaks (Frimoldt, 1995a). Due to its high quality meat, the shortfin mako is typically offloaded and sold in overseas ports by Taiwanese distant-water longline vessels to preserve its quality, while other species are generally landed in Taiwan (Chen et al., 1996).

The blue shark, another pelagic species that is caught in large numbers in both directed and incidental fisheries, is less preferred for human consumption, as it is relatively soft and the flavor considered strong (Frimoldt, 1995b), although Paust and Smith (1986) report that this species is used for sashimi in Japan. Limited markets also exist for this species in Europe. Surveys in France, for example, found blue shark in supermarkets and wholesale and open air markets. Blue shark landed in the United Kingdom and Ireland is generally exported to France. Blue shark is also consumed in Spain and Germany, and in Italy, it is falsely marketed as spiny dogfish or smoothhound. Small fisheries have also arisen in Canada and the United States for export to the European market.

The salmon shark, closely related to the porbeagle and associated with the blue shark through much of its range, is caught commercially by Japanese longliners and is one of the most important species in Japanese landings. This species is reported to be consumed regularly in northern Honshu. Although it is not generally marketed domestically in significant quantities (Frimoldt, 1995a), it is exported to Europe and marketed along with porbeagle (Paust and Smith, 1986). Attempts to market this species in the United States and Canada have thus far been unsuccessful (Paust, 1987; Paust and Smith, 1986).

The requiem sharks (Carcharinidae) are also distributed widely and commonly preferred for human consumption (Frimoldt, 1995a, 1995b). The sandbar shark, found in the eastern and western Atlantic and in the South China Sea, has soft reddish meat of acceptable quality and is consumed fresh, frozen, and dried and salted. The whitetip shark is caught incidentally by high seas longliners and is used as food in Europe, North America, and Asia. The blacktip reef shark is widely consumed throughout the Indian, Pacific, and South Pacific Oceans and is consumed or marketed fresh, frozen, or dried and salted. Tiger shark, which also produces a good quality meat is widely consumed and particularly favored in the Caribbean. In the United States and in Central and South America, blacktip, dusky, sandbar, lemon, and nurse sharks are also consumed. These species are, however, typically reported in local and domestic markets rather than international trade.

Consumption of fresh and frozen shark meat requires careful handling. The bodies of sharks contain high concentrations of urea, and unless the carcass is quickly chilled or frozen, ammonia quickly begins form, causing an unpleasant odor that makes the product unacceptable to the consumer. Preventing the formation of ammonia requires not only immediate bleeding and icing or freezing, but the removal of the shark from the water soon after death. Smaller sharks, such as dogfish, are not bled, but are immediately put on ice or frozen (Kreuzer and Ahmed, 1978; Anon., 1991). Fresh and frozen shark meat may be packaged in a number of forms for storage and shipment, including whole carcasses (headed and gutted), split carcasses, fillets, and blocks. In many areas, where facilities for immediate refrigeration or freezing or other necessary quality control measures are not available, sharks and rays are more commonly filleted and then salted and dried. The urea content of the blood varies by shark species from 1,600 mg% in spiny dogfish to 2,300 mg% for hammerhead sharks. The urea gives shark meat a somewhat bitter acid taste, affecting not only the species preferred for human consumption but also processing techniques. In general, both carcasses and fillets for fresh consumption require washing or soaking in a brine solution. Very fresh meat from species such as spiny dogfish does not require soaking; while hammerhead shark fillets require soaking in brine for several hours (Anon., 1991).

Because sharks are long-lived predators, the accumulation of mercury and other heavy metals in their flesh is also significant, particularly in larger sharks. Smaller sharks, such as spiny dogfish and smoothhounds, tend to accumulate lower concentrations of urea and heavy metals and are therefore more widely preferred for human consumption. Spiny dogfish and smoothhounds are typically finned and gutted and landed as a whole carcass with the skin intact; typically, meat and fillets do not require soaking. The backs are marketed in Europe and Australia and the belly flaps are smoked in Germany for the preparation of schillerlocken (Frimoldt, 1995a). These species are typically marketed as fresh whole carcasses in South America, where they are sold as cazon.

Spiny dogfish landed in the United States and Canada are typically processed for export to Europe. The "back" or "tube" is the main body of the fish, accounting for 28 to 30 percent of the total body weight. This product is exported for sale as fillets, steaks, portions, and fish and chips. The belly "flap" or "nape" accounts for an additional 7 percent of the round weight and is exported only to Germany. European markets favor larger dogfish for production of backs and belly flaps (fish of 2.3 kg or more are sought for backs); while the German market favors belly flaps of 3.5 cm or greater in length, requiring a fish of some 4 kg. Small fish are typically discarded or sold to scientific and laboratory suppliers for use in education or research. A smaller volume of whole, headed and gutted, and frozen dogfish is exported to Japan, and some dogfish is supplied to a manufacturer of kamaboko--a type of Japanese fish cake.

The United States is a major world consumer and trader of shark meat. Reported production of shark steaks and fillets alone rose from 3,514 mt in 1984 to 5,679 mt in 1993. Imports of shark averaged 2,600 mt annually in most years from 1989 to 1995, the years for which trade data are available. Approximately 60 percent of U.S. imports consist of dogfish, primarily from Canada, that are processed for re-export. The remaining 40 percent appear to consist almost entirely of pelagic species--primarily mako, thresher, and porbeagle--which are imported from Chile, Ecuador, Mexico, Panama, Peru, Surinam, Uruguay, Canada, Portugal, Japan, Philippines, and Taiwan. Importers, exporters, and processors widely report that these species are the only ones, other than dogfish, that are of sufficiently high value to appear in trade. They are supplied primarily to restaurants and other dealers in high quality fisheries products. By contrast, domestic landings of sandbar, blacktip, and other coastal sharks are used primarily for domestic consumption and are sold to supermarkets and processors of frozen packaged products (e.g., frozen shark fillets, frozen shark medallions).

In Canada, porbeagle and blue sharks are typically exported to Europe, while mako is consumed domestically or exported as steaks to the United States. Spiny dogfish is also consumed domestically in small quantities, but is primarily exported to Europe. Dogfish and other sharks landed in Canada are also frequently exported to the United States for processing. Total Canadian exports of fresh and frozen dogfish and other sharks averaged 2,259 mt annually from 1988 to 1995. This volume is likely to consist in large part of fresh dogfish shipped to the United States for processing; in 1995, the U.S. reported imports of 1,253 mt of fresh dogfish from Canada. Imports of dogfish, primarily from the United States, are also rising, reaching a total of 760 mt in 1995.

Sharks and rays are widely consumed in Mexico. Small sharks, including juveniles, are traditionally marketed fresh as cazon in both coastal and rural areas. Shortfin mako and thresher sharks are typically processed as headed and gutted. They are marketed fresh or frozen to urban areas, exported, or smoked, filleted, salted, and dried for local markets. Rays are marketed fresh as wings or strips, smoked or dried, and salted. According to data supplied by the Ministry of Fisheries, annual production of shark from 1990 to 1992 averaged 17,477 mt tons of fresh and chilled shark, 3,891 mt of frozen shark, and 396 mt of dried, salted shark. According to the FAO (Anon., 1996), Mexico first began to report imports of fresh or chilled shark in 1990. Reported imports rose from 219 mt in 1990 to 863mt in 1994. Smaller quantities of frozen shark began to be reported in imports, rising from 30 mt in 1990 to 246 mt in 1994. Reported exports of fresh or chilled shark rose from 143 mt in 1990 to 853 mt in 1994; no exports of frozen shark or of shark fillets are reported. The Bank of Mexico, however, reported exports of fresh shark totaling 589 mt in 1992, 739 mt in 1993, and 853 mt in 1994. Exports of 12 mt of frozen shark were reported in 1994. All shark exports are reported to the United States with the exception of 0.3 mt of fresh shark reportedly exported to Japan in 1993.

Shark Fin

Unlike the bony fishes, sharks achieve buoyancy through their lighter cartilage and large oil-filled livers (Last and Stevens, 1994). Shark fins largely consist of ceratotrichia--soft collagen and elastin fibres commonly referred to as fin rays or fin needles--which have been used for human consumption for centuries. Shark fins are among the world's most expensive fishery products. The value of shark fins varies according to color, size, thickness, and fin needle content, but nearly all species have commercially valuable fins (Kreuzer and Ahmed, 1978; Subasinghe, 1992). Essentially tasteless, but appropriately gelatinous, processed shark fin needles resemble rice noodles in wet, dried, or cooked forms. Shark fin soup is typically prepared by adding other ingredients for taste, such as chicken or abalone. Shark fin substitutes are usually made from seaweed extract or a combination of similar products. They can occasionally be found on the market selling as "vegetarian sharkfin," or falsely marketed as true shark fin (Parry Jones, 1996a).

The consumption of shark and shark fin has a long and venerable history in Chinese cuisine and culture. Hong Kong is currently acknowledged as the shark cuisine capital, boasting the highest quality and most diverse cooking methods in the world. The popularity of shark fin in Hong Kong began to rise after World War II when shark fin soup became a popular and affordable dish selling for about HK$0.50 per bowl. In the early 1970s, when the Hong Kong stock market experienced explosive growth, shark fin rice soup became a popular dish. By the 1980s and 1990s, a large number of exclusive and specialty restaurants serving shark fin emerged. Demand is highest during October to February--popular months for weddings and other feasts--and peaks in February with the Chinese New Year (Parry Jones, 1996a).

According to Cook (1990), consumption of luxury shark fin was discouraged in China by the PRC government, but, in the mid 1980s, relaxation of state market controls, increased disposable income, and growing official acceptance of shark fin consumption led to a dramatic increase in domestic consumption and a corresponding impact on world fin prices and trade. Beginning in 1987, due to the development of domestic shark fisheries and shark fin processing facilities, China began to play an important role in world shark fin trade, as both a consumer and a processing center. However, the results of TRAFFIC research suggest that much of the reported world trade in shark fins currently involves imports, exports, and re-exports among China and two other important processing and trade centers--Hong Kong and Singapore (Parry Jones, 1996a).

Increasing Asian demand for shark in the late 1980s and 1990s with the opening of China as a seemingly unlimited market for shark fin, has been accompanied by a significant increase in world shark fin prices. As a result, opportunities for cash earnings in subsistence and commercial fisheries have increased in some areas. In some cases, this has contributed to increased catches or increased landings of shark bycatch previously discarded, for example, by tuna and swordfish longliners faced with declining catch and increased regulation of target species. In some areas, national agencies or international organizations such as the FAO have offered assistance in developing markets for shark fins. For example, the FAO has published a number of technical manuals detailing the processing and marketing of shark fins (Trachet et al., 1990; Subasinghe, 1992).

According to the FAO, total world imports of dried and salted shark fins averaged 4,700 mt annually from 1984 through 1993, peaking in 1988 at 5,915 mt. Total reported world exports averaged 4,139 mt annually during this period, peaking in 1989 at 5,481mt (Anon., 1995a). Again however, FAO published data remain substantially incomplete, since imports are reported for only nine countries and exports reported for fifteen countries. Data are also often incompletely reported for the countries included. For example, the United States records imports but not exports of shark fins; imports are included in published data only beginning in 1989.

Hong Kong customs data provide a more comprehensive view of world trade in shark fins since much of the world trade passes through Hong Kong for processing, consumption, or re-export. From 1980 to 1995, Hong Kong reports shark fin imports from 125 countries and re-exports to 75 countries. Indeed, much of the trade volume included in FAO reports is contributed by Hong Kong. As discussed below, a significant proportion of fins imported into Hong Kong are subsequently processed in China. Reported China and Hong Kong imports since 1987 are greatly inflated by repeat transactions, as fins are imported into Hong Kong, exported to China for processing, and then re-imported into Hong Kong. Much of the apparent increase in fin trade as reported by FAO is, therefore, actually due to the increase in reported repeat shipments of fins between Hong Kong and China.

Both published reports and the results of interviews and field research by TRAFFIC investigators reveal widely different rankings by species in both dealer preference and contributions to traded volumes. This is presumably due, in part, to regional differences in species availability. Interviews with Hong Kong shark fin traders indicate that hammerhead, tiger, oceanic whitetip, blacktip, dusky, and blue shark fins are among the species preferred (Parry Jones, 1996a). Although the fins of blue shark are not of high quality because of their low fin needle content, they are abundant and relatively inexpensive, and are therefore important in the trade. Estimates by fin traders suggest that blue shark may comprise some 50 to 70 percent of the shark fins traded in Hong Kong (Parry Jones, 1996a). Mako pectoral fins, thresher, nurse, and leopard shark fins and ray and skate wings are reported as having little or no commercial value (Parry Jones, 1996a). Generally speaking, retail prices for blue shark fins in Hong Kong range from approximately US$40 to US$564 per kilogram, although a retail price of as much as US$846 has been reported for a fin weighing 7.3kg. Shark fin soup ranges in price from US$5 to US$90 (Parry Jones, 1996a)

Fin dealers in the United States report that hammerhead and sandbar sharks produce the highest quality fins, while the fins of dusky, tiger, blacktip, bull, and silky sharks are also considered of high quality. Lemon, whitetip, and sand tiger are considered of medium quality, while mako, porbeagle, blue, thresher, and dogfish sharks all produce fins of low quality, with the exception of the lower caudal fin of the mako. Basking shark and whale shark fins appear in small numbers in international trade.

As with blue and other pelagic shark species, spiny dogfish fins are of relatively low value. In addition, only the pectoral and caudal fins are used and, in their fresh form, together account for only 2.5 to 3.0 percent of the body weight of the fish. However, because of the tremendous volume of spiny dogfish and other dogfish species caught in the United States and Europe, they have been routinely traded for at least the past 10 to 20 years. In many areas, including the United States and Europe, they may comprise a significant proportion by volume of the shark fins reported in trade.

In many cases, shark fin dealers are able to identify individual countries as major suppliers of particular species. Hong Kong dealers note that Japan and Spain are major suppliers of blue shark fins, blacktip reef sharks from the Philippines and the Middle East, hammerhead shark fins from Mexico, and oceanic whitetip and tiger shark fins from Mexico, Brazil, the Philippines, and Venezuela of (Parry Jones, 1996a). Dealers in the United States who routinely import fins from Latin America and Africa for re-export to Hong Kong report abundant supply of hammerhead, sandbar, and blacktip fins from Mexico; sandbar and blacktip fins from Venezuela; mako, blue, and hammerhead fins from Peru; and dogfish fins from Argentina.

Shark fins are processed and marketed in the following forms (Kreuzer and Ahmed, 1978; Lai, 1983): dried shark fins with the skin intact; semi-prepared fins with the skin removed but the fibres intact; fully prepared with individual strands of the cartilaginous platelets showing separately; frozen prepared fins; shark fin in brine; fin nets, in which the cartilaginous fin needles have been boiled, separated, redried, and packaged in loose groupings; and canned shark fin soup.

Fins from larger sharks are sold as fin sets, consisting of the larger more valuable fins-- the first dorsal, pectorals, and lower caudal fins. Buyers offer a better price for a set of four fins from the same shark than for an assorted mixture. The lower caudal fin is the most valuable of the set due to its higher fin needle content and size. In some species, the lower caudal fin may account for up to 50 percent of the weight of the fin set. The second dorsal fin, the pair of ventral fins, and the anal fin are typically sold as secondary or miscellaneous fins, and are of lower commercial value. They are often taken only from large sharks or from species with particularly large fin sets, such as the lemon shark, and sold as mixed fins or fin nets after processing (Subasinghe, 1992).

Shark fins are removed from the carcass as quickly as possible and cut at the fin base where the fin needles begin. The dorsal and pectoral fins are thick at the base, with muscle tissue extending into the base of the fins. The "half-moon cut" is preferred for these fins in order to minimize the amount of meat left attached to the fin. A poor cut leaves residual meat, affects the odor and color of the fin, and results in a fin of lower quality and value. The caudal fin is removed with the "straight cut." Freshly cut fins are cleaned and washed and may be stored on ice, frozen, or dried immediately (Subasinghe, 1992; Lai , 1983). Only the two dorsal fins and the caudal fin are taken from the giant guitarfish (Barnett, 1996b), while only the pectoral and caudal fins are taken from the spiny dogfish.

Kreuzer and Ahmed (1978) report that the average fin-to-body weight ratio for wet fins is 5 percent, with a range of 1.5 to 11.2 percent; the figure of 5 percent (wet fin to carcass weight) is also used in the United States management plan for sharks (Anon., 1993). Anderson and Ahmed (1993) derive a slightly lower estimate of 4.5 percent for wet fins and 1.44 percent for dried fins. The difference in estimates is likely due, in part, to different species mixes, different methods of cutting the fin, and different methods of preparation. For example, in the Maldives, the straight cut is often used, which requires further trimming by buyers.

Drying of shark fins can be performed in a number of ways. Fresh, cleaned fins can be hung from a line, either onboard the vessel or after landing, or sun dried on mats, trays, or racks, and turned periodically to avoid scorching or curling; large fins are typically hung to dry. In some cases, salt is lightly dusted over the fins and applied liberally to the cut before drying. Mechanical dryers may also be used, although traders prefer sun-dried to oven-dried fins. Drying results in a reduction by weight of approximately 30 to 50 percent, however, moisture content and subsequent loss of volume during drying varies by species. The fins may be packed for shipping in cartons, wooden cases, or burlap sacks (Lai, 1983; Subasinghe, 1992; Parry Jones, 1996a).

Lai (1983) reports that in Hong Kong, wet and dried fins may be graded in one of two ways. Fins from domestic fisheries are typically sold wet. They are graded first according to species and then by size within a species. Imported fins are generally shipped in their raw, dried form. These may be graded either according to the species or grouped according to skin color. Given the difficulty of identifying species for imported dried fins, the latter system has become more widespread. The color of the skin is black or white depending on the species. White fins are generally priced higher than black fins because of their generally higher fin needle content. Shark fins are then generally further classified according to size and other factors. Size is measured along the length of the base, or from the center of the base to the tip of the fin. According to Subasinghe (1992), fins are graded as extra large (40cm and above), large (30-40cm), medium (20-30cm), small (10-20cm), very small (4-10cm), and mixed or assorted, the latter including ventral and anal fins.

Processing of shark fins begins with soaking in water; fresh fins are soaked for 8 to 10 hours and dried fins for 16 to 24 hours. After the initial soaking, the fins are further soaked in hot water until the skin is soft. The softened fins are then placed in chilled water and the skin and scales are removed with a wire brush or metal scraper. They are washed to remove any remaining meat, the cartilagenous base plate is removed, and they are then re-washed in running water. In some cases, the fins may be soaked in a bleaching agent to remove blood from the cartilagenous base (Kreuzer and Ahmed, 1978; Lai, 1983; Subasinghe, 1992).

Processed fins are dried in the sun or by a mechanical dryer, retaining their original shape. In some cases, processors may remove the hard cartilage of the dorsal fins and the cartilaginous platelets between the two layers of fin needles before drying. The fins may be further processed to fin needles or fin nets by again soaking the processed fins for up to 12 hours and boiling them for up to ten minutes to remove the gelatinous membrane and expand and expose the fin needles. The fins are then transferred to chilled water and fin needles are separated from the membrane. Fin needles may be removed to form wet fin needles, or may be further processed to fin nets. For fin nets, wet needles are arranged into bundles of approximately 100g each and then sun dried (Kreuzer and Ahmed, 1978; Lai, 1983; Subasinghe, 1992).

Nair and Madhavan (1974) report that the fin needle yield as a percentage of total wet fin weight for white varieties ranges from 3 to 5 percent for the dorsal and ventral fins and 2 to 4 percent for caudal fins. The fin needle yield for black fins ranges from 2 to 3 percent for dorsal and ventral fins and 1.5 to 2.5 percent for caudal fins. The respective yields for dried fins are 12 to 25 percent and 3 to 6 percent for white varieties; and 6 to 15 percent and 4 to 6 percent for black varieties. Fin needle yield reported by these authors for caudal fins is apparently based on both the upper and lower caudal lobes. However, as the upper caudal lobe yields almost no fin needles and is not used commercially, the respective yields for the lower caudal lobes appearing in trade would be much higher.

Although in recent years, the United States has played a significant role in world shark fin trade as a supplier, importer, consumer, and transshipment point, the U.S. does not report production or exports of shark fins. Data reported by U.S. seafood processing plants indicate domestic production of 118 mt in 1989, but this figure is likely to significantly underestimate domestic production. The development of large-scale commercial directed shark fisheries in the mid to late 1980s was undoubtedly accompanied by an increase in shark fin production, much of it a byproduct of directed fisheries for spiny dogfish on the Atlantic and Pacific coasts. Since the late 1980s, much of the U.S. shark fin production has consisted of spiny dogfish fins, as processors and dealers report that these fins are universally taken and have been in trade for at least the past ten to twenty years. Indeed, the finning of dogfish is reported to have occurred in the past, when prices for dogfish meat were too low to make it economically viable to land and process the entire fish. After 1993, the implementation of landing quotas and other restrictions for the Atlantic coast and the decline of the Atlantic spiny dogfish fishery reduced the volume of supply available from the United States.

From 1972 to 1985, annual U.S. imports averaged approximately 54 mt, then increased rapidly to a peak of 281 mt in 1992. Rising imports from Latin America and the Caribbean--notably Brazil, Costa Rica, Ecuador, El Salvador, Guatemala, Guyana, Mexico, Netherlands Antilles, Nicaragua, Panama, Peru, Trinidad and Tobago, Uruguay, and Venezuela--accounted for much of this increase. Significant imports from Canada, Africa, and the Pacific also began to appear in the late 1980s and early 1990s. Although the bulk of both domestic production and imports are exported or re-exported, there is significant and apparently growing domestic consumption of shark fins in urban areas with large populations of ethnic Chinese. Shark fins are however, typically exported to Hong Kong and Singapore for processing, then re-imported from Asia as processed fins.

Exports of shark fins are not reported in customs, but Hong Kong reports imports of shark fins from the United States averaging 366 mt annually from 1988 to 1994; increasing from 261 mt in 1988 to a peak of 479 mt in 1992; then declining to 418 mt in 1994. Singapore reports average annual imports from the United States of 17 mt from 1990 to 1995; increasing from 3 mt in 1990 to 34 mt 1995. China's customs data--available only for 1992 and 1994--report imports from the United States of 37 and 44 mt, respectively.

Canadian customs do not specifically report trade in shark fins, but market research conducted by TRAFFIC suggests that the fins of primarily spiny dogfish and blue sharks are processed for export. Dockerty (1992), analyzing the customs records of nine Asian importing nations (Hong Kong, Japan, Indonesia, Malaysia, Singapore, South Korea, Sri Lanka, Taiwan, and Thailand), reported minimum Canadian exports of shark fin averaging 18 mt annually from 1984 to 1990, increasing from 7 mt in 1984 to 23 mt in 1990. Hong Kong customs reports imports of dried shark fins averaging 7 mt annually from 1988 to 1994, and the United States reports average imports of dried fin from Canada of 14 mt annually from 1988 to 1995.

In Mexico, shark fins are typically removed by processors for drying and sale and, in many cases, collected by the agents of fin dealers at open-air markets. From 1978 to 1988, Mexico's Ministry of Fisheries reports average exports of 137 mt of shark fins annually; data are not available from this source after 1988. Hong Kong customs reports average imports of shark fin from Mexico of 150 mt annually from 1984 to 1994, peaking in 1994 at 207 mt. Much of Mexico's shark fin exports are, however, likely to be shipped first to the United States. U.S. customs report imports of shark fin from Mexico averaging 29 mt annually from 1986 to 1995 .

Shark Skins and Leather

Shark skins are characterized by the presence of small placoid plates called dermal denticles on the skin and the attachment of the muscles directly to the skin. These characteristics make it difficult to skin sharks and process their hides. Shark skins were originally used as a rough abrasive for rasping and polishing; shark skin in its rough form is known as shagreen. Boroso leather, taken from the hides of small shark species, is made by polishing the denticles to a high gloss and is extremely expensive. The discovery by Ocean Leather Corporation of a chemical process for removing the denticles from shark skins brought shark hides into wider usage for tanned leather. Shark leather is extremely durable and has an attractive grain that sometimes resembles crocodile skin (Kreuzer and Ahmed, 1978). Traditionally, the Japanese used shark skin in armor and sword handles. Currently, shark leather is used in Japan for handbags and watchbands (Kiyono, 1996), and in the United States for cowboy boots, belts, and watchbands.

A significant market for shark leather originally developed in the United States, with significant markets subsequently developing in Japan and Europe (Kreuzer and Ahmed, 1978). Even in the United States, however, fisheries based primarily on the production of hides have historically proven unsuccessful economically. Tanneries require skins from sharks of 1.5 m in length or greater, and it is difficult to supply a sufficient number of large sharks in a single area over a long time period. Moreover, the skins of large mature females tend to be heavily scarred from wounds inflicted during mating, therefore, many large hides are not marketable or are of low value (Kreuzer and Ahmed, 1978).

The increasing popularity of fresh and frozen shark meat also discourages the use of shark skins for leather production. Shark is often sold as gutted or headed and gutted carcasses, with the skin left intact to protect the meat and delay oxidation. Shark skins are damaged by exposure to fresh water or to ice, but on-board processing for the production of meat typically includes gutting and immediate refrigeration or freezing of the carcass. On the other hand, retaining shark skins is much more feasible during production of dried and/or salted meat from large sharks, especially in small-scale fisheries with short trip durations (Kreuzer and Ahmed, 1978; Limpus, 1987). Production of shark leather, therefore, remains significant in some developing countries, such as Mexico (Rose, 1992).

According to Kreuzer and Ahmed (1978), shark species preferred for the production of leather are tiger, nurse, lemon, dusky, sandbar, bull, porbeagle, night (Hyporion signatus), blacktip, shortfin mako, scalloped hammerhead, shortnose saw shark (Pristiphorus nudipinnis), blue shark, and Taiwan gulper shark *(Centrophorus niaukang)*. These authors report that the nurse shark produces the most highly valued hide. The blue shark is preferred by Japanese tanners but is not marketable in the United States or Europe (Kreuzer and Ahmed, 1978; Limpus, 1987). Tanneries in the United States and Mexico report tiger shark to be the preferred species for the production of leather; and, while the skins of lemon, dusky, blacktip, and whitetip are also suitable, the skins of nurse sharks may be tanned, but are of considerably lower value.

In many cases, species that are heavily fished for fresh or frozen consumption may not be utilized for their leather, due to different processing requirements; for example, shortfin mako, thresher, and porbeagle skins are not likely to appear in markets and trade. Processing and marketing characteristics vary widely, however, according to available facilities for storage and processing, characteristics of the fishery, and other factors. In Mexico, for example, skins are frequently taken from a number of species used for the production of dried and salted shark meat.

Shark skins are removed by starting a main cut down the center of the back of the shark whose fins have already been removed. Additional cuts are made around the head, behind the gills and pectoral fins, and around the edge of the lower jaw. The skin is then peeled back with a knife, fleshed, washed with saltwater, and salted. The H-shaped hides are packed by folding the flesh side in, and sorted by species and grades prior to shipment to the tannery (Kreuzer and Ahmed, 1978; Rigney, 1991).

All shark hides intended for leather tanning are graded according to the number of imperfections (sour spots, cuts, scars, damage from prolonged exposure to the sun). Generally speaking, the skin is graded by inspecting three sections--the center and two flanks. A top grade hide has no imperfections, while, if all three sections are damaged, the hide is worthless. Grading of blue shark hides in Japan is based on the area damaged, but also requires that no imperfections be found in the center of the skin (Kreuzer and Ahmed, 1978).

The Ocean Leather Corporation of the United States succeeded in monopolizing the production of shark leather for several decades, and, in the mid 1980s, reportedly handled some 50,000 shark skins annually (Taylor, 1993). More recently, tanneries in Europe, Japan, Australia, and Thailand have begun to process shark leather, and attempts made to utilize otherwise discarded shark skins in the Bay of Bengal region (Bostock, 1991; Rigney, 1991). Unfortunately, neither domestic production data nor trade data for shark skins are available from the majority of producing countries, including Australia, Japan, China, Bangladesh, Thailand, or Europe.

The principal demand for shark leather in the United States is for the manufacture of cowboy boots in Texas, with smaller sales to manufacturers of small leather goods, particularly watch straps and belts, in the United States, Europe, and Asia. The Ocean Leather Corporation no longer exists and a single tannery now produces shark skins, along with other exotic leathers. The popularity of Western boots has declined since the 1980s, so tanning of shark skins within the United States has reportedly fallen sharply. In previous years, the tannery purchased some raw skins from U.S. suppliers, but, due to the difficulty of processing raw skins, they purchase only crusted skins of tiger, dusky, blacktip, whitetip, and nurse sharks from a single supplier in Mexico. Tanned shark leather also continues to be imported directly by brokers and leather goods manufacturers.

During the 1980s, significant trade of shark skins existed across the U.S.-Mexico border. The shark skins were imported by U.S. companies, cut, exported to Mexico for assembly into Western boots and other products, and then reexported from Mexico to the United States. In addition to this cross-border trade for assembly purposes, a number of shark skins and shark leather goods entered the United States directly from Mexico. Although Mexico is known to be a major supplier of shark skins to the United States, the nature of the trade and the fact that U.S. exports are more commonly underreported than imports make it difficult to determine what proportion of these skins and leather products originated in Mexico. Moreover, at least one Mexican shark leather tannery has historically purchased raw shark skins from several Central American countries.

There are a number of shark skin tanneries currently operating in Mexico. Buyers in the Yucatan purchase wet salted skins from processors at approximately US$4 each and generally can use skins from all species. Shark skins are exported to the United States, and to a lesser extent Europe, and are used for the domestic manufacture of boots and small leather goods. Tanneries on both the Gulf of Mexico and Pacific coasts report that shark skins are becoming more difficult to supply, due to increased marketing of fresh and frozen shark meat; carcasses are often processed whole with the skin intact or as splits (halves), which destroys the belly flap favored by tanneries and leather goods manufacturers. The Bank of Mexico reports exports averaging 4 mt of raw shark skins annually from 1983 to 1993, and 14 mt of finished skins annually from 1984 to 1988.

Shark Liver Oil

Sharks have no swimbladder; instead, hydrostatic functions are performed by their large livers saturated with oil. Shark livers vary in size and weight by species and by season. The relative weight of the liver to total body weight tends to increase with total body weight (Kreuzer and Ahmed, 1978). Shark oil has been widely used historically as a lubricant in the preservation of small vessels, in the tanning and curing process of leather, and for a variety of other uses. For example, the Maori of New Zealand used the liver oil of the tope shark in cosmetics, for traditional ceremonies, and mixed with pigment for painting canoes, houses, and carvings (Hayes, 1996a). In the late 19th century, a fishery for spiny dogfish existed on the Atlantic coast of the United States exclusively for liver oil, which was used for the tanning and curing of leather. After World War II, dogfish liver oil also began to be used as a rubber extender (Jensen, 1965). In Japan, shark oil was used as a lubricating oil in combat planes during World War II (Kiyono, 1996).

In the 1930s, global markets developed shark liver oil for use in the production of vitamin A supplements; by the 1950s, these markets had collapsed due to the development of synthetic vitamin A. Currently, a limited market remains for shark liver oil, which is sold in capsule form as a health supplement. The liver and body oils of spiny dogfish and other sharks continue to be used in the United States and in Europe in the tanning and curing of leather (Buranudeen and Richards-Rajadurai, 1992). Shark liver oil is also sometimes used as an ingredient in Preparation H, an over-the-counter hemorrhoid ointment manufactured in the United States and distributed internationally.

Shark liver oil also yields squalene, an acyclic hydrocarbon ($C_{30}H_{62}$) that facillitates the biological process of sharks, enabling them to live in deep water. It is also used in the manufacture of lubricants, bacteriocides, pharmaceuticals, and cosmetic products, such as skin cremes. Squalene is included as a non-active ingredient in pharmaceutical applications as it imparts increased skin permeability, while squalane, a compound produced by hydrogenating squalene, is miscible with natural skin oils, and is therefore useful as a skin moisturizer. Diacyl glyceryl ethers, another chemical compound found in shark liver oils, is reported to have bacteriostatic action that protects against radiation and heals wounds (Summers and Wong, 1992; Buranudeen and Richards-Rajadurai, 1986; Kreuzer and Ahmed, 1978).

In 1993, the chemical compound squalamine was isolated from dogfish. Studies conducted in the United States since 1993 suggest that this chemical is effective against bacterial infection, and acts against viruses, including HIV. Magainin Pharmaceuticals of Pennsylvania, in collaboration with the National Institutes of Health, is currently testing the use of squalamine for potential use in the treatment of several sexually transmitted diseases, including herpes, gonorrhoea, and chlamydia (Mestel, 1995). In 1996, researchers at Johns Hopkins Medical Institute reported that in preliminary tests using laboratory animals, synthetic squalamine also appeared to slow the process of vascularization in solid brain tumors, suggesting that it may be useful in the treatment of cancer (Altman, 1996).

Several species of shark are known or reported to yield liver oil rich in Vitamin A. These include the tope shark, spiny dogfish, Cuban dogfish *(Squalus cubensis)*, catsharks (*Galeus* spp)., longfin mako shark, starspotted smoothhound *(Mustelus manazo)*, and hammerhead sharks (Frimoldt, 1995a and 1995b; Kreuzer and Ahmed, 1978). Sharks that have a high squalene level tend to have a lower vitamin A content in their liver oil. Shark species preferred for the squalene content of their liver oil are usually found at depths of some 600 to 1,000 m and include the shortspine spurdog *(Squalus mitsukurii)*, gulper sharks *(Centrophorus squamosus, C. calceus, C. acus, C. atromarginatus, C. lusitanious,* and *C. niaukang*), and basking sharks *(Cetorhinus maximus)* (Kreuzer and Ahmed, 1978). Also reported for the high yield of squalene from their liver oil are the longnose velvet dogfish *(Centroscymnus crepidater)*, Mandarin dogfish *(Cirrhigaleus barbifer)*, kitefin shark *(Dalatias licha)*, and birdbeak dogfish *(Deania calcea)* (Compagno, 1984; Last and Stevens, 1994). Several other shark species are exploited for their liver oil for more generalized uses. These include the roughskin shark *(Centroscymnus owstonii)*, bluntnose sixgill shark *(Hexanchus griseus)*, thresher sharks, great white *(Carcharodon carcharias)*, salmon shark, and porbeagle (Compagno, 1984; Frimoldt, 1995a, 1995b; Kiyono, 1996).

In the 1930s and 1940s, the use of shark liver oil as a lubricant and source of vitamin A prompted a boom in fisheries for tope shark and spiny dogfish, but the development of synthetic substitutes soon caused the shark liver oil market to collapse. Although the oil is still used in the manufacture of cosmetic and pharmaceutical products, little production or trade information is available. One trend evidenced by regional market studies is that in many former supplying countries, processing and marketing of shark livers and liver oil appears to have declined, partly because of the difficulty of collecting the liver and the strong odor of the products. Much of the current production of shark liver oil, therefore, appears to have shifted to developing countries.

In the United States, fisheries dealers and processors report that although shark liver oil was produced in the past, shark livers are now rarely taken because they are "messy," difficult to process, and have a strong odor. Although shark liver oil capsules are manufactured in the United States and available on the domestic market to a limited extent, recent customs data are not available to determine the quantity of imports to supply this market. U.S. customs data for imports of shark liver oil are available from 1972 to 1986, revealing limited and sporadic imports from Canada, Japan, Mexico, Norway, and Switzerland, totaling 43,116 kg for the entire period. Packaged capsules are in turn marketed worldwide.

In Mexico, shark livers are occasionally retained and the oil consumed directly or sold in local markets for medicinal use, while a small number of manufacturers offer shark liver oil capsules for the domestic health products market. No information is available on the production or use of shark liver oil in Canada.

Shark Cartilage

Several pharmaceutical and food products are produced from the soft and hard cartilage of sharks. Kreuzer and Ahmed (1978) report that in Japan, the soft cartilage of sharks or skates is cut into pieces, boiled, cleaned, boiled again, and then dried in the sun to form a product known as meikotsu. Chondrichthyan natrium, a chemical compound found in the hard and soft cartilage of sharks, is used in Japan as a treatment for eye fatigue and rheumatism. Blue sharks are considered a good source of chondrichthyan natrium. The chemical compound, chondrichthyan natrium, contains chondroitine--a pharmaceutical substance used in eye drops (Kreuzer and Ahmed, 1978; Kiyono, 1996). At least one pharmaceutical company in Japan uses chondrichthyan natrium in the manufacture of eye drops, although mammalian sources are also used (Kiyono, 1996). A chemical extracted from shark cartilage has also been used in the development of a synthetic skin for burn victims.

In recent years, shark cartilage powder and capsules have been marketed extensively worldwide as a treatment for cancer. Bovine and other mammalian cartilage has demonstrated effectiveness in inhibiting vascularization in tumors; several trials have also been conducted to explore the potential use of shark cartilage in the treatment of cancerous tumors. Trials with shark cartilage have demonstrated that concentrated extracts directly applied to the affected area inhibit vascularization in laboratory animals (Lee and Langer, 1984; Luer, n.d.). Positive research results were widely publicized beginning in the 1980s by I. William Lane, a nutritionist and biochemist from the United States, whose book *Sharks Don't Get Cancer* (Lane and Comac, 1993) and featured television interview on 60 Minutes in 1993, prompted a boom in sales of freeze-dried cartilage powder in capsule form. However, conclusive tests involving human subjects are not yet available, and there is as yet no evidence that shark cartilage administered orally contains sufficient amounts of active ingredients to be effective, or that it can even reach the affected area (Luer, n.d.; Dold, 1996).

Although mammalian--and particularly bovine cartilage--are also being tested in the treatment of cancerous tumors, all sharks have a skeleton that is entirely cartilaginous and are viewed as a significant potential source of cartilage for pharmaceutical use. One Hong Kong-based dealer reports that blue shark cartilage is preferred because of its high chondroitine content (Parry Jones, 1996a), but no further information is available regarding preferred species. In general, shark cartilage appears to be a byproduct of existing shark fisheries. Therefore, the species in trade for cartilage are the same species as those taken in local and regional fisheries.

A variety of methods are used in the preparation of shark cartilage for pharmaceutical use. Cartilage is generally retained and sold by the processor. In Mexico, small-scale processors sun dry the vertebrae only prior to sale to manufacturers, while in both Mexico and the United States, large-scale manufacturers of shark cartilage products may purchase raw frozen vertebrae directly from fish wholesalers/processors for freeze-drying. Industrial fan dryers may be used to dry raw cartilage. Some spiny dogfish processors in the United States retain the head and vertebrae, while at least one U.S.-based manufacturer of shark cartilage powder and capsules imports heads, jaws, and "breast," as well as the vertebrae. Discards of cartilage from the processing of shark fin in Hong Kong are exported to Japan, presumably for the production of shark cartilage powder (Parry Jones, 1996a). At least one shark cartilage manufacturer in Japan produces shark cartilage reportedly obtained only from shark fins, although most dealers report that both the vertebrae and the branchia gills are used (Kiyono, 1996).

Shark cartilage is a relatively new product on the market, and neither national fisheries agencies nor customs agencies report the volume of production or trade. Major producing nations include the United States, Japan, and Australia. It is likely that shark cartilage is supplied by and manufactured in a large number of additional countries, but, due to the nature of the trade, tracing trade routes is difficult. The volume of production is also difficult to assess because only a limited number of companies appear to actually manufacture the cartilage powder. These companies purchase cartilage directly from the vessel (if the shark is processed on board), from processors or retail outlets or from shark fin dealers, who often handle a variety of dried products, such as shark fin, shark cartilage, fish maws, and beche de mer. Manufacturers often import cartilage from abroad, as well as from domestic suppliers, and then market their own brand names and/or supply ground cartilage to other companies domestically and abroad. Medical research also provides a significant market for cartilage in several countries.

In the United States, there are four or five companies that actually process shark cartilage powder, which is sold worldwide under dozens of brand names. U.S.-based processors import raw cartilage from several countries; processed cartilage and cartilage powder is usually imported from Japan. One major manufacturer obtains all of its supply of raw cartilage overseas. The cartilage undergoes primary processing in Costa Rica and is then imported into the United States for further processing and bottling. Packaged cartilage products are marketed within the United States and exported to some 35 countries worldwide, while 5 to 10 percent of the processed cartilage powder is exported to foreign manufacturers for bottling under their own brand names.

Additional cartilage processing plants are located in Mexico. Shark processors sun-dry or freeze-dry shark vertebrae, and ocasionally the cartilaginous base of fins, for sale to domestic manufacturers or export to the United States. Although Mexico's shark fisheries are among the largest in the world, many manufacturers report that they continue to import processed cartilage powder from Japan, rather than obtaining supplies domestically.

No information is available on the use of shark cartilage in Canada.

Other Products and Uses

Processing wastes of sharks, skates, and rays may be used in the production of fishmeal for animal feed or fertilizer, or to yield fish oils for industrial uses. For example, processing wastes of the spiny dogfish are reportedly used in the production of fishmeal and fertilizer (Compagno, 1984), however, only limited information on the use of chondrichthyans in the production of fishmeal and fertilizer was collected during the TRAFFIC regional studies. Shark processing wastes were observed to be routinely collected, along with other fish waste, for the manufacture of fishmeal in Mexico. No information is available on the extent of this practice in the United States and Canada, although rising catches of skates and rays are likely to be utilized for fishmeal production in these countries.

In many areas, small sharks that are unmarketable are not discarded, but are instead used as bait, often in shark fisheries themselves. In the U.S. Gulf of Mexico directed shark fishery, large numbers of small Atlantic sharpnose sharks caught incidentally are nearly always used as bait by the same vessels. In the southeastern United States, restrictions on gillnet fisheries have led to shortages of baitfish, so fishers increasingly purchase spiny dogfish heads from northeastern fisheries. No observations of this practice were made in Mexico.

Shark teeth and jaws have traditionally been used in many cultures in the making of both functional and ceremonial objects. In the Solomon Islands, for example, Melanesians use shark teeth in carvings, while the Gilbertese use shark teeth for making the "Terere," a traditional Gilbertese fighting sword that features shark teeth lashed to both edges and a stingray spike at the end (Matthew, 1996). In Hawaii, shark teeth were used as a cutting edge and to make knives, war clubs, and other hand-to-combat weapons (Taylor, 1993).

Shark teeth and jaws are presently widely used in local curio trades. Kreuzer and Ahmed (1978) and Anderson and Ahmed (1993) note that the shortfin mako is a preferred species because of its teeth. The great white and the tiger shark also yield particularly large--and therefore valuable--jaws and teeth. Typically, a fully grown shark yields approximately 150 teeth of saleable size (Kreuzer and Ahmed, 1978).

Use of shark teeth and jaws--particularly for sale to tourists and tourist shops--is common in coastal areas of the United States and Mexico. Since demand appears to be limited and usually confined to tourist areas, teeth and jaws are collected only occasionally. In the southeastern United States, shark teeth can be and frequently are collected along the shoreline. Other shark products reported to appear in the curio trade include preserved shark foetuses and stuffed specimens.

The extent of world trade in sharks for use as aquarium specimens is not known. Nurse sharks are frequently maintained as live specimens in public aquaria and, in some areas of the United States, juveniles may be captured for sale to private hobbyists. Live catshark (Scyliorhinidae) juveniles and egg cases are also imported to the United States from Indonesia for sale to private aquarists. The freshwater stingray *(Potamotrygon laticeps)*, found in the Amazon Basin, is also known to be collected for the aquarium trade (Axelrod, 1986), as is the epaulette shark *(Hemisciyllium ocellatum)* (Last and Stevens, 1994).

Discussion

Implications of Chondrichthyan Fisheries for Management and Conservation

Available information on chondrichthyan fisheries worldwide remains substantially incomplete. Because chondrichthyan fisheries are often incidental or seasonal and historically have made only a minor contribution to overall fisheries production, little emphasis has been placed on gathering data on these species or their exploitation. As a result, data on the volume and species composition of chondrichthyan catches is often sparse or nonexistent. Because of insufficient information, trends in existing data on catches and landings typically cannot be interpreted. National agencies often do not report chondrichthyan catches at all, report them as a single category or as "sharks" and "skates and rays," or report sharks but not related species. National reporting by species is rare and generally occurs only in the few cases where chondrichthyans are included in existing management plans. There is consequently a paucity of reliable information on which to base status assessments at the local, not to mention the global, levels.

Many important chondrichthyan fishing nations do not maintain species-specific data on landings. For many fisheries, neither the volume of catches and landings nor the species composition are known. Even in the few existing managed chondrichthyan fisheries, management systems designed for other species are believed to result in significant underreporting of chondrichthyan catches and landings, and, as in the case of the United States, face continued difficulties in species identification.

Several nations, including the United States, also have offshore or distant water fleets with large incidental catches of sharks, rays and skates that are unreported or underreported. The low relative value of chondrichthyans compared to many target species, such as tuna and billfish, encourages high rates of chondrichthyan discards in these fisheries in order to conserve limited cargo space. Further encouraging high rates of discards is the fact that, as sharks accumulate high concentrations of urea in their blood, these species typically require immediate on-board processing and refrigeration or freezing, and often must be stored separately from the rest of the catch. Each year an estimated 230,000 to 240,000 mt of chondrichthyans may be discarded worldwide in high seas fisheries alone, or only shark fins retained (Bonfil, 1994). Although distant water fisheries are of special concern, due to the sheer volume of incidental catches, varied but largely unknown rates of chondrichthyan bycatch also occur in a number of coastal and offshore fisheries, including shrimp and prawn fisheries and other trawl fisheries, gillnet fisheries targeting demersal species, hook-and-line fisheries, tuna purse seine fisheries, and longline fisheries targeting tuna and billfish.

In recent years, the issue of "finning," or removing the shark's fins and discarding the carcass, has been raised as an issue in the management and conservation of sharks and rays. In general, species most likely to be finned and discarded include those captured in large numbers in offshore and distant water fisheries, such as blue shark; species with high value fins such as hammerhead sharks; and species for which the meat and other products are not marketable, (e.g., blue shark in many areas). Finning generally appears to occur more frequently in incidental than targeted chondrichthyan fisheries. Although finning may also occur in directed shark fisheries, the economic viability of directed fisheries often depends on the marketing of both meat and fins, and, in some cases, additional products such as skins, livers, and cartilage.

The management and conservation implications of bycatch in general, and finning in particular, depend upon a number of factors, including the volume and species composition of bycatch and the destination of bycatch (i.e., whether retained, discarded alive, or discarded dead). In most cases, chondrichthyan bycatch is not reported and species composition is not known. The destination of bycatch is also largely undocumented and depends upon highly variable factors, such as including catch rates of target species, relative values of targeted species and bycatch, the availability of markets for chondrichthyan bycatch, vessel processing and storage capacity, and trip duration.

The importance of incidental catches also depends upon mortality rates among different species and fisheries. In trawl, gillnet, and possibly purse seine fisheries, mortality of chondrichthyan bycatch is probably 100 percent. In some cases, this incidental catch is landed and utilized. For example, small juveniles caught incidentally in Mexico are popular in many regional markets, and appear to be frequently landed for sale. Landings based on such incidental catches may inflate reported landings without necessarily implying greater conservation impact than that of fisheries reporting lower chondrichthyan landings.

Longlines, on the other hand, permit some survival among hooked sharks because they allow limited movement, and thus, respiration and the elimination of metabolic wastes. With this method, it is possible for sharks to be released alive, but mortality varies among species (Bonfil, 1994). For example, species believed to be highly dependent on forward movement for the elimination of metabolic wastes include sharks of the families Carcharinidae and Sphyrnidae, but this aspect has not been extensively studied (Horan, 1995). Sivasubramaniam (1992) reports that in the Bay of Bengal tuna fisheries, large numbers of requiem sharks (*Carcharhinus* spp.) are alive when brought aboard, but that blue and mako sharks are typically dead. Furthermore, although chondrichthyans may be released alive, post-release mortality may occur due to stress during capture (Horan, 1995).

Many researchers have raised concerns regarding the impacts of incidental catch on pelagic species (Casey, 1992). Species such as blue shark, thresher sharks, mako sharks, porbeagle shark, salmon shark, silky shark, oceanic whitetip shark, and hammerhead sharks are relatively abundant and widely distributed, but may be of conservation concern due to the sheer numbers caught incidentally. Others, such as the great white, whale shark, cookiecutter sharks *(Isistius brasiliensis, I. labialis,* and *I. plutodus),* and pygmy sharks *(Squaliolus aliae, S. laticaudus, Euprotomicrus bispinatus,* and *Heteroscymnoides marleyi),* are caught in relatively low numbers, but are less abundant and, therefore, potentially at risk from pelagic fisheries. Generally, however, too little is known of the species or of the fisheries to reliably assess conservation impacts.

Interpreting Reported Trade in Chondrichthyan Products

With fisheries for sharks and other chondrichthyans largely unregulated and unmonitored, trade statistics are increasingly viewed as a readily available source of information for assessing the management and conservation implications of growing domestic and international markets for chondrichthyan products, particularly for shark fin. For example, trade statistics have been used to estimate catches and landings where reliable records are unavailable, or compared to reported catches and landings to estimate the volume of unreported catches and landings. In the latter case, discrepancies between reported shark fin exports and reported shark catches and landings may be interpreted as evidence of finning.

There are, however, several important limitations on the use of such data, and considerable caution is warranted in any attempt to relate reported trade to real catches and landings, global trade patterns, or even market trends. As discussed below, trade data are problematic and are often poor indicators of the real volumes in trade. Therefore, estimates of production or assessments of market trends derived from trade statistics may be similarly flawed. Furthermore, chondrichthyan catches and landings are known to be widely underreported, particularly in the case of artesanal fisheries, incidental fisheries, and high seas fisheries. Comparison of trade data and reported landings for a given country or region may suggest that underreporting of catches and landings is problematic without necessarily indicating that finning is also problematic.

World trade in shark fins is an increasing source of concern to conservationists due to the high value of fins in international markets, reports of finning from a number of fisheries, and the potential for further increase in demand posed by the opening of markets in China. Trade data are more readily available for shark fins than for other chondrichthyan products. For example, Hong Kong customs data for trade in shark fins has been made widely available, and FAO reporting for this product, although incomplete, is more complete for shark fins than for any other product, in part because it includes Hong Kong trade data. Both sources confirm the widespread perception that world trade in shark fin is rising. The rate of this increase, the fisheries affected, and the management implications remain less clear.

The TRAFFIC Network study found that a significant proportion of world trade in shark fins appears to involve import as well as production of unprocessed fins, export of fins to another country for processing, then re-importation of the same fins in a different stage of processing. Thus, the same fins entering international trade may be counted more than once. This is particularly important with regard to shark fin trade among Hong Kong, China, and Singapore, the world's largest shark fin trading nations. It is also true of a number of regional entrepots in the trade, such as the United States (for Latin America and the Caribbean, and to a lesser extent Africa) .

For example, dried shark fins are exported from Peru to the United States where they are mixed with other imported and domestic fins, repackaged, and shipped to Hong Kong. The Hong Kong trader then ships the dried fins to China for processing, re-imports the processed fins, then exports the processed fins to the United States. Hong Kong import records report the same fins twice, and export records report the same fins twice. An examination of total reported world imports would count the same fins in trade five times. An examination of total reported world exports would count the same fins four times.

This finding may have important implications for interpreting available trade data. Analysis of trade between Hong Kong and China concluded that much of the apparent increase in Hong Kong shark fin imports may be attributed to a shift in the location of processing from Hong Kong to China (Parry Jones, 1996a). While total reported shark fin imports into Hong Kong suggest a dramatic rise in world trade in fins, separating out repeat transactions for processing suggests a much more gradual increase in the volumes traded.

A similar problem occurs in assessing Asian imports of shark fin from other countries. For example, the United States records imports of shark fin but does not report exports. Reported Hong Kong imports of shark fin from the United States suggest that the United States is a major supplier of shark fin. However, both an increase in reported imports and interviews with fin traders based in the U.S. suggest that reported trade with Hong Kong consists in large part of reexports of fins that have been shipped through or processed in the United States.

Trade patterns such as those found in Hong Kong or the United States may not be immediately apparent because reexports are often not recorded as such. Fin dealers may accumulate fins from domestic fisheries or foreign sources for a considerable amount of time before re-exporting. During this period, the fins are likely to be sorted and repackaged before re-exporting, in which case the original country of origin for the fins will not appear in trade records. In many cases, dried or frozen fins may be imported for processing, then re-exported in one of several forms of processed fins. Not only does the volume by weight of traded fins change during this period, but trading countries may not report separately each of the product forms in which fins are traded. In many cases, official export statistics also should be interpreted cautiously, as a number of the TRAFFIC studies indicate that complete data are not available or that significant loopholes exist in export procedures.

Even accurate statistics may be misleading if trade data are used as the basis for assessments of production. First, several countries that serve as important producers of shark fin are also characterized by significant levels of domestic consumption, so reported trade may not account for a significant volume of world production. For example, China is undoubtedly an important producer but there is no evidence that shark fins produced in China enter world trade to any significant extent (Parry Jones et al., 1996). In addition, Taiwan is one of the world's largest producers of shark fin with reported annual production averaging nearly 1,000 mt from 1980 to 1996, but annual imports remained below 100 mt from 1980 to 1995, and exports are much lower because most production is consumed domestically (Chen et al., 1996).

The difficulty of relating reported world trade to global or national production of shark fins is compounded by the fact that few countries report domestic production of shark fins. In those countries where production is reported, it may significantly underestimate real production, because, in many cases, fins are retained by the fishermen as a supplement to their wages and sold independently to dealers or processors (Kiyono, 1996; Parry Jones et al., 1996; Matthew, 1996). Fins are also frequently sold at sea to vessels of other nations (Parry Jones et al., 1996).

Official trade data also pose some difficulties in monitoring price trends and market trends for shark fins. In some countries, reported values for exports may be misreported in an effort to avoid export duties or requirements for repatriation of hard currency. Import values may be similarly misrepresented, although in the case of Hong Kong--a free port--reported values may more accurately represent real market prices.

Another limitation of trade data is that it does not necessarily serve to indicate the fisheries, regions, or species of greatest management concern. Many of the chondrichthyan products in trade are not identified, and, in some cases (e.g., processed fins), are not identifiable to species. Nor are trade records sufficiently precise to indicate the country or region of origin. Available data do suggest a general rise in demand, prices, and traded volumes of shark fin, however, the impacts on specific fisheries, countries, and regions are likely to vary considerably according to characteristics of the fisheries, market conditions, and local and external demand for a wide range of shark products.

In order to assess the impact of rising world demand for shark fin on shark fisheries, it would be necessary to examine on a regional and local basis the absolute and relative values of shark fins in relation to other fishery species, other shark products, and local costs of living. The relative value of shark fins is likely to vary considerably, due not only to fluctuations in demand and supply, but also according to species availability, quality of cut and processing, the number of dealers to which sellers have access, difficulty and cost involved in transportation and shipment, and relationships among local and external buyers. Therefore, although Hong Kong may set the world price for shark fins, it should be kept in mind that these are prices to fin dealers at various levels of the market chain in locations as varied as Fiji and France. For example, in Taiwan, most production is consumed domestically and market prices are directly linked to domestic supply, so that a significant increase in production is accompanied by a dramatic fall in prices (Chen et al., 1996). By contrast, fin dealers in the United States report the entry of numerous entrepreneurs into the trade over the last decade, increased market development and communications, and, therefore, increased competition for shark fin supplies. In an effort to obtain reliable supplies, dealer prices to the fisher for shark fins in some cases have risen above average world prices. A sample range of ex-vessel prices for wet primary fins is US$37-46/kg for large fins, US$26-37/kg for medium fins, and US$11-13/kg for small fins, while secondary and low-grade fins range in price from US$3-9/kg. Prices for dried fins, which lose approximately 50 percent by weight during drying, are approximately twice this range. This increase in shark fin prices is considered to have greatly stimulated the development of a directed shark fishery in the southeastern United States.

An assessment of the management implications of rising shark fin trade and finning must also take into account the different characteristics of directed and incidental fisheries. In most cases, chondrichthyan fisheries are predominantly incidental, and a rise in world shark fin prices may result in 1) no significant increase in landings; 2) an increase of fin landings despite stable catches; or 3) increased catches and landings, as vessels increasingly target sharks, either generally or on a seasonal basis. Because neither catches nor landings are routinely reported in such fisheries, and because few studies link trends in landings to trends in target fisheries, it is difficult to determine which is the case. Directed shark fisheries typically utilize a variety of products in addition to fins, however, without effective controls on entry and effort, an increase in the value of fins and other products may encourage new entrants into the fishery and new investments in gear.

Despite the importance of shark fin trade as an impetus to rising shark landings, it would be misleading to characterize this trade as the sole--or even the primary--force driving shark catches and landings. Economic constraints clearly encourage the finning and discarding of some species in some fisheries, most notably in distant-water fisheries, where limited storage capacity and high potential for spoilage contribute to high discard rates. Further contributing to discards from these fisheries is the predominance of blue sharks in the shark bycatch of many fleets, as markets for this species remain nonexistent or extremely limited in most regions. However, in many cases, a number of species may be retained for their meat and other products, including shortfin mako, porbeagle, and thresher. In general, even less valuable species caught in directed shark fisheries are not discarded, but are consumed domestically. In fact, even relatively low unit values for meat may be deceptive when compared to high international prices for shark fins and other products, given that the meat accounts for a much larger proportion of total body weight.

Production and trade data for products other than shark fin are often even more severely limited. In many cases, the remainder of the carcass is marketed domestically rather than traded internationally, but domestic production is unreported. Available trade data are also even less specific than production data regarding product forms, so that reported volumes in trade may be misleading. For instance, a customs classification for frozen shark might include whole carcasses, split carcasses, headed and gutted carcasses with the fins removed, blocks or clippers, or fillets. Even if the product form is known, conversion factors needed to assess the live or carcass weight represented by traded volumes vary widely by species, processing technique, country, and region.

Again, as in the case of shark fins, the chondrichthyan species represented in domestic production or international trade of meat cannot be determined without accurate information on the species composition of catches and detailed market information regarding imports and exports. Market information is particularly needed in areas such as the United States and Europe that are characterized by significant imports of shark meat for processing and re-export. This information remains generally unavailable or extremely limited for most producer nations. The results of market research by TRAFFIC suggest that international trade in shark meat appears to include a significant volume of highly preferred food species, such as the dogfishes and smoothhounds, and preferred pelagic species, such as shortfin mako and thresher sharks, although these species are also utilized for their fins, cartilage, liver oil, and other products. However, although these are among the few species for which targeted fisheries can be linked to relatively high demand and value in domestic and international markets, it is not at all clear that other species are not traded in significant volumes.

Due to the relatively low value of the meat of most chondrichthyan species, domestic markets and trade of meat have not generally been considered to lead to severe depletion of stocks. In most cases, fisheries have exploited a range of products in addition to meat, including fins, liver oil, and hides. Historically, in fact, industries centered entirely on meat production have generally proven uneconomical, as in Uruguay (Kreuzer and Ahmed, 1978) and the United States. Important directed chondrichthyan fisheries in countries such as Australia, Mexico, Taiwan, and the United States currently tend to exploit a variety of products. However, the status of spiny dogfish is believed to have been negatively impacted by overfishing in Europe, specifically France, Norway, Ireland, and the United Kingdom (Fleming and Papageorgiou, 1996). In recent years, spiny dogfish stocks off the Atlantic coast of the United States are believed to have been negatively impacted by directed fisheries that have intensified since the early 1990s to meet European demand. The status of shortfin mako and thresher sharks is more difficult to assess given their offshore movements and the paucity of information on stock size and structure. Thresher stocks off the Pacific coast of the United States are believed to have been severely depleted as the result of a directed fishery in the 1980s, but the decline of the fishery has also been attributed to economic and regulatory factors.

In the majority of producer nations, there is not enough data to determine the implications of trade in shark skins and leather for fisheries management and conservation. However, market information from Mexico suggests that the impact of use and trade of shark skins is extremely limited and is dependent on the relatively close proximity and accessibility of specialized tanneries. In general, shark skins appear to be a relatively low value product that, when taken as a byproduct of existing fisheries, contribute marginally to the overall value of the fish to the producer .

The production and trade of shark liver oil is also poorly documented. Targeted fisheries for shark liver oil have clearly led to fisheries in the past; the decline of liver oil fisheries for the tope or soupfin shark on the Pacific Coast of the United States in the World War II era is one of the best-documented cases of shark fishery overexploitation in history. Although shark liver oil production continues today at drastically reduced levels, several fisheries specifically target deepwater shark species that may be vulnerable to localized overfishing. And, in Europe, new fisheries for deep-water shark species are developing as new fishing grounds are exploited following the decline of traditional species. Little information on the impact of these fisheries is available, however. In Taiwan, fisheries for dogfish and gulper sharks for the production of shark liver oil have declined significantly in recent years, but data on catch levels, fishing effort, stock abundance, and markets are too insufficient to be able to determine any relationship with liver oil utilization (Chen et al., 1996).

Conservationists have expressed growing concern that new markets for shark cartilage pose an additional source of pressure on shark stocks worldwide. Such concerns are typically based on two types of observation. First, the high retail prices of packaged pharmaceutical products are considered to contribute to markets for meat, fins, and other products, thereby stimulating unsustainable rates of exploitation. Second, observation of the volume of shark cartilage purchased by specific processing plants is generally perceived to be extremely high, and therefore, contributing to overexploitation in nearby fisheries. However, research for the present study suggests that although there is little basis for claims of the medical efficacy of cartilage, there is also little evidence that the use of cartilage is stimulating shark fisheries.

Retail prices for shark cartilage are high, in some cases reaching more than US$100 for a single bottle of capsules, but processors in the United States and Mexico report selling dried cartilage for approximately US$1 per pound and wet cartilage for less than US$1. According to Kreuzer and Ahmed (1978), shark "bones" [cartilage] account for an average of 4 percent of total shark body weight, with a range of 3.0 percent (Tiger, Kitefin) to 9.4 percent (smoothound). Thus, unit prices received by the fishermen are minimal and the total value of the cartilage relative to meat and fins are extremely low. For example, if an average 23 kg shark yielded 1 kg of cartilage, 1.2 kg of fins, and 10kg of fillets, prices to a U.S.-based harvester for these products would be US$2, US$25, and US$12.50, respectively.

Moreover, although the trade remains entirely undocumented, TRAFFIC market research and industry interviews suggest that cartilage processed by known manufacturers is often imported from several countries, as well as locally. For example, one highly publicized processing plant in Costa Rica is perceived to contribute to the overexploitation of local fisheries, but, in fact, purchases raw cartilage from numerous sources worldwide for initial processing before shipping semi-processed cartilage to the United States. Casual observation of the operations of the plant, therefore, does not provide a basis for any assessment of the volume of supply obtained from local or even national or regional fisheries. As for many other chondrichthyan products, trade in shark cartilage is complex, virtually undocumented, and poorly understood.

Conclusions

In many of the countries and regions reviewed during the course of the TRAFFIC Network study, chondrichthyan fisheries and trade provide an increasingly important contribution to 1) total fisheries production and consumption; 2) cash earnings among coastal communities; 3) the fisheries processing sector; and 4) export earnings. A number of complex factors contribute to the enhanced role of chondrichthyans in world fisheries, including development of gear and gear changes in offshore and distant water fisheries; increasing regulation or declining availability of traditional fisheries species; increased demand for products such as meat, fins, and cartilage; and increased penetration of market networks for these products into new regions, such as Africa and South America. Therefore, although increasing world trade in products such as shark fins, fresh and frozen shark and skate wings, cartilage, and shark liver oil undoubtedly plays a significant role in recent increased chondrichthyan landings in many regions, attributing the rise of chondrichthyan fisheries solely to trade, or particularly to trade in a single product, ignores both the complexity of these issues and significant regional variations in the dynamics of both fisheries and markets.

Chondrichthyan resources are valuable--in many cases, much more valuable than previously documented uses and markets would suggest. They are also vulnerable to overexploitation, but ecologically sensitive species--or those most vulnerable to a combination of targeted and incidental fisheries, habitat disturbance, and other factors--are difficult to identify. This is due to a notable lack of information on biology, life history, stock structure and movements, abundance, fisheries, volume, and species composition of catches and landings. Since few countries have enacted management plans, chondrichthyan fisheries are characterized by poor reporting, limited research effort, and lack of restrictions on entry or fishing effort. Consequently, fisheries agencies are generally ill-equipped to recognize or respond to changes in fisheries and markets for these species.

Available production and trade data are useful in highlighting important markets and uses for chondrichthyan products. However, these data are currently subject to a number of reporting problems that severely limit the accuracy of reported volumes and values of chondrichthyan products in trade, and, in most cases, are not sufficiently precise to indicate the species and regions most affected by trade. In other words, improved trade monitoring is needed to assess regional and worldwide trends in demand and supply, but it is by no means an effective substitute for improvements in fisheries management, research, and data collection.

References

Altman, Lawrence K. 1996. Shark Substance Found to Limit Tumor Growth. *The New York Times*, May 1, 1996): 15.

Anderson, R.C. and H. Ahmed. 1993. *The Shark Fisheries of the Maldives.* Ministry of Fisheries and Agriculture, Republic of Maldives, and FAO. Madras, India.

Anonymous. 1991. Draft Code of Practice for the Full Utilization of Sharks. FAO Fisheries Circular No. 847. Food and Agriculture Organization of the United Nations.

Anonymous. 1993. *Fishery Management Plan for Sharks of the Atlantic Ocean.* United States Department of Commerce, National Marine Fisheries Service, Washington, D.C.

Anonymous. 1994. *World Review of Highly Migratory Species and Straddling Stocks.* FAO Fisheries Technical Paper No 337. Food and Agriculture Organization of the United Nations.

Anonymous. 1995a. *Yearbook of Fisheries Statistics: Catches and Landings, 1993.* Food and Agriculture Organization of the United Nations, Rome.

Anonymous. 1995b. *Yearbook of Fisheries Statistics: Production, 1993.* Food and Agriculture Organization of the United Nations, Rome.

Anonymous. 1996. Fishstat PC. Fishery Information, Data and Statistics Unit, FAO Fisheries Department, Food and Agriculture Organization of the United Nations, Rome.

Axelrod, Herbert R., Cliff W. Emmens, Duncan Sculthorpe, William Vorderwinkler, Neal Pronek, and Warren E. Burgess. 1986. *Exotic Tropical Fishes.* TFH Books, Hong Kong.

Barnett, R. 1996. The Shark Trade in Mainland Tanzania and Zanzibar. In: TRAFFIC East/Southern Africa, *Overview of Shark Fisheries and Trade in Shark Products in the Western Indian Ocean and Southeast Atlantic Ocean.* TRAFFIC East/Southern Africa, Lilongwe.

Bonfil, Ramon. 1994. *Overview of World Elasmobranch Fisheries.* FAO Fisheries Technical Paper, No. 341. United Nations Food and Agriculture Organization, Rome.

Bostock, T. W. 1991. Shark Leather. *INFOFISH International* 2: 30-32.

Buranudeen, F. and P. N. Richards-Rajadurai. 1986. Squalene. *INFOFISH International.*

Casey, John G. 1992. The Status of Pelagic Elasmobranchs: Concerns and Commentary. *Chondros* 3(4): 3-6.

Chen, George C. T., Kwang-Ming Liu, Shoou-Jean Joung, Dau-Jye Lu, and Marcus J. Phipps. 1996. TRAFFIC Report on Shark Fisheries and Trade in Taiwan. In: Marcus J. Phipps, comp., TRAFFIC East Asia] *Report on Shark Fisheries and Trade in the East Asian Region.* TRAFFIC East Asia, Taipei.

Compagno, Leonard J.V. 1984. *Sharks of the World.* FAO Species Catalogue, Vol. 4, Parts 1 and 2. FAO Fisheries Synopsis No. 125. UNDP and FAO, Rome.

Compagno, Leonard J.V. 1990. Shark Exploitation and Conservation. In: H. L. Pratt, Jr., S. H. Gruber, and T. Taniuchi, eds., *Elasmobranchs as Living Resources: Advances in the Biology, Ecology,* *Systematics, and the Status of the Fisheries*. NOAA Technical Report NMFS 590. United States Department of Commerce, Washington, D.C.

Cook, Sid. 1990. Trends in Shark Fin Markets: 1980s, 1990s and Beyond. *Chondros* (March 15): 3-5.

Dockerty, Trudie. 1992. *International Trade in Shark Fins*. World Conservation Monitoring Centre, Wildlife Trade Monitoring Unit, Cambridge. Unpublished report.

Dold, Catherine. 1996. Shark Therapy. *Discover* (April): 51-57.

Fleming, Elizabeth H. And Philippe Papageorgiou. 1996. *European Regional Overview of Elasmobranch Fisheries and Trade in Selected Atlantic and Mediterranean Countries*. TRAFFIC Europe, Brussels.

Frimoldt, Claus. 1995a. *Multilingual Illustrated Guide to the World's Commercial Coldwater Fish*. Fishing News Books, Denmark.

Frimoldt, Claus. 1995b. *Multilingual Illustrated Guide to the World's Commercial Warmwater Fish*. Fishing News Books, Denmark.

Hayes, Elizabeth. 1996a. New Zealand. In: G. Sant and E. Hayes (eds.), *The Oceania Region's Harvest, Trade and Management of Sharks and Other Cartilaginous Fish*. TRAFFIC Oceania, Sydney.

Hayes, Elizabeth. 1996b. Oceania Overview. In G. Sant and E. Hayes (eds.), *The Oceania Region's Harvest, Trade and Management of Sharks and Other Cartilaginous Fish: An Overview*. TRAFFIC Oceania, Sydney.

Horan, Stan. 1995. Capture Myopathy and Stress Heart Rate in Sharks: Oxygen Saturation, Respiration, Breathing, and Circulation. *Chondros* 6(2): 1-3.

Jensen, Albert C. 1965. Life History of the Spiny Dogfish. *Fishery Bulletin* 65(3): 527-554.

Ketchen, K.S. 1986. *The Spiny Dogfish (Squalus acanthias) in the Northeast Pacific and a History of its Utilization*. Canadian Special Publication of Fisheries and Aquatic Sciences 88. Department of Fisheries and Oceans, Ottawa.

Kiyono, Hisako. 1996. TRAFFIC Report on Shark Fisheries and Trade in Japan. In: Marcus J. Phipps, comp., TRAFFIC [East Asia] *Report on Shark Fisheries and Trade in the East Asian Region*. TRAFFIC East Asia, Taipei.

Kreuzer, Rudolf and Rashid Ahmed. 1978. *Shark Utilization and Marketing*. FAO, Rome.

Lai Ka-keong, Edward. 1983. Shark fins - processing and marketing in Hong Kong. *INFOFISH Marketing Digest* (5/83): 35-39.

Lane, I. W. and L. Comac. 1993. *Sharks Don't Get Cancer: How Shark Cartilage Could Save Your Life*. Avery, New York. 192 pp.

Last, P.R. and J.D. Stevens. 1994. *Sharks and Rays of Australia*. CSIRO. Australia. 512 pp. + 84 color plates.

Lee, Anne and Robert Langer. 1984. Shark Cartilage Contains an Inhibitor of Tumor Neovascularization. In: Rita R. Colwell, Anthony J. Sinskey, and E. Ray Pariser, eds., *Biotechnology in the Marine*

Sciences: Proceedings of the First Annual MIT Sea Grant Lecture and Seminar. John Wiley & Sons, New York.

Limpus, L.G. 1987. Preservation of Shark Skin. *INFOFISH Marketing Digest* No. 2: 35-37.

Luer, Carl A. n.d. Sharks and Cancer. Information sheet, Mote Marine Laboratory, Sarasota, Florida.

Matthew, Peter A. 1996. Solomon Islands Western Province. In: G. Sant and E. Hayes (eds.), *The Oceania Region's Harvest, Trade and Management of Sharks and Other Cartilaginous Fish*. TRAFFIC Oceania, Sydney.

Mestel, Rosie. 1995. Shark Extract Takes a Bite out of Sexual Diseases. *New Scientist* December 2).

McEachran, John D. 1990. Diversity in Rays: Why Are There So Many Species? *Chondros* 2(5): 1-6.

Nair, K. G. Ramachandran and P. Madhavan. 1974. Shark Fin Rays - Technology of Extraction. *Fishery Technology* XI(1): 60-63.

Nichols, P.V. 1993. Sharks. In: A. Wright and L. Hill, eds., *Nearshore Marine Resources of the South Pacific*. Institute of Pacific Studies, Suva, Forum Fisheries Agency, Honiara, and International Centre for Ocean Development, Canada.

Parry Jones, Rob. 1996a. TRAFFIC Report on Shark Fisheries and Trade in Hong Kong. In: Marcus J. Phipps, comp., TRAFFIC [East Asia*] Report on Shark Fisheries and Trade in the East Asian Region*. TRAFFIC East Asia, Taipei.

Parry Jones, Rob, Zhou Kaiya, Xang Guang, and Xu Xinrong. 1996. TRAFFIC Report on Shark Fisheries and Trade in China. In: Marcus J. Phipps, comp., TRAFFIC [East Asia] *Report on Shark Fisheries and Trade in the East Asian Region*. TRAFFIC East Asia, Taipei.

Paust, Brian. 1987. The Developing Alaska Salmon Shark Fishery. In: S. Cook, ed., *Sharks: An Inquiry into Biology, Behavior, Fisheries, and Use*. Proceedings of a Conference, Portland, Oregon, 13-15 October, 1985. EM 8330/March 1987. Oregon State University Extension Service, Portland.

Paust, Brian and Ronald Smith. 1986. *Salmon Shark Manual*. AK-SG-86-01. Alaska Sea Grant College Program, University of Alaska, Fairbanks.

Rigney, Helen. 1991. *Shark Skins*. Australian Fisheries (February): 38-41.

Rose, Debra A. 1992. The Sharks of Mexico: A Resource for All Seasons. *TRAFFIC USA* 11(4): 4-6.

Sivasubramaniam, K. 1992. Pelagic Shark in the Indian Ocean. *Bay of Bengal News* 48: 2-7.

Subasinghe, S. 1992. Shark Fin, Sea Cucumber and Jelly Fish: A Processor's Guide. *INFOFISH Technical Handbook* 6. Kuala Lumpur, Malaysia.

Summers, Graeme and Ron Wong. 1992. Cosmetic Products from Semi-Refined Shark Liver Oil. *INFOFISH International* 2: 55-58.

Taylor, Leighton. 1993. *Sharks of Hawaii: Their Biology and Cultural Significance*. Honolulu: University of Hawaii Press.

Trachet, Nick, Mose Pelasio, and Robert Gilett. 1990. *So You Want to Sell Some Shark Fin? A Manual for Rural Fisherman*. Field Document 90/6, FAO/UNDP Regional Fishery Support Programme, Suva

Suva, Fiji, RAS/89/039.

SHARK FISHERIES AND TRADE IN CANADA

Introduction

Historically, Canada has been a minor shark fishing nation. During the 1980s, total commercial shark landings averaged slightly over 3,000 metric tons (mt) annually, with most commercial landings comprised of piked or spiny dogfish *(Squalus acanthias)* (table 1). Until the early 1990s, the capture of sharks other than spiny dogfish generally occurred only incidentally to other fisheries, with most of the bycatch discarded. However, landings of sharks other than dogfish reached 100 mt in 1990; increased to 531 mt in 1991; and to over 1,000 mt in subsequent years. In 1994, Canada initiated the federal Atlantic Management Plan for Atlantic sharks, which established a number of precautionary management measures for an experimental shark fishery, including species-specific landing quotas.

Canadian exports and imports of shark products are poorly documented, but suggest low levels of trade in shark meat and fins. Much of this international trade is accounted for by the movement of fresh and frozen shark across the U.S.-Canada border, as the proximity of fishing areas and ports permits landing and processing on either side of the border. Dried and frozen shark fins are also likely to be mutually transshipped on their way to Hong Kong and other processing centers. Imports exceed exports, and low domestic production of shark meat and fins suggests that Canada is likely a net consumer of both.

Atlantic Shark Fisheries

The majority of Canadian shark landings occur on the Atlantic coast, with the province of Nova Scotia accounting for approximately 40 to 50 percent of dogfish landings in recent years, and virtually all landings of other sharks (table 2). Of the 19 shark species known to occur in Canadian Atlantic waters, very few are present in commercially exploitable quantities (Scott and Scott, 1988). Historically, most catches in Canadian Atlantic waters have been as bycatch, particularly in foreign and domestic tuna and swordfish fisheries. Shark species reported in such incidental catches include porbeagle *(Lamna nasus)*, shortfin mako *(Isurus oxyrinchus)*, blue *(Prionace glauca)*, white *(Carcharodon carcharias)*, whitetip *(Carcharinus longimanus)*, dusky *(C. obscurus)*, common thresher *(Alopias vulpinus)*, Greenland *(Somniosus microcephalus)*, basking *(Cetorhinus maximus)*, Portuguese *(Centroscymnus coelolelpis)*, smooth hammerhead *(Sphyrna zygaena)*, and deep sea cat sharks *(Apristurus profundorum)* (C. Dauphine, 1996). The black dogfish *(Centroscyllium fabricii)* is occasionally caught in large numbers, but typically discarded or used for fishmeal processing (Scott and Scott, 1988). In recent years, a small directed fishery for porbeagle, shortfin mako, and blue sharks has emerged. Since 1994, this fishery has been subject to a management plan that establishes species-specific quotas for the experimental fishery.

Only five shark species are reported in commercial landings: blue, porbeagle, shortfin mako, smooth hammerhead, and spiny dogfish. Prior to 1992, porbeagle and shortfin mako sharks were listed together in reported landings as mackerel sharks. Recent reports list porbeagle separately, with shortfin mako recorded as mackerel sharks. As the two species are very similar in appearance, there is likely to be some confusion in species identification in reported landings. Although hammerhead sharks are reported in Canadian landings statistics, very few were actually landed in 1993 and 1994. The proportion of unidentified species reported in commercial landings is relatively low--less than five percent in recent years--but appears to be increasing (Hurley, 1995; Department of Fisheries and Oceans, 1995).

Porbeagle

The porbeagle is found on the Scotian Shelf in late spring and in the Gulf of Lawrence and the Grand Banks during summer and early fall. In late fall, the porbeagle moves into deeper water where it is taken off the continental shelf, and in deep water basins in late fall and winter. Landings are highest during the months from April to June and September to November (Department of Fisheries and Oceans, 1995).

Domestic Fisheries

For years, a Canadian directed fishery existed off the Atlantic coast, but it ceased in 1970, due to the discovery of high mercury in shark muscle tissue. Reportedly, incidental catches were sometimes retained, however, for shipment to the United States (Scott and Scott, 1988). In 1991, a directed shark fishery was reinitiated, primarily targeting porbeagle sharks; most catches were reported by refrigerator longline vessels participating in the fishery (Porter, 1994; Department of Fisheries and Oceans, 1995). A single Canadian vessel entered the fishery in 1991 and a second entered in 1992. By 1994, the fishery consisted of three pelagic longline vessels and a number of smaller inshore vessels that directed for porbeagle sharks in the fall. Porbeagle is also reportedly taken incidentally in small numbers by the Canadian swordfish longline fishery and by a number of inshore fisheries.

Reported Canadian landings of porbeagle increased from zero in 1990 to 300 mt in 1991, 741 mt in 1992, 832 mt in 1993, and 1,545 mt in 1994. In 1992, a single longline vessel landed 700 mt of porbeagle. By contrast, inshore vessels contributed landings of only 80 mt in 1994. Total landings (domestic and foreign) reached 1,200 mt in 1991 and 1,718 mt in 1992 (O'Boyle and Zwanenburg, 1994; Porter, 1994; Department of Fisheries and Oceans, 1995).

In 1994, the Atlantic Management Plan set a precautionary catch quota of 1,500 mt annually for porbeagle sharks. This quota was continued during 1995 (Department of Fisheries and Oceans, 1995).

Foreign Fisheries

A directed pelagic longline fishery for porbeagle sharks in Canadian waters was initiated in 1961 by Norwegian vessels, which were soon joined by vessels from the Faroe Islands. Landings from the fishery reportedly increased from 1,800 mt in 1961 to 9,300 mt in 1964, declined to about 1,000 mt in 1968, and averaged 100 to 300 mt annually from 1969 to 1977. After 1977, Faroese vessels continued to fish for porbeagle sharks in Canadian waters, with landings ranging 100 to 300 mt annually until 1988, and increasing in 1990 to approximately 600 mt.

During most of the 1980s, a single Faroese vessel participated in the fishery. As of 1993, two Faroese vessels participated in the fishery under a total porbeagle allocation of 400 mt (O'Boyle and Zwanenburg, 1994). From 1990 to 1993, foreign shark landings averaged 915 mt annually; porbeagle contributed an annual average of 771 mt, or more than 84 percent of the total (table 3). All foreign participation in the directed shark fishery was terminated by the Canadian government in 1994.

Porbeagle also continues to be taken incidentally by the Japanese tuna longline fishery in Canadian Atlantic waters (Department of Fisheries and Oceans, 1995; Porter, 1994).

Blue Sharks

Seasonal movements and distribution of the blue shark are similar to those of the porbeagle. Until recent years, there has been no directed fishing for blue sharks, although significant numbers are taken as bycatch in other fisheries.

Domestic Fisheries

Blue sharks are reportedly taken in the Japanese tuna longline fishery, especially in waters adjacent to the Gulf Stream; in the Canadian swordfish longline fishery in offshore waters; and in a number of inshore fisheries during summer and early fall (O'Boyle and Zwanenburg, 1994). Blue sharks caught as bycatch have typically been discarded Finning of this species is known to occur, but fishing mortality as a result of this practice is unknown (Department of Fisheries and Oceans, 1995).

Both federal and provincial governments have attempted to stimulate development of blue shark fisheries and markets, and a small number of inshore vessels have begun to target blue sharks during the summer months (O'Boyle and Zwanenburg, 1994). Commercial landings of blue shark, while low, appear to be increasing in recent years. Reported landings by Canadian vessels totaled 101 mt in 1992, 21 mt in 1993, and 113 mt in 1994 (table 3).

Anderson (1985) estimated total shark bycatch by the Canadian swordfish longline fleet in waters off the coast of Nova Scotia to Newfoundland at 35,808 from 1962 to 1981, with annual totals averaging approximately 3,200 mt from 1963 to 1970, virtually ceasing in 1971 to 1973, and averaging approximately 1,600 mt from 1974 to 1977. Estimates were derived by applying observer data indicating bycatch rates of 2.34 sharks per swordfish to reported swordfish catches, and by using an average weight per shark of 41 kg. Applying similar estimation methods for Canadian swordfish longline catches reported by Porter (1994) from 1988 to 1992 estimated shark bycatch in the Canadian swordfish longline fishery at 1,702 mt in 1988, 2,024 mt in 1989, 1,288 mt in 1990, 1,499 mt in 1991, and 2,501 mt in 1992, or an annual average of 1,802 mt of sharks. Most of this shark bycatch is presumed to be blue shark. If these estimates in fact approximate swordfish longline bycatch, incidental catch from this fishery alone represents more than seven times the quota established for the directed fishery.

Foreign Fisheries

Blue shark represented a relatively minor portion of foreign shark landings from 1990 to 1993, averaging 124 mt annually, or 14 percent of foreign shark landings. According to observer data from the Japanese tuna longline fleet fishing in the Canadian 200-mile fisheries zone, incidental catch in this fishery totaled an additional estimated 325 mt of blue sharks in 1994 (Department of Fisheries and Oceans, 1995).

Shortfin Mako

The shortfin mako is occasionally caught as a bycatch of the swordfish longline fishery, and less frequently in tuna longline fisheries. Most are taken off the continental shelf as the shortfin mako appears only occasionally in coastal waters during the summer months. Reported commercial landings by Canadian vessels is slowly increasing, however, with a rise from 79 mt in 1990 to 157 mt in 1994. A precautionary quota of 250 mt was set for mako in 1994 and 1995. Landings by foreign vessels averaged less than 14 mt from 1990 to 1992, and no landings were reported in 1993 (Department of Fisheries and Oceans, 1995).

The Atlantic Spiny Dogfish Fishery

Historically, the spiny dogfish has not been the object of a significant targeted fishery in Atlantic Canada. According to the Food and Agriculture Organization of the United Nations (FAO), reported commercial landings averaged less than 6 mt annually from 1983 to 1992, with no landings reported for several of the years during this period (FAO, 1993 and 1994). In recent years, however, landings appear to be rising as a result of the increased abundance of spiny dogfish in the waters of the Northwest Atlantic and the collapse of traditional Atlantic groundfish fisheries (see U.S. chapter). Although most spiny dogfish landings since the early 1980s have been reported for the Pacific, Atlantic dogfish landings rose sharply from 0 in 1992 to 1,434 mt in 1993, and 1,640 mt in 1994 (table 4). Canadian landings, although rising, remain extremely low in proportion to U.S. Atlantic dogfish landings. The fisheries of both countries harvest dogfish from a shared migratory stock (see previous chapter).

Pacific Shark Fisheries

The Pacific Spiny Dogfish Fishery

On the Pacific coast, the spiny dogfish fishery is the only significant shark fishery. The Pacific spiny dogfish is believed to consist of two separate stocks: an offshore stock extending from Alaska to California and a separate stock located in the Strait of Georgia-Puget Sound area, both shared with the United States (Thomson, 1995).

Ketchen (1986) reviews the historic development of the Canadian spiny dogfish fishery beginning with an initial period from the 1870s through the late 1930s, when dogfish liver and body oil was used extensively for lighting and industrial lubrication purposes, and the carcass was used in the production of fertilizer or fishmeal. From 1937 to 1950, the boom in spiny dogfish liver oil for the production of Vitamin A led to a surge in catches off the British Columbia coast, as in the U.S. state of Washington. Dogfish livers continued to be landed in significant numbers in subsequent years, but at a much lower level. Beginning in 1959, a number of federal projects were introduced to encourage the commercial fishery and to introduce control measures, but these were ended in 1962.

Sporadic marketing programs were implemented in the 1960s and 1970s, but achieved little success until the decline in European dogfish fisheries in the mid-1970s created an export market for fresh and frozen dogfish from North America. The current foodfish fishery was initiated in 1977; in that year, landings in the Strait of Georgia and vicinity increased to 1,637 mt from less than 240 mt the previous year. Landings peaked in 1979 at 4,334 mt, then fell to between 1,000-2,000 mt from 1980 to 1982 as the result of an apparent decline in stock abundance (Ketchen, 1986). Total commercial landings averaged 3,033 mt annually from 1982 to 1992 (FAO, 1993 and 1994), then fell to 372 mt in 1993 (table 2) after fire damage to a major processor in the United States limited processing facilities (Thomson, 1995). Landings recovered somewhat in 1994 to 904 mt. Total landings data are not available after 1994, however, commercial landings appear to be continuing to recover (Adams, 1996, pers. comm.; Saunders, 1996, pers. comm.).

The Pacific spiny dogfish fishery is a limited, low value fishery, with the proportion landed or discarded fluctuating according to market value, production costs, and the catch and market value of other target species. The fishery, subdued for the last few years, now appears to be increasing again as a result of the decline of the salmon fishery (D. Adams, 1996, pers. comm; M. Saunders, 1996, pers. comm.). In addition, machines for skinning, heading, and gutting of dogfish and skates for onboard processing are now available, making processing more economical. Fisheries personnel have recently begun to observe high landings of dogfish fins. It remains unclear whether fins are removed during onboard processing and simply landed separately from the carcasses, or whether dogfish are being finned and discarded. It is speculated, however, that fish below marketable size (36 inches) may be finned and discarded (Adams, 1996, pers. comm.).

Offshore catches by longline and trawl account for most commercial landings. In addition to reported landings, estimated discards average 1,543 mt annually in offshore fisheries, 70 mt in inshore fisheries, and 896 mt annually by foreign vessels operating in a joint venture fishery. In addition, an average of 217 mt of spiny dogfish are caught annually for use as trap bait in the commercial prawn fishery (Thomson, 1995).

Fisheries surveys for Pacific spiny dogfish were carried out by Fisheries and Oceans Canada in 1986 and 1989 (Saunders, 1996, pers. comm.); in addition, annual stock assessments have been conducted since 1980. Total biomass for the offshore stock is estimated at 280,000 mt, with biomass in the Canadian zone estimated at 150,000 to 200,000 mt. A low-risk yield estimate of 9,000 mt was calculated for combined U.S. and Canadian catches, which remain below this estimate. For the inshore stock, biomass estimates total 60,000 mt for the entire stock, with a low-risk yield estimate of 4,000 mt for the Strait of Georgia-Puget Sound area. Again, combined Canadian and U.S. catches remain well below this level (Thomson, 1995).

Other Fisheries

A small and poorly documented fishery for the bluntnose sixgill shark (Hexanchus griseus) existed some years ago off the coast of British Columbia. In the early 1990s, attempts were made to develop the fishery and marketing of sixgill sharks. However, biological assessment by Fisheries and Oceans Canada revealed that the fishable population of this species consists primarily of juveniles. This finding, coupled with the lack of additional biological information, led to the establishment of a zero quota for this species (Saunders, 1996, pers. comm.).

Recreational Fisheries

An Atlantic recreational shark fishery was initiated in 1990, primarily targeting blue sharks but also landing small numbers of shortfin mako. No data are available, as recreational landings are not recorded or reported (Hurley, 1995). Under the 1994 and 1995 Atlantic Management Plans, recreational licenses are required for sharks and are currently available only for hook and release, although one goal of the management plan is the development of criteria that would allow the retention of recreational shark catches (Department of Fisheries and Oceans, 1995).

Domestic Use and Trade

The growing importance of Atlantic shark fisheries is reflected in product listings by seafood producers and processors in Nova Scotia, where the bulk of shark landings are reported. Of 194 producers and processors listed in the Nova Scotia Seafood Directory, a total of 71 report porbeagle and mako among their primary product line; 54 report blue shark. Porbeagle, mako, and blue shark are reportedly processed as fresh and/or frozen; in addition, several processors report production of blue shark fins, while none report production of fins from porbeagle and mako (Nova Scotia Department of Fisheries, 1995). An additional five processors in Newfoundland report production of shark, primarily fresh and frozen, although one processor is also producing dried salted shark (Newfoundland Seafood Market Council, n.d.).

Meat

An unknown volume of porbeagle, mako, and blue shark is processed in the United States and often purchased from swordfish longline vessels along with target species or exported to the United States for domestic consumption. In 1995, the United States reported imports from Canada of 169 mt of fresh sharks other than dogfish and 16 mt of frozen shark.

Porbeagle sharks are reportedly marketed primarily for export to Europe in fresh or frozen form, while mako is both consumed fresh within Canada and exported in the form of steaks to the United States. These two species may be intentionally mislabeled according to the target market. Blue shark is produced fresh or frozen, and at least one company is producing dried salted blue shark for export to the West Indies and Africa--traditional markets for Canadian seafood products. There is also an ethnic market developing across Canada for shark meat (Hurley, 1996).

Dogfish is consumed in small quantities domestically and is primarily exported to Europe. Dogfish meat is also processed as jerky for the gourmet pet food market (Hurley, 1996). Of producers and processors listed in the Nova Scotia Seafood Directory, a total of 40 report production of fresh and/or frozen dogfish; many also report production of dogfish fins (Nova Scotia Department of Fisheries, 1995). At least two companies in Newfoundland are also processing fresh and frozen dogfish (Newfoundland Seafood Market Council, n.d.). Processors and dealers on the U.S. Atlantic coast report that Canadian dogfish have been imported for processing within the United States, but imports have been few and sporadic due to the difficulty of obtaining spiny dogfish of marketable size from the Canadian Atlantic fishery.

On the Pacific, spiny dogfish are processed either in British Columbia, Canada, or in Washington in the United States. The fins of spiny dogfish are typically taken by processors and fisheries personnel report that they are commonly offered for sale in Asian shops in British Columbia; dogfish is the only species observed in these markets (Adams, 1996, pers. comm.). The local price for spiny dogfish fins is CAN$1.20/lb or US$0.73.

Ketchen (1986), in an analysis of published and unpublished trade records from 1977 to 1982, notes that just over half of spiny dogfish exported from British Columbia during this period were exported raw to the United States for processing, due to the high costs of shore handling and processing in Canada (table 5). The remainder were exported as frozen, dressed product to the United States and Japan, or as backs and belly flaps to Europe. Exports of dogfish fins and tails was apparently initiated in 1980, with total exports from 1980 to 1982 of 79 mt, valued at less than US$1.00 per kg.

Reported Canadian exports of fresh and frozen dogfish and other sharks averaged 2,259 mt annually from 1988 to 1995 (tables 6 and 7). Canadian customs data do not report dogfish and other shark species separately, but, as virtually all exports of fresh shark continue to be destined for the United States, it appears that a large proportion of this category continues to consist of dressed dogfish shipped to the United States for processing. This conjecture is supported by U.S. trade statistics, which report total 1995 imports of dogfish from Canada of 1,261 mt, of which 1,253 mt were traded fresh. Processed dogfish is exported to Japan and Europe. In addition, reported Canadian exports of frozen dogfish and other shark to Hong Kong--and possibly to Singapore, Taiwan, and Thailand-- may include frozen dogfish fins.

Canadian Customs also report significant imports of fresh and frozen dogfish and other shark, consisting almost entirely of increasing imports from the United States (tables 8 and 9). U.S. Customs statistics for 1995 report exports to Canada of 213 mt of frozen dogfish and 547 mt of fresh dogfish, with no reported exports to Canada of fresh or frozen shark other than dogfish. Canadian imports from the United States may consist of dogfish landed in Canada by U.S. vessels,or processed dogfish that is reshipped to Canada for domestic consumption, however, present information does not indicate the origin of this trade.

Fins

Canadian customs statistics do not specifically report trade in shark fins. Dockerty (1992), analyzing the customs records of nine Asian importing nations (Hong Kong, Japan, Indonesia, Malaysia, Singapore, South Korea, Sri Lanka, Taiwan, and Thailand), reports minimum Canadian exports of shark fin, averaging 17,939 kg annually, from 1984 to 1990 (table 10); and increasing from 7,053 kg in 1984 to 23,849 kg in 1990. Hong Kong customs report imports of dried shark fins averaging 9,639 kg annually from 1984 to 1994. In addition, Hong Kong customs report imports of shark fins salted or in brine, averaging 12,261 kg annually from 1988 to 1994. The relatively low value of fins imported from Canada (US$2.89 per kg, as compared to US$76.92 per kg for similar product imported by Hong Kong from the United States), suggests that this category may consist primarily of spiny dogfish fins. In 1995, Hong Kong customs alone reported imports of dried fin from Canada of 26,005 kg, suggesting a continuing upward trend in Canadian shark fin exports.

Much of the dried shark fin originating in Canada appears to be exported to the United States, likely for reexport to Asia. The United States reported imports of dried shark fins averaging 13,873 kg annually from 1988 to 1995. It is possible that the United States also imports fresh or frozen shark fins from Canada, but these are not reported specifically in U.S. customs data. It is not possible to determine the extent to which exports to the United States represent additional Canadian exports, or whether shark fins originating in Canada are reexported directly to Asia and therefore are already accounted for in the customs reports of importing nations. It is likely, however, that at least a proportion of exports from Canada to the United States represent additional production, as dried fin exports from Canada to the United States generally exceed the volume of dried fin from Canada reported by Asian importing nations.

Canadian imports of dried shark fin are also significant, increasing from 6,960 kg in 1984 to 24,707 kg in 1994 (table 11). Dockerty (1992) also reports significant exports of dried shark fin from Asia to Canada from 1984 to 1990. As Canadian imports of shark fin from Asia generally exceeded exports to the same countries from 1984 to 1990, Dockerty concludes that Canada appears to be a net shark fin consuming nation. Although this analysis does not include Canadian exports to the United States, and may, therefore, not be completely accurate, Asian nations do report significant exports to Canada, totaling more than 115,397 kg from 1984 to 1990, or an annual average of 16,485 kg. Canadian imports presumably represent dried and processed shark fin for domestic consumption.

Research, Management, and Conservation Measures

Until recently, both research and management measures for Atlantic sharks in Canada have been extremely limited. In early 1993, a research program for large pelagic sharks was initiated at the Bedford Institute of Oceanography in Dartmouth, Nova Scotia. Activities initiated under the program include 1) analysis of Catch Per Unit Effort (CPUE) and sampling data collected by Canadian observers aboard Faroese directed longline vessels; 2) analysis of shark bycatch by Japanese longline tuna vessels operating in the Canadian 200-mile fisheries zone; 3) at-sea sampling aboard Canadian, Faroese, and Japanese longline vessels; and 4) port sampling of sharks landed by the recreational fishery (Porter, 1995). Following cessation of foreign shark fishing in 1995, research effort has focused on the collection of basic fisheries information. A tagging program has also been initiated with the cooperation of recreational and commercial fishermen (Department of Fisheries and Oceans, 1995).

Lack of information on stock sizes, movements, and status led to the development of an Atlantic Management Plan for porbeagle, shortfin mako, and blue sharks in 1994 (Department of Fisheries and Oceans, 1995). The purpose of the management plan is to control and monitor developing fisheries for these species and gather data needed for the development of management measures. Although the management plan establishes precautionary quotas for all three species, the fishery is considered experimental rather than commercial.

Precautionary quotas were established by the management plan for porbeagle, mako, and blue sharks and apply only to the commercial directed longline fishery. Permitted gears in the directed shark fishery include only longline, handline, or rod and reel. Vessels of more than 65 feet are permitted to participate in the fishery on an Atlantic-wide basis, while all others are subject to regional restrictions. A seasonal area closure has been established for waters west of 65° 30' from June 1 to August 1 to minimize bycatch of other pelagic species in the directed shark fishery

Under the management plan, exploratory licenses are required for participation in the directed shark fishery. Eligibility for licenses during the 1995 fishing season was determined by substantive participation in the fishery prior to 1994, defined as having directed for and landed at least 1,500 kg of covered species in any year from 1990 to 1992, as well as in 1994. Vessels are required to maintain and submit detailed log and shark sampling records of catches, participate in a dockside monitoring program established in 1995, and carry observers if requested. The practice of finning was prohibited in 1995; fins may be sold, traded, or bartered, but only in proportion (5 percent) to dressed carcasses sold, traded, or bartered. Fins must be weighed and monitored at the time of landing, and may not be stored aboard the vessels without the accompanying carcasses. The pelvic fins and all, or a portion of, the tail fin are required to be left attached to the carcass in order to aid in species and sex identification of landings. In addition, species identification guides are included in the management plans to assist reporting in logbooks and shark sampling records (Department of Fisheries and Oceans, 1995).

Porbeagle, mako, and blue sharks all share contiguous distribution with the United States, and tagging studies conducted from the United States report movement between U.S. and Canadian waters by all three species (Casey et al., 1995). The management plan recognizes the need for collaborative management effort, and developed it in collaboration with U.S. agencies, based in part on the provisions of and experience under the U.S. Atlantic Fisheries Management Plan for Atlantic Sharks (Department of Fisheries and Oceans, 1995).

Spiny dogfish fisheries on the Atlantic and Pacific coasts are managed under general provisions for groundfish. On the Pacific, permitted gear types are trawl and hook and line. In addition, quotas have been established for two areas: a 5,000 mt quota for the Strait of Georgia and vicinity and a 12,000 mt quota for the remainder of the coast. In addition, a dockside monitoring program was instituted at the beginning of 1996 to record dogfish landed weight and bycatch. Stock assessments are available for this fishery, although the development of more specific management measures was postponed because of the apparent decline in fishing pressure, as well as urgent crises in other Pacific fisheries (Adams, 1996, pers. comm.). Dockside monitoring should assist in the monitoring of dogfish fin landings and allow a determination of whether finning of discarded dogfish is occurring on a significant scale. If so, federal regulations restricting onboard processing to heading and gutting may serve as an available means of controlling this practice.

Conclusions and National Recommendations

Canadian directed fisheries for spiny dogfish and other sharks continue to produce relatively low commercial landings, with total shark landings well below 5,000 mt annually. With the emergence of a domestic targeted fishery for Atlantic sharks, the Atlantic Management Plan for porbeagle, mako, and blue sharks was developed. The plan establishes precautionary catch quotas intended to serve as interim measures while considerable information needs are being addressed. The exploratory fishery established under the management plan and associated reporting and research should greatly improve the quality and quantity of available information on covered species.

Specific management measures have not yet been developed for spiny dogfish on either coast. On the Pacific, current landings are well below total quotas of 17,000 mt; a dockside monitoring program was instituted in 1996 to improve data collection. Spiny dogfish landings on the Atlantic--minimal over the last decade--have only recently begun to rise. They remained below 2,000 mt annually in 1993 and 1994, however, historic cyles of boom and collapse in the Pacific spiny dogfish fishery and the recent rapid rise and decline of the United States Atlantic spiny dogfish fishery, suggest the possibility that dogfish fisheries may emerge and collapse before adequate management measures can be developed. Given the crisis affecting other groundfish species on both the Atlantic and Pacific coasts, the development of additional precautionary measures for dogfish fisheries may be advisable.

References

Adams, Devona. 1996. Personal communication by telephone, January 13. Fisheries and Oceans Canada, British Columbia.

Anderson, Emory D. 1985. Analysis of Various Sources of Pelagic Shark Catches in the Northwest and Western Central Atlantic Ocean and Gulf of Mexico with Comments on Catches of Other Large Pelagics. In: *Shark Catches from Selected Fisheries off the U.S. East Coast.* NOAA Technical Report NMFS 31. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Washington, D.C.

Casey, J. G., N. E. Kohler, C. E. Stillwell, P. A. Turner, R. Briggs, H. W. Pratt, and L. J. Natanson. 1995. "A Summary of Shark Tag/Recapture Data from the NMFS Cooperative Shark Tagging Program (1963-1993)." Paper presented at the American Fisheries Society 125th Annual Meeting, Tampa, Florida, August 27-31, 1995.

Dauphine, Charles. 1996. In litt: to CITES Secretariat, March 19, 1996. Canadian Wildlife Service, Environment Canada, Ottawa, Ontario.

Department of Fisheries and Oceans. 1995. *1995 Atlantic Management Plan: Porbeagle, Shortfin Mako, and Blue Sharks.* Department of Fisheries and Oceans, Ottawa.

Dockerty, Trudie. 1992. *International Trade in Shark Fins.* World Conservation Monitoring Centre, Wildlife Trade Monitoring Unit, Cambridge. Unpublished.

Food and Agriculture Organization of the United Nations. 1993. *FAO Yearbook of Fishery Statistics: Catches and Landings, 1991*, Vol. 72. FAO, Rome.

Food and Agriculture Organization of the United Nations. 1994. *FAO Yearbook of Fishery Statistics: Catches and Landings, 1992*, Vol. 74. FAO, Rome.

Hurley, Peter C. F. 1995. "A Review of the Fishery for Pelagic Sharks in Atlantic Canada." Paper presented at the American Fisheries Society 125th Annual Meeting, Tampa, Florida, August 27-31, 1995.

Hurley, Peter C. F. 1996. Personal communication by telephone, 4 January. Marine Fish Division, Bedford Institute of Oceanography, Dartmouth, Nova Scotia.

Ketchen, K. S. 1986. *The Spiny Dogfish (Squalus acanthias) in the Northeast Pacific and a History of its Utilization.* Canadian Special Publication of Fisheries and Aquatic Sciences 88. Department of Fisheries and Oceans, Ottawa.

Newfoundland Seafood Market Council. n.d. Seafood Products and Processors Directory. St. John's, Newfoundland.

Nova Scotia Department of Fisheries. 1995. Nova Scotia Seafood Directory. Nova Scotia Department of Fisheries, Halifax, Nova Scotia.

O'Boyle, R. N. and K. C. T. Zwanenburg, eds. 1994. Report of the Scotia-Fundy Regional Advisory Process (RAP). Canadian Manuscript Report of Fisheries and Aquatic Sciences, No. 2252.

Porter, J. M. 1994. National Report of Canada. In: *International Commission for the Conservation of Atlantic Tunas. Report for Biennial Period, 1992-93*, Part II (1993). ICCAT, Madrid.

Saunders, M. 1996. Personal communication by telephone, 30 April. Fisheries and Oceans Canada, Pacific Biological Station, Nenaimo, British Columbia.

Scott, W. B. and M. G. Scott. 1988. Atlantic Fishes of Canada. *Can. Bull. Fish. Aquat. Sci.* 219: 731 p.

Thomson, B. L. 1995. Spiny Dogfish. In: M. Stocker and J. Fargo (eds.), Groundfish stock assessments for the west coast of Canada in 1994 and recommended yield options for 1995. Canadian Technical Report. *Fisheries and Aquatic Sciences* 2069: 321-333.

SHARK FISHERIES AND TRADE IN MEXICO

Introduction

Mexico's shark fisheries have long served as an important source of protein to subsistence users and lower income urban households. An estimated 80 percent of landings continue to be accounted for by multispecies seasonal artesanal fisheries that take approximately 40 of the nearly 100 species of shark known to inhabit Mexican waters (Castillo, 1992; Castillo and Márquez, 1993; Applegate et al., 1993). These fisheries were completely unrestricted until recent years, which increased their value as a resource for coastal communities when other species such as lobster and shrimp were depleted, unavailable, or closed.

Landings of shark for direct human consumption grew from 459 metric tons (mt) in 1940 to 1,920 mt in 1960, and 23,904 mt in 1980, making Mexico one of the world's largest producers (INEGI, 1990; Castillo, 1991; Anonymous, 1989). Landings remained relatively stable over the next decade, averaging approximately 33,000 mt annually from 1982 to 1993 (table 1). Growing demand for shark meat, fins, and cartilage in recent years and concern over the status of stocks shared with the United States has led to the development of a national research program on these valuable fisheries, and development of a regulatory framework is underway.

Methods

Research for the current report was initiated in 1991 and 1992 as part of the author's dissertation research on wildlife management policy in Mexico. The information gathered during this period, which focused primarily on skins, liver oil, and fins, was updated and expanded as part of a TRAFFIC North America (then TRAFFIC USA) project during a four-week follow-up visit to the Yucatan peninsula and Mexico City in June, 1995. During these surveys, the author was able to observe shark fisheries and wholesale and retail markets directly. Unfortunately, direct observation was not possible for the Pacific coast fisheries, with the exception of a survey of retail outlets for shark leather products conducted in 1992. Additional information was obtained from reviews of published reports of the United Nations Food and Agriculture Organization (FAO) and other published research, and in the course of market research conducted by the author within the United States from 1994 to mid 1996 on behalf of TRAFFIC North America.

Chondrichthyan Fisheries in Mexico

An estimated 80 percent of Mexico's shark catches are accounted for by the artesanal fleet, consisting of "pangas," small one-ton fiberglass boats of 5 to 10 meters equipped with outboard motors, with a range of operation of some 20 nautical miles from the coast. The remaining 20 percent is captured by 10-ton scalefish vessels and 120-ton longline vessels. Gear includes hand lines, harpoons, longlines, gillnets, and trawls.

Large-scale longline vessels use lines of up to 100 km, with an average of 2,000 hooks (Castillo, 1992). Recreational fisheries, particularly those on the Pacific coast, also take an unreported volume of sharks, but little information is available on these fisheries.

Approximately two-thirds of reported shark landings are from the Pacific Ocean, with the remainder from the Gulf of Mexico and the Caribbean Sea (table 2). Shark fisheries on both coasts are seasonal. A significant bycatch--generally undocumented and unreported--occurs in other fisheries, particularly shrimp nets, trawls, and longline fisheries targeting tuna, billfish, and reef fishes. No data are available on effort for any of these fisheries, and shark catches and landings are not reported by species (Castillo, 1992). Rays are also frequently taken and landed for human consumption but no national data are available on the volume or species composition of landings. The FAO (Anonymous, 1996) reports average landings of 2,360 mt of skates and rays in Mexico from 1988 to 1993.

Historical Background

Mexican shark landings began to rise in the 1950s and 1960s as a result of growing world demand for products such as fins and skins. In the mid 1970s, the Mexican government attempted to encourage production of shark skins, fins, and other products with the establishment of parastatal processing plants (Productos Pesqueros Mexicanos, or PROPEMEX), capable of complete processing of sharks as well as other species. One of the first such plants was established in Puerto Madero, Chiapas, and remains an important producer of raw skins. By 1982, nine PROPEMEX plants located in Guerrero, Baja California, Sinaloa, Oaxaca, Chiapas, Tabasco, Campeche, Yucatan, and Quintana Roo, were processing shark captures purchased from fishing cooperatives (Ramírez, 1982; del Toro, 1975; Díaz, Iturbide and García, 1985; Chenaut, 1985). PROPEMEX also assisted the cooperatives in the purchase of a series of aging shrimp boats which were adapted to the shark fishery. In the early 1980s, the company also acquired 10 large Japanese longliners that were operated by the parastatal. The latter, however, were inactive during much of the 1980s, affected by a lack of operating funds resulting from Mexico's economic crisis (Anonymous, 1987). In the late 1980s and early 1990s, with the process of economic liberalization, nearly all of PROPEMEX's operations were dissolved or sold.

PROPEMEX processed only about 17 percent of national production, but its impacts on shark and other fisheries were far-reaching. Not only had the parastatal encouraged the production and marketing of shark products, but it was largely responsible for the development of refrigeration and freezing facilities in Mexico's coastal zones. Before the construction of such facilities, the meat had to be dried and salted on site for local consumption or transport to internal markets. With the availability of refrigeration, coupled with growing demand for the meat both domestically and abroad, much of the product is now commercialized fresh or frozen and is transported whole with the skin in place. This has permitted the development of a significant export market for shark meat, primarily to the United States.

Shark Fisheries in the Gulf of Mexico and Caribbean

The highest shark landings in the Gulf of Mexico and Caribbean are reported for the states of Campeche, Tamaulipas, and Veracruz (table 2). Nonetheless, the fisheries of Yucatan, Campeche, and Quintana Roo are better documented than any other states of Mexico, primarily due to the efforts of the Regional Fisheries Research Centers (Centro Regional de Investigaciones Pesqueras) in these states, and, more recently, to the efforts of the National Shark Program. Bonfil et al. (1988, cited in Castillo, 1992) reported that the silky shark *(Carcharhinus falciformis)* was the most abundant species in catches in the waters of Yucatan and the Campeche Sound, with captures dominated by juveniles. Bull shark *(Carcharhinus leucas)*, dusky shark *(C. obscurus)*, sandbar shark *(C. plumbeus)*, Atlantic sharpnose shark *(Rhizoprionodon terraenovae)*, narrowfin smooth-hound shark *(Mustelus norrisi)*, dusky smooth-hound shark *(M. canis)*, and bonnethead shark *(Sphyrna tiburo)* were also abundant in catches. In the Caribbean, nurse shark *(Ginglymostoma cirratum)*, silky shark, bull shark, and Caribbean reef shark *(Carcharhinus perezi)* were the most abundant species.

The Caribbean shark fishery in the state of Quintana Roo is a small, seasonal fishery pursued around the season for lobster (Castillo and Márquez, 1993; Basurto, 1994). Applegate et al. (1984, cited in Castillo and Márquez, 1993) reported that the most abundant species in the fishery were nurse shark, silky shark, bull shark, and Caribbean reef shark. In Bahía de La Ascensión, ten seasonal fishers reported a total catch of 17.5 metric tons (mt) annually during 1993 (Zárate, Basurto, and Euán, 1994). Blacktip shark *(Carcharhinus limbatus)*, Atlantic sharpnose shark, and lemon shark *(Negaprion brevirostris)* dominated catches; also present were Caribbean reef shark, nurse shark, bull shark, blacknose shark *(Carcharhinus acronotus)*, scalloped hammerhead shark *(Sphyrna lewini)*, silky shark, dusky smooth-hound shark, tiger shark *(Galeocerdo cuvieri)*, bonnethead shark, Cuban dogfish *(Squalus cubensis)*, and dusky shark (Zárate and Basurto, 1995). At Isla Contoy on the northern tip of the state, surveys reported that the bulk of catches were accounted for by multispecies fishermen targeting shark, primarily during the off season for lobster, with the exception of four directed fishermen from Isla Mujeres and Holbox. The principal species captured were bull shark, lemon shark, blacktip shark, and nurse shark (Basurto, 1994). Recreational fisheries off Cozumel take shortfin mako sharks *(Isurus oxyrinchus)* and other species (Applegate et al., 1993).

In the state of Yucatan, a total of 53 vessels were engaged in the directed shark fishery from 1991 to 1992 (Castillo and Márquez, 1993). Catches were dominated by silky shark, bull shark, dusky shark, blacktip shark, Atlantic sharpnose shark, narrowfin smooth-hound shark, and bonnethead shark (Bonfil et al., 1990). Other species present in the fishery included dusky smooth-hound shark, blacknose shark, bignose shark *(Carcharhinus altimus)*, spinner shark *(C. brevipinna)*, night shark *(C. signatus)*, smalltail shark *(C. porosus)*, lemon shark, great hammerhead shark *(Sphyrna mokarran)*, scalloped hammerhead, tiger shark and blue shark *(Prionace glauca)*.

Nursery grounds for some of these species, including the silky shark, spinner shark, and bull shark, are known to exist off the coast of the Yucatan peninsula, notably in the coastal bays and lagoons of Quintana Roo and Campeche. Large quantities of juveniles of these species are caught in a number of directed as well as incidental fisheries, but are landed for domestic markets. A number of stocks are also shared with the United States, including the bull shark, dusky shark, and sandbar shark (Bonfil et al., 1990).

Studies in the state of Campeche during the 1980s and early 1990s suggested the existence of four distinct fisheries (Castillo and Márquez, 1993). The first, using small vessels with outboard motors and gillnets to target small sharks, consisted of 5,118 vessels using gillnets of 2.5 to 5-inch mesh, and shark nets with 7 to 8 inch mesh. These vessels operated approximately 270 days per year and generally fished at night in waters of 2 to 12 fathoms in depth, using 400 m nets. Three species: blacknose shark, Atlantic sharpnose shark, and bonnethead shark, contributed 91 percent of the individuals captured. The shark fishery proper consisted of some 3,189 vessels using 450-meter gillnets with 12-inch mesh, fishing some 120 days per year. The nurse shark, bull shark, and blacktip shark contributed 96 percent of total shark landings. A third fishery, consisting of approximately 18 vessels with inboard motors, employed gillnets of 12 to 16 inch mesh and 800 m in length, in waters of 10 to 40 fathoms in depth. Such vessels averaged a 7-day fishing trip, with an average of 30 trips per year. The principal species captured in this fishery were nurse shark, bull shark, blacktip shark, scalloped hammerhead shark, and great hammerhead shark. Finally, the large-scale fishery consisted of 11 vessels, fishing at night with three to five nets measuring up to 4,500 m in length and 7.5 to 10 m in depth, with a mesh size of 12 to 17 inches. Fishing in waters of 25 to 60 fathoms, this fleet captured primarily nurse shark, silky shark, bull shark, dusky shark, Caribbean reef shark, sandbar shark, scalloped hammerhead shark, and great hammerhead shark, with individuals measuring 144 to 373 cm in length.

More recent surveys of shark fisheries in Campeche (Chávez, 1995) described a total of 187 7.6 m vessels with outboard motors, utilizing shark gillnets during October through February and cazon gillnets from March through September. An additional 60 vessels of 7.6 to 10.2 meters, using variable net mesh for shark and cazon, depending on the season, made trips of 4 to 6 days at sea, capturing primarily Atlantic sharpnose shark, bonnethead shark, blacknose shark, and bull shark. Mid-size vessels of 8.8 to 11.8 meters carried shark gillnets, cazon gillnets, and long lines. The 13 vessels in this class captured primarily bull shark, blacktip shark, nurse shark, scalloped hammerhead shark, great hammerhead shark, and blacknose shark. Overall catches were dominated by Atlantic sharpnose shark and bonnethead shark. Other species recorded in the fishery were pelagic thresher shark, spinner shark, silky shark, dusky shark, sandbar shark, smalltail shark, and lemon shark.

Available data from other states during 1991-1992 report that the number of artesanal and mid-size vessels engaged in directed shark fisheries in other states bordering the Gulf of Mexico totaled 49 in Tamaulipas, 28 in Veracruz, and 44 in Tabasco

(Galindo, 1994). Preliminary surveys in the state of Veracruz identified 15 chondrichthyan species in catches: nurse shark, dusky smooth-hound shark, tiger shark, lemon shark, silky shark, bull shark, blacktip shark, dusky shark, scalloped hammerhead shark (*Narcine brasiliensis*, species unidentified), and the rays *(Raja texana, Rhinobatus lentiginosus*, *Dasyatis sabina*, and *Gymnura micrura)* (Montiel, 1988).

There is also a significant incidental but utilized catch of sharks by the small Gulf of Mexico longline fleet targeting tunas, groupers, and snappers. As of 1990, a fleet of five tuna longliners in the state of Veracruz reported catches of approximately 20 metric tons of shark (Galindo, 1994); similar data for other states are not available. Species reported to occur in such incidental catches include silky, spinner, blacktip, bull, oceanic whitetip *(Carcharhinus longimanus)*, tiger, blue, shortfin mako, longfin mako *(Isurus paucus)*, common thresher *(Alopias vulpinus)*, bigeye thresher *(A. superciliosis)*, great hammerhead, scalloped hammerhead, and other requiem sharks (Castillo, 1992; Gonzalez, pers. comm., 1995).

Shark Fisheries of the Pacific Ocean

Artesanal shark fisheries of the Pacific have been little studied, and consequently species composition of catches is poorly known. The states of Chiapas and Sonora account for the bulk of reported shark landings on the Pacific (table 2). A review of shark fisheries in northern Chiapas (Díaz, Iturbide and García, 1985) reported that artesanal fishers used nylon gillnets of 7-to-15 inch mesh for sharks and cazon, and long lines to target larger sharks. Gillnets were set at night, with blacktip shark dominating catches of this fishery. Long lines were set at mid-day or afternoon and soaked overnight, catching primarily tiger shark.

Perhaps the most famous shark fishery of the Pacific Ocean is an artesanal fishery that follows migrating schools from their bases in the southern state of Chiapas to southern Baja California, into the Gulf of California. The Gulf of California fishery for migrating thresher and hammerhead sharks is seasonal, beginning in late June and running through October, and captures primarily gravid females. Sharks migrating into the Gulf travel closer to the coast and closer to the surface than usual. While returning to Chiapas, they travel in deeper waters farther offshore, so the fishery resumes again in the warmer southern waters of Chiapas in the winter. A single well-known dealer, based in Baja California, outfits several artesanal vessels in Chiapas, both for local fisheries and for the annual migration into the Gulf, and in a single day may purchase the catch of 50 boats, or an estimated 1 metric ton daily (Eccardi and Velarde, pers. comm., 1995).

A recent survey of central Gulf of California drift gillnet and hook and line shark fisheries from May through September (Villavicencio et al., 1995) reported catches comprised of 19 species, including pelagic thresher shark (43.2%), common thresher shark (22.2%), silky shark (17.4%), and scalloped hammerhead shark (4.4%). A historic account of this fishery (Harris, 1972) reported several additional species in Gulf of California fisheries, including blacktip shark, shortfin mako, smooth hammerhead shark, bonnethead shark, tiger shark, bull shark, leopard shark, nurse shark, white shark, horn shark *(Heterodontus francisci)*, Pacific angelshark *(Squatina californica)*, shovelnose guitarfish *(Rhinobatos productus)*, manta ray *(Manta birostris)*, and bat ray *(Myliobatis californicus)*.

Saucedo (1992, cited in Galindo, 1993) reported that catches out of the major port of Mazatlán, Sinaloa, were dominated by Pacific sharpnose shark, scalloped hammerhead shark, whitenose shark *(Nasolamia velox)*, and shortfin mako.

A number of small, localized fisheries are described by Applegate et al. (1993). In Baja California, in the late 1960s, a shark processing plant was developed near San Jose del Cabo, but closed within three years. In the 1970s, a shark fishery in Zihuatanejo, Guerrero, produced jaws, fins, skins, liver oil, and livestock feed from viscera and other wastes, but the fishery soon closed due to exhaustion of local stocks. Another fishery developed near Santa Rosalía, Baja California Sur in 1991, targetet primarily the bigeye thresher shark. A seasonal shark fishery also currently exists off Isla Isabela, Nayarit.

Although shark fisheries of the Pacific, like those of the Gulf and Caribbean, are primarily artesanal, there are important exceptions. As of 1995, for example, a mid-size longliner operating out of the port of Manzanillo was responsible for a catch of some 1,000 to 2,000 individuals per year. Another company operating out of Ensenada, Baja California Norte had a single large longline vessel targeting billfish and sharks. From 1980 to 1990, there was also a fleet of 15 large Japanese longliners operating off the Pacific and targeting billfish and sharks, but their concession reportedly ended after 1990 (Castillo, pers. comm., 1995). Recreational fisheries target silky sharks in Mazatlán, Sinaloa (Applegate et al., 1993), and other important recreational shark fisheries take place in Cabo San Lucas and Santa Rosalía, Baja California Sur.

Shark catches by the Pacific coast swordfish fleet are also marketed domestically and abroad, with at least seven companies represented in export markets by the National Congress of Fisheries Industries (Cámara Nacional de Industrias Pesqueras, or CANAINPES). Thresher, mako, and blue sharks are marketed in export markets. Swordfish production peaks from October through February, while shark production is highest from March through June. Some production of shark occurs during the swordfish season, with some swordfish vessels targeting shark on a seasonal basis following the swordfish season. The primary port for swordfish and shark landings is Ensenada/Sauzal, Baja California Norte, with other ports including San Carlos and La Paz in Baja California Sur and Mazatlán, Sinaloa.

There is also a significant incidental catch of sharks by the tuna longline fleet in the Pacific. This bycatch is believed to include silky, spinner, blacktip, bull, oceanic whitetip, tiger, blue, shortfin mako, common thresher, bigeye thresher, pelagic thresher *(Alopias pelagicus)*, great hammerhead, scalloped hammerhead, and other requiem sharks (Gonzalez, pers. comm., 1995).

Other commercially important species on the Pacific coast include grey smooth-hound *(Mustelus californicus)*, brown smooth-hound *(M. henlei)*, sicklefin smooth-hound *(M. lunulatus)*, leopard shark *(Triakis semifasciata)*, silvertip shark *(Carcharhinus albimarginatus)*, bignose shark, blacktip shark, dusky shark, tiger shark, blue shark, Pacific sharpnose shark *(Rhizoprionodon longurio)*, scalloped hammerhead shark, and great hammerhead shark (Castillo, 1992). A significant artesanal fishery for Pacific angelshark *(Squatina californica)* also occurs in the Gulf of California, utilizing trawls, gillnets, hand lines, and harpoons (Castillo, 1992), and the diamond stingray *(Dasyatis brevis)* is subject to commercial fishing year round (Mariano and Villavicencio, 1994).

Undoubtedly, Pacific coast shrimp fisheries also take a large but unreported bycatch of chondrichthyan species. Trial sets carried out in the early 1980s reported a bycatch including hammerheads, smooth-hounds, guitarfishes, Pacific angelshark, torpedo rays, stingrays, and other rays (precise species identification not possible due to incorrect nomenclature) (Amezcua, 1985; Perez-Mellado and Findley, 1985).

Management and Conservation Measures

In Mexico, as elsewhere, the status of sharks as secondary fisheries resources led, until recently, to the virtual absence of information on stocks, fisheries, and utilization. However, in 1992, the Ministry of Fisheries' National Fisheries Institute initiated a national shark program for improving biological and fisheries research as a basis for developing further management measures for shark fisheries. Biological and fishery studies were initiated in 1993 in the Gulf of Mexico region. Research was initiated in the Pacific region in 1995, but the results of that research were not available in time to be included in this report.

To date, Mexico's shark fisheries have remained unregulated, with the exception of a permit requirement for engaging in the fishery. Since 1994, the Ministry of Fisheries reportedly has operated according to an internal memorandum that dictates no new permits for sharks are to be issued. Only those who received such permits for the previous ten years are eligible to have their permits renewed. This measure, however, is reportedly evaded on a frequent basis by brokers who own multiple vessels or outfit a number of vessels in return for exclusive purchase of their catch. It also applies only to those engaged in the directed fishery, while tuna and other commercial vessels continue to be permitted to land shark bycatch. More specific management measures have not yet been developed due to the lack of information on catches and landings by species (Castillo, pers. comm., 1995).

Mexico has also undertaken multinational research and management measures. A joint bioassessment research cruise is planned with the United States in the Gulf of Mexico during 1997 (Bailey, 1997). In addition, in late 1996, Mexico initiated a training program to monitor shark fisheries of Guatemala's Pacific coast, where shared stocks of silky shark, common thresher, scalloped hammerhead, and whitenose shark are exploited (Márquez, 1997).

Chondrichthyan Products in Trade

Meat

Sharks are referred to in Mexican fisheries statistics and markets as cazon or tiburon. Cazon are specimens not exceeding 1.5 m in length and 5 kg in weight (Castillo and Márquez, 1993). Cazon includes both smaller species and juveniles of species that reach well above this size as adults, while tiburon refers to specimens greater than these sizes. Small sharks are typically marketed fresh and whole in both coastal and urban areas.

Surveys of Mexico City's La Nueva Viga fish market (Barreto, 1994) reported the sale of several species identified as originating in the Yucatan peninsula. The following species were marketed as cazon: sharpnose sevengill shark *(Heptranchias perlo)*, bluntnose sixgill shark *(Hexanchus griseus)*, little gulper shark *(Centrophorus uyato)*, nurse shark, sand devil *(Squatina dumeril)*, shortfin mako, chain catshark *(Scyliorhinus retifer)*, smooth-hound sharks (*Mustelus* spp.), blacknose shark, spinner shark, silky shark, finetooth shark *(Carcharhinus isodon)*, bull shark, blacktip shark, smalltail shark, night shark, tiger shark, lemon shark, Atlantic sharpnose shark, scalloped hammerhead shark, great hammerhead shark, and bonnethead shark. Nurse shark, shortfin mako, spinner, silky, bull, blacktip, tiger, scalloped hammerhead, and great hammerhead sharks were also marketed in trunks. Shortfin mako, blacknose, silky, spinner, bull, blacktip, Atlantic sharpnose, scalloped hammerhead, and great hammerhead sharks were found marketed as fillets. Requiem, hammerhead, and sharpnose sharks were also marketed as dried and salted fillets. Species marketed as tripa--specimens measuring under 80 cm--included Cuban dogfish, chain catshark, smooth-hound, silky, spinner, blacktip, Atlantic sharpnose, great hammerhead, scalloped hammerhead, and bonnethead sharks.

In La Nueva Viga fish market in 1995, extremely small specimens of cazon (approximately 7-8 inches in length) sold for about US$1 per kg, while larger specimens, including silky and Atlantic sharpnose sharks, sold for about US$2 per kg. Juvenile hammerhead sharks were often mixed with other species and their characteristic "hammers" removed to disguise their identity. Fillet of cazon sold for roughly US$3 per kg, dried and salted cazon for US$6 per kg. Whole mature hammerheads were sold for less than US$1 per kg, while mako sharks were sold whole for US$1.50 to $1.80 per kg.

In the Yucatan peninsula, shortfin mako sharks and thresher sharks are typically headed and gutted for their high quality meat and marketed fresh or frozen in urban areas or exported. Hammerhead sharks are typically smoked due to the high urea content of their flesh, while tiger and nurse sharks are typically filleted, dried, and salted, for local markets. Rays are marketed fresh whole or as wings or strips, smoked, or dried and salted. Similar processing occurs on the Pacific coast, depending on the species.

According to data supplied by the Ministry of Fisheries (table 3), annual production of shark from 1990 to 1992 averaged 17,477 mt of fresh and chilled shark, 3,891 mt of frozen shark, and 396 mt of dried, salted shark. It is likely, however, that official statistics underestimate the production and consumption of dried, salted product in coastal communities. Much of the country's production of fresh and frozen shark is transported to Mexico City for sale at La Nueva Viga.

According to the FAO (Anon., 1996, table 4), Mexico first began to report imports of fresh or chilled shark in 1990; reported imports rose from 219 mt in that year to 863 mt in 1994. Smaller quantities of frozen shark also began to be reported in imports in 1990, rising from 30 mt in that year to 246 mt in 1994. The United States reports exports of shark meat to Mexico averaging 10 mt annually from 1989 to 1995, increasing from 36 mt in 1989 to 400 mt in 1993, before dropping again to 56 mt in 1995 (table 5). Although U.S. trade statistics report dogfish and other sharks in trade separately beginning in 1995, a breakdown for that year reveals that reported Mexican imports consisted entirely of fresh and frozen dogfish (*Squalus acanthias* and related species).

Mexico's FAO reported exports of fresh or chilled shark rose from 143 mt in 1990 to 853 mt in 1994 (table 4). No exports of frozen shark or of shark fillets are reported. However, separate statistical records of the Bank of Mexico reported exports of fresh shark totaling 589 mt in 1992, 739 mt in 1993, and 853 mt in 1994, with exports of 12 mt of frozen shark reported in 1994 (tables 7and 8). All shark exports are reported to the United States, with the exception of 0.3 mt reportedly exported to Japan in 1993. The United States reports imports of shark meat from Mexico averaging 272 mt annually during 1989-1995, including 281 mt in 1989 and 176 mt in 1990, peaking at 681 mt in 1994 (table 6). In 1995, U.S. imports from Mexico included only sharks other than dogfish, and consisted almost entirely of fresh product (Rose, 1996a). Market surveys in the United States and Mexico suggest that shortfin mako, thresher, bigeye thresher, and pelagic thresher sharks caught in longline tuna and swordfish fisheries comprise the bulk of Mexican shark exports (Rose, 1996a).

Internal Organs and Other Edible Products

No information is available on the consumption of internal organs and other edible shark products in Mexico.

Fins

According to Hernandez (1976), the first shark fins were exported in 1888 from La Paz, Baja California, where constant markets were maintained from then onward. A 1959 review of fisheries resources of the Gulf of Mexico and Caribbean (Beltrán, 1959) described an active shark fishery, in which fins, as well as oil and skins, were retained for export to the United States. Unfortunately, fisheries and export statistics rarely distinguish fins from other shark or fishery products, so long-term trends in fin trade cannot be determined. Conversations with fishermen on both the Pacific and Gulf of

Mexico and with personnel of the Ministry of Fisheries in 1991, 1992, and 1995 suggested that the export market for this product has grown rapidly in recent years and that Mexican fishermen have taken advantage of rising prices.

Available national data show that between 1982 and 1987, Mexico exported a total of 1,034,420 kg of fins valued at US$15,880,798 (data from the Mexican Secretariat of Commerce and Industrial Development, or SECOFI, table 9). After 1987, fins were again grouped with other shark products in Mexican tariff classifications, so no data are available. Principal reported import markets from 1982 to 1987 were Hong Kong, Japan, Taiwan, Singapore, Indonesia, and the United States. Hong Kong Customs report average imports of shark fin from Mexico of 150 mt annually from 1984 to 1994, peaking in 1994 at 207 mt.

Much of Mexico's shark fin exports however are likely to be shipped first to the United States, where customs report imports of shark fin from Mexico averaging 29 mt annually from 1986 to 1995, peaking at some 44 mt in 1994 (table 6). U.S.-based fin dealers report that shark fins imported from Mexico are typically of low-quality cut and therefore subject to high rates of spoilage, but, due to the abundance and relatively easy, low-cost transportation, it is likely that large volumes enter the United States. Fins produced within the United States, rather than purchased domestically for processing and consumption, are typically merely re-exported--frozen or dried--to Asia for processing. Limited exceptions to this rule were found during market surveys in San Francisco and Los Angeles, California, where a small number of trading and retail establishments have begun to import dried fins directly from Mexico and elsewhere in Latin America for sale and consumption within the United States, as well as for reexport. Some restaurants have begun purchasing fresh and frozen fins from Mexico for the preparation of shark fin soup (Rose, 1996a). A much smaller proportion of fin production has reportedly been destined for fine Asian restaurants within Mexico (Hernandez, 1976).

In the Yucatan peninsula, sharks are landed with their fins intact. Fins are removed for drying by the processor, or, if the shark is sold fresh and whole in local markets, removed at the point of sale and later collected by fin dealers. Even the fins of small juveniles are retained. Reported prices to middlemen ranged from approximately US$15-38 for small fins to US$75-94 for large fins. Personnel of federal fisheries agencies report the increasing incidence of U.S. buyers visiting local ports to arrange for purchase directly (Mena and de Anda, pers. comm., 1995). One local processor reportedly sold dried fins to Miami-based U.S. buyers for an average price of US$86 per kg in 1995, while another was observed packing plastic-lined cardboard boxes with fins for export to San Francisco. The fins are then shipped to the United States for direct re-export or for further processing and re-export.

In La Nueva Viga in Mexico City, fins are similarly collected from wholesalers and processors for export. One dealer interviewed in this market described a single middleman who employed several collectors to routinely purchase fins and cartilage from stalls in La Nueva Viga. Fins were graded into five classes, with prices to wholesalers and processors ranging from US$8 for low-grade fins to US$113 for high-quality fins. The fins were then exported to Hong Kong vía Mazatlán.

Shark Skins

In the mid 1920s, export of shark skins to the United States began to gain commercial importance (Ramirez, 1982). Industrial markets at first demanded the tough skins for use as an abrasive to polish metal. The skins were also occasionally used to produce leather, but the product obtained was of poor quality and never generated significant demand (Carranza, 1959; Anonymous, 1976b). In the early 1960s, however, the Ocean Leather Company of Guaymas, Sonora, a subsidiary of Ocean Leather Company of the United States, began to produce high-quality leather using a chemical tanning process that the company had perfected and patented some years earlier in the United States (Carranza, 1959; Rose, 1992; Rose, 1996).

In the early years of the shark leather industry, most of the skins were apparently exported raw. No exports of tanned skins were reported for this period, while reported exports of raw skins grew from 85,000 kg in 1965 to 172,000 kg in 1968, declining to 22,000 kg in 1971 (Elizalde, 1973). This decline in the late 1960s and early 1970s appears to be the result of accelerated development of Mexican tanning, however, no production or export statistics are available for these years.

By 1976, some four or five companies were manufacturing shark leather cowboy boots, belts, jackets, handbags, briefcases, wallets, shoes, and key chains. Many of the tanneries, both private and state-owned, processed both sea turtle leather and shark (Anonymous, 1976b). By the early 1980s, Mexico was exporting large volumes of raw and tanned shark skins, primarily to Japan, Spain, and the United States.

Much of the shark leather trade during the 1980s was related to the manufacture of cowboy boots, primarily in El Paso-Ciudad Juarez, much of which was accounted for by U.S. maquiladoras on the Mexican side of the border. Shark skins were imported by U.S. companies, cut, exported to Mexico for assembly, and then re-exported from Mexico to the United States. Although no complete listing is available, there were at least three such maquiladoras in El Paso-Ciudad Juarez in the early 1990s: CowTown Boots, Tony Lama, and Western Boots, while Montana Boot remains an important Mexican-owned manufacturer of sharkskin boots (Rose, 1992).

According to Mexican export data (table 9), from 1982 to 1987, Mexico exported a total of 17,227 kg of raw skins and 78,986 kg of tanned skins. From 1988 to 1991, Mexico exported another 20,937 kg of raw skins, but data on tanned skins ceased to be reported separately (data from SECOFI). The Bank of Mexico reported exports averaging 4 mt annually of raw shark skin from 1983 to 1993, and 14 mt of finished skins annually from 1984 to 1988.

From 1987 to 1990, however, the United States alone reported imports of more than 69,283 whole skins, 38,380 partial skins, 192,430 pairs of shoes and boots, and 22,361 other shark leather products from Mexico. Reported U.S. exports to Mexico during this period totaled 2,528 skins; 15,916 partial skins and 120 m of skins; 11,202 pairs of shoes and boots; 11,699 small leather products; and 1,134 other products (Rose, 1991). Although Mexico is known to be a major supplier of shark skins to the United States, the nature of the trade and the fact that exports are more commonly under-reported than are imports make it difficult to determine what proportion of these skins and leather products originated in Mexico.

The sharkskin industry received another strong stimulus in 1990 when the Pacific Coast sea turtle fishery was closed by Presidential decree. While many Mexico City tanneries that specialized only in sea turtle leather were forced to close down, others--especially those that already produced small quantities of shark and other fish leather--began to work almost exclusively with shark leather. The fishing cooperatives that had earned their living from the sea turtle industry were offered shark nets in compensation, a fact that may have contributed to increased reported exports of shark leather and shark leather products in 1990 and 1991, and widespread availability of shark leather goods in domestic retail outlets (Rose, 1992).

There are a number of shark skin tanneries currently operating in Mexico. A single tannery in the Yucatan peninsula purchases wet, salted skins from processors in the states of Quintana Roo, Yucatan, Campeche, Veracruz, and Tabasco. Prices to processors for salted skins are approximately US$4 each, and the tannery is generally able to use the skin from all species. Crusted skins are then exported to a single tannery in the United States, and finished skins valued at US$6-6.50 per foot length to brokers in Texas. Tanneries in both the United States and Mexico report that the tiger shark is the preferred species for leather production, while the skins of lemon, dusky, blacktip, and whitetip sharks are also suitable. The skins of nurse sharks are of considerably lower value, but comprise a significant proportion (approximately 15 percent) of the skins tanned in the Yucatan peninsula, and are typically stamped and dyed to provide the texture necessary for commercial use. Thresher, blue, and hammerhead sharks are considered unusable because of their thinness or lack of texture. In the Yucatan peninsula, however, the skins of most specimens over 1.5 m in length are retained for sale to tanneries, unless they are highly damaged. At least one Mexican tannery has historically purchased raw skins from Central America as well.

Shark skins, as well as finished products, are exported in small quantities to Europe as well as the United States, and are marketed within Mexico. Western boots are also sold domestically in Mexico, but, in 1992, retail prices of US$135 to $200 limited domestic demand (Rose, 1992). By the mid 1990s, worsening economic conditions within Mexico appeared to have severely reduced domestic demand for these luxury products. The popularity of Western boots has also declined sharply in the United States since the 1980s. The Ocean Leather Corporation of the United States no longer exists, and a single U.S. tannery now purchases only crusted skins of tiger, dusky, blacktip, whitetip, and nurse sharks from a sole supplier in Mexico (Rose, 1996a).

Another factor influencing the shark skin industry is the spread of refrigeration and freezing facilities and other trends in markets for shark meat. Traditionally, shark skin removed whole during the processing of dried, salted meat was also salted and sold to tanneries. Much of the product is now commercialized fresh or frozen and is transported whole with the skin in place, or marketed as "splits" or halves, which destroys the belly flap favored by tanneries and leather goods manufacturers. These marketing trends have served to reduce the available supply of shark skins for tanning. During the early 1990s, one Pacific coast tannery reported importing shark skins from Florida shark fisheries in the United States due to this decreased availability of domestic supply (Rose, 1992). Tanneries in Guadalajara, Mexico are also reported to import shark skins from Pacific coast shark fisheries of Guatemala (Márquez, 1997).

Shark Liver Oil

In the 1930s, shark liver oil began to be used in the United States in the manufacture of vitamin A supplements. By 1942, Mexican production for export to the U.S. reached 1,342 tons of shark liver, with 81 percent produced in the northwest, primarily Sonora (Hernandez, 1976). In 1943, a factory was established in Guaymas to extract the vitamin within Mexico, and another was established in Guadalajara in 1944. In the late 1940s, cheaper synthetic substitutes were developed and, by 1949, these plants were forced to close and the earnings were invested in the fledgling Pacific shrimp industry (Hernandez, 1976). The vitamin A plants were reopened in 1958 for export of liver oil to England, France, Norway, the United States, and Japan, but, by 1961, these markets were also closed. From 1961 onward, production was destined only for the domestic market (Anonymous, 1976a).

On the Pacific coast of Mexico, the oil reportedly continues to be consumed directly as a vitamin supplement by shark fishermen (Díaz, Iturbide and García, 1985). In the Yucatan peninsula, shark livers are occasionally retained. The oil is consumed directly or sold in local markets for medicinal use or used in the maintenance of small wooden vessels. One processor in Campeche reported that oil produced for local consumption was extracted by cutting the liver into strips and then salting it. Livers were reportedly retained only occasionally in Mexico City's La Nueva Viga. A small number of domestic manufacturers also offer shark liver oil capsules for the health products market; a total of three national brands were observed on the market in 1995.

It is not clear whether shark liver oil is currently exported from Mexico as that country does not report liver oil in trade. From 1972 to 1986, the United States reported imports of shark liver oil from Mexico only in 1982, when a total of 771 kg of oil was imported. The product ceased to be reported in U.S. trade statistics after 1986 and no further information is available (Rose, 1996a).

Shark Cartilage

Shark processors in the Yucatan peninsula typically sun-dry or freeze-dry shark vertebrae and occasionally the cartilaginous base of fins, either for sale to domestic manufacturers or for export to the United States. The dried cartilage reportedly sold for approximately US$2 per kg in 1995 to U.S. buyers, who then processed, ground, and bottled the cartilage for sale as capsules. One dealer based in Baja, California, also reported selling frozen cartilage to a domestic pharmaceutical company for approximately US$2 per kg. In Mexico City's La Nueva Viga, a dealer reportedly collects fresh and frozen cartilage as well as fins, paying about US$2.60 per kg, for export to San Francisco.

A domestic manufacturer of shark cartilage capsules based in Mexico City was interviewed in 1995 and reported buying an estimated 3,000 mt of fresh and frozen cartilage over a 12-month period. The cartilage was obtained from Veracruz and Baja, California, and presumably was purchased from an intermediary at US$3.40-$4.10 per kg. The capsules were marketed in bottles of 100 600-mg capsules at a retail price of US$31. In addition, the manufacturer supplied processed powder to three domestic companies for packaging and retail sale.

Although Mexico's shark fisheries are among the largest in the world, many domestic manufacturers reported in 1995 that they continued to import processed cartilage powder from Japan, rather than obtaining supplies domestically.

Domestic demand for these products appears to be growing rapidly, with a 1995 market survey revealing at least four national brands and four other brands (manufactured in the United States, Costa Rica, and New Zealand) offered in retail outlets.

Sharks as Bait

In many areas of the world, undersized or unmarketable shark catches are often used as bait in other fisheries. In Mexico, however, all species and sizes find a ready market in local--if not national--markets, so, this practice is unlikely to occur on any significant scale. The use of sharks as bait was not observed or reported during research for this report.

Fishmeal, Fertilizer, and Related Products

Shark processing wastes are routinely collected, along with other fish waste, for the manufacture of fishmeal in the Yucatan peninsula. It is not known whether fishmeal production currently takes place on the Pacific coast; processors at La Nueva Viga in Mexico City report that shark waste is not utilized. No data are available to suggest the volume or importance of national production.

Teeth, Jaws, and Other Curios

Processors throughout Mexico routinely retain shark teeth and jaws for sale as curios. These markets appear to be limited and opportunistic, as is true worldwide (Rose, 1996b). The Seri of Sonora are also reported to have used shark "bones" to make necklaces for sale to tourists (Cuellar, 1980), but it is not known if this practice continues.

Aquarium Specimens

No information is available on the use or marketing of chondrichthyans as aquarium specimens in Mexico.

Conclusions and National Recommendations

Shark fisheries represent an important resource in Mexico, not only because of the continued high volume of landings, but also because of the preponderance of artesanal vessels in the fishery. Recent years have witnessed a gradual shift in the importance of inshore versus offshore fisheries, which may account in part for the consistency of landings over the past decade. At present, too little information is available on both fisheries and stocks to determine the status of individual species, stocks, or localized fisheries. However, since 1992, the National Shark Program of the National Fisheries Institute has sponsored a growing body of research, and a number of joint research initiatives with the United States are underway. Improved data will be used in future to develop appropriate management measures. These measures will have to take into account the socioeconomic context of shark fisheries in Mexico, which differs greatly from that of the United States and Canada: in particular, the constraints faced by small-scale fisheries, the growing importance of Mexico's longline fleet, the full or near-full utilization of sharks in Mexico's fisheries, and entirely different connotations of "bycatch," which in Mexico is not discarded, but destined for human consumption.

With regard specifically to trade of shark products, Mexican fisheries agencies benefit from a long history of detailed reporting of catches and landings by state, analysis of fisheries production, and monitoring of the vessel composition of the fisheries. Improved reporting of shark products in trade, including fins, cartilage, skins, and liver oil, would greatly assist efforts to monitor and analyze trends in the fisheries.

References

Amezcua Linares, F. 1985. Recursos Potenciales de Peces Capturados con Redes Camaroneras en la Costa del Pacifico de Mexico. In: Alejandro Yañez-Arancibia, ed., *Recursos Pesqueros Potenciales de Mexico: La Pesca Acompañante del Camaron*. Mexico, D.F: Universidad Nacional Autonoma de Mexico.

Anonymous. 1976a. El Tiburon: Mas Benefico que Terrible. *Tecnica Pesquera*, No. 99.

Anonymous. 1976b. La Piel mas Fuerte del Mundo. *Tecnica Pesquera*, No. 99.

Anonymous. 1987. Permanece anclado El Tiburon V en Tampico por Falta de Cuidados. *Tecnica Pesquera*, No. 233.

Anonymous. 1989. Servicio de Actualizaciór Pesquera. No. 61.

Anonymous. 1994. Estadísticas Basicas Pesqueras 1993. Mexico City, Secretaría de Pesca. Internal Document.

Anonymous. 1996. Fishstat PC. Fishery Information, Data and Statistics Unit, FAO Fisheries Department, Food and Agriculture Organization of the United Nations.

Anonymous. Various years. Anuario Estadístico de Pesca. Mexico City, Secretaría de Pesca, Dirección General de Informática y Registros Pesqueros.

Applegate, S. P., S. Estrada, F. Sotelo, and L. Espinoza. 1984. Reporte Final del Proyecto "Tiburones Mexicanos (Area Caribeña)." CONACyT, PCMA BNA-001991. Unpublished report, Mexico.

Applegate, Shelton Pleasants, Fernando Soltelo-Macías, and Luis Espinosa-Arrubarrena. 1993. An Overview of Mexican Shark Fisheries, with Suggestions for Shark Conservation in Mexico. In: *NOAA Technical Report NMFS 115*.

Bailey, Michael. 1997. NMFS Takes Aggressive Stance to Prevent Continued Overfishing. *Shark News* 9 (June): 10.

Barreto Salinas, Claudia. 1994. Descripción de la Pesquería del Tiburon del Golfo de Mexico, Su Distribución y Consumo el la Capital del Pais. Social Service Project for the title of Biologist, Universidad Autónoma Metropolitana - Xochimilco, Mexico City, November 1994.

Basurto, Martha. 1994. Influencia de la Pesca en Isla Contoy. Amigos de Sian Ka'an, *Boletín* 13 (December): 21-23.

Beltrán, Enrique, Ed. 1959. Los Recursos Natural del Sureste y Su Aprovechamiento. Vol. 3. Mexico, D.F.: INIREB.

Bonfil S., Ramon, David de Anda F., and Roberto Mena A. 1990. Shark Fisheries in Mexico: The Case of Yucatan as an Example. In: Harold L. Pratt, Jr., Samuel H. Gruber, and Tonu Taniuchi, eds., Elasmobranchs as Living Resources: Advances in the Biology, Ecology, Systematics, and the Status of the Fisheries. NOAA Tech. Pub. NMFS 90. Washington, D.C.: U.S. Department of Commerce.

Carranza, Jorge. 1959. Pesca y Recursos Pesqueros. In: Enrique Beltran, ed., *Los Recursos Naturales del Sureste y su Aprovechamiento*. Vol. 3. Mexico, D.F.: INIREB.

Castillo Géniz, José Leonardo. 1991. Tiburon. *Panorama Pesquero* 1(3).

Castillo Géniz, José Leonardo. 1992. Diagnóstico de la Pesquería de Tiburon en México. Mexico, D.F.: Secretaría de Pesca.

Castillo Géniz, José Leonardo and Juan Fernando Márquez Farias. 1993. La Pesquería de Tiburon en México: Una Revisión Histórico del Golfo de México. Unpublished report.

Castillo Géniz, José Leonardo. 1995. Personal communication, July 4. Programa de Investigaciones Biológico-Pesqueras del Recurso Tiburon, Instituto Nacional de Pesca, Dirección de Analisis de Pesquerías, Mexico, D.F.

Chávez Contreras, Ana Maria. 1995. Análisis de la Pesquería de Tiburon en el Estado de Campeche de Diciembre 93 a Mayo 94. Thesis for the B.S. in Hidrobiology. Universidad Autónoma Metropolitana - Iztapalapa. Campeche.

Chenaut, Victoria. 1985. *Los Pescadores de la Peninsula de Yucatan*. Cuadernos de la Casa Chata #121. Mexico, D.F.: CIESAS.

Cuellar, José Arturo. 1980. La Comunidad Primitiva y Las Políticas de Desarrollo (El Caso Serí). Mexico, D.F.: UNAM.

de Anda, David. 1995. Personal communication, June 20. Centro Regional de Investigaciones Pesqueras-Yucalpeten. Yucalpeten, Yucatan, Mexico.

Díaz, Marcial, Galdino Iturbide, and Imelda García. 1985. Los Pescadores de Nayarit y Sinaloa. Cuadernos de la Casa Chata #12. Mexico, D.F., CIESAS.

Eccardi Ambrosi, Fulvio. 1995. Personal communication, July 5. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO), Mexico City.

Elizalde David, Jose Luis. 1973. Situación Económico Actual, Problemas y Perspectiva de la Industria Curtidura en Mexico. Thesis, B.A. in Economics, UNAM. Mexico, D.F.

Gonzalez, Vicente. 1995. Personal communication, July 4. Programa Nacional de Aprovechamiento del Atun y Protección al Delfin, Instituto Nacional de Pesca, Mexico, D.F.

Harris, David. 1972. Vagabundos del Mar: Shark Fishermen of the Sea of Cortez. *Oceans* 5(1): 61-72.

Hernandez, Anatolio. 1976. La Pesquería de Tiburon en Mexico. *Tecnica Pesquera*, No. 99.

INEGI (Instituto Nacional de Estadistica, Geografia e Informatica). 1990. *Estadísticas Historicas de Mexico*. Volume II. Mexico, D.F.: INEGI.

Mariano, Everardo and Carlos Villavicencia-Garayzar. 1994. "Size Composition, Sex Ratio and Reproductive Condition of the Diamond Stingray, Dasyatis brevis, in Bahia Almejas, B.C.S. Mexico." Paper presented at the 1994 Meetings of the American Elasmobranch Society, University of Southern California, Los Angeles, California, June 2-8, 1994.

Márquez, Fernando. 1997. Mexico/Guatemala: A Collaboration in Shark Fisheries. *Shark News* 9 (June): 14.

Mena, Roberto. Personal communication, June 20. Centro Regional de Investigaciones Pesqueras-Yucalpeten. Yucalpeten, Yucatan, Mexico.

Perez-Mellado, J. and L. T. Findley. 1985. Evaluación de la Ictiofauna Acompañante de Camaron Comercial Capturado en las Costas de Sonora y Norte de Sinaloa. In: Alejandro Yañez-Arancibia, ed., *Recursos Pesqueros Potenciales de Mexico: La Pesca Acompañante del Camaron.* Mexico, D.F: Universidad Nacional Autonoma Mexico.

Rose, Debra A. 1991. *A North American Free Trade Agreement: The Impacts on Wildlife Trade.* Washington, D.C.: World Wildlife Fund - United States.

Rose, Debra A. 1992. *The Sharks of Mexico: A Resource for All Seasons.* TRAFFIC USA 11(4): 4-6.

Rose, Debra A. 1993. *The Politics of Mexican Wildlife: Conservation, Development, and the International System.* Unpublished Ph.D. dissertation, University of Florida, Gainesville, Florida.

Rose, Debra A. 1996a. *Shark Fisheries and Trade in the United States.* Draft report. Washington, D.C.: TRAFFIC North America.

Rose, Debra A. 1996b. *An Overview of World Trade in Sharks and Other Cartilaginous Fishes.* Cambridge, TRAFFIC International.

Velarde, Enriqueta. 1995. Personal communication, July 5. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO), Mexico City.

Villavicencio G., Carlos J., Everardo Mariano M., Carolina Downton H., and Gabriel Estrada A. Presentation at the American Fisheries Society 125th Annual Meeting, Tampa, Florida, August 27-31, 1995.

Zárate Becerra, Edith, Martha Basurto Origel, and Rosendo Euán Canché. 1994. Los Tiburones de la Ascensión. CRIP Informa - Puerto Morelos. No. 1 (September): 9.

Zárate, Edith and Martha Basurto. 1995. Especies de Tiburones Presentes en las Capturas de Bahía de la Ascensión. CRIP Informa - Puerto Morelos, Año 2, No. 1 (January): 11.

SHARK FISHERIES AND TRADE IN THE UNITED STATES

Introduction

The United States is the world's fifth largest fisheries producer in terms of commercial landings and ranks second in terms of the value of its fisheries imports and exports. U.S. commercial marine fisheries take place within United Nations Food and Agriculture Organization (FAO) statistical areas 21 (Northwest Atlantic), 31 (Western Central Atlantic), 67 (Northeast Pacific), 77 (Eastern Central Pacific), and 71 (Western Central Pacific). In 1993, commercial landings of all species totaled approximately 11 billion pounds, or 5 million metric tons (mt), valued at approximately $3.7 billion. The U.S. imported $12 billion in edible and nonedible fishery products in 1994, exporting products valued at $7.4 billion (NMFS, 1995).

Chondrichthyan fisheries are increasingly important in the United States. Total commercial chondrichthyan landings totaled 38,074 mt in 1993, or some 0.8 percent of total U.S. landings (FAO, 1995). Chondrichthyan landings in the United States are dominated by piked or spiny dogfish *(Squalus acanthias)* and skates (Rajidae). Spiny dogfish landings have risen rapidly from 8,812 mt in 1982 to 21,242 mt in 1994 (table 1), while landings of skates also increased to more than 10,000 mt annually during the early 1990s. Fisheries for both dogfish and skates are concentrated on the U.S. Atlantic coast, and landings are destined primarily for Europe.

After 1985, directed commercial fisheries for sharks other than dogfish also developed on the Atlantic coast, in response to rising prices for shark fins, growing popularity of shark fillets and steaks in domestic markets, and declining stocks of tuna and swordfish. Total U.S. landings of sharks other than dogfish rose from 2,554 mt in 1985 to 7,436 mt in 1994 (table 1), with the bulk of landings occurring on the Atlantic. Rising concern over the status of shark stocks due to rapidly increasing landings led to the establishment of catch and landing quotas and other regulatory measures through the federal Fishery Management Plan for Sharks of the Atlantic Ocean, implemented in 1993, and increased state regulation in the Pacific.

ATLANTIC AND GULF OF MEXICO SHARK FISHERIES

Historical Background

The U.S. Atlantic and Gulf coast shark fisheries have historically been confined to small, localized fisheries scattered along the U.S. coast. In 1919, a commercial shark fishery was established in North Carolina by the Ocean Leather Corporation of New Jersey, which developed the first chemical processing to remove denticles from shark skin to produce leather. Three vessels employed set nets some 8 km from shore, catching 50 to 60 sharks averaging 2.1 mt per day. Processing facilities were established for the production of skins, liver oil, meal, and fertilizer. The operation ended in 1922 due to processing difficulties and insufficient supply. Another small commercial fishery developed in 1936, taking skins, livers, and teeth and using the remainder of the carcass for fertilizer or discarding it; this operation was closed in 1941. North Carolina shark landings totaled 464 mt from 1937 to 1939, and then dropped to 0.5 mt by 1945 (Schwartz and Burgess, 1975).

From 1936 to 1950, a small longline fishery operated from Salerno, Florida, targeting sharks primarily for liver oil and hides but also producing fresh and salted meat, fins, and fish meal. The development of synthetic vitamin A led to the disappearance of the fishery in 1950 (NMFS 1993). In the 1960s, another small shark fishery developed in the northeastern United States when Norwegian fishermen, faced with declining catches of porbeagle *(Lamna nasus)* in the eastern Atlantic, shifted to the Newfoundland Banks and New York waters. Catches rose from 1,800 mt in 1961 to 9,300 mt in 1964, then fell sharply to 200 mt (NMFS, 1993).

Estimates of total shark mortality from all sources, including commercial, recreational, and incidental catches, averaged 9,840 mt from 1965 to 1980. These data suggest that from 1960 to 1981, recreational fisheries and swordfish longline bycatch accounted for the bulk of shark catches by the U.S. in the Atlantic. Total U.S. shark catches increased from an estimated 3,334 mt in 1965 to 15,452 mt in 1980. Estimated shark catch by foreign vessels averaged 4,600 mt from 1965 to 1969; declined to an average of 2,566 mt in 1970-1974, and 1,354 mt in 1975-1979; and rose again to an average of 2,237 mt in 1980 and 1981 (Anderson, 1985).

In the Gulf of Mexico, recreational fisheries and bycatch from the shrimp trawl and other miscellaneous fisheries were responsible for most shark catches by U.S. vessels during this period. Total estimated U.S. shark catch averaged increased from 3,504 mt in 1965 to 10,059 mt in 1980. Estimated shark catch by foreign vessels averaged only 351 mt from 1965 to 1981, while total estimated shark catch from all sources averaged 6,761 mt from 1965 to 1980 (Anderson, 1985).

Prior to the early 1970s, small-scale directed shark fisheries in the Atlantic continued to provide small quantities of meat for sale and consumption in coastal areas. Beginning in the early 1970s, domestic consumption of shark meat began to increase, and expanding links between U.S. fishermen and Asian markets increased the marketing of shark fins from U.S. fisheries. Interest in the development of shark fisheries was stimulated by high incidental catches of sharks by the longline fleet targeting swordfish *(Xiphias gladius)*. The development of large-scale directed fisheries, however, did not occur until significant increases in ex-vessel prices for both meat and fins began to be realized in the mid 1980s. Shark landings began to increase sharply beginning in 1985, with large scale commercial fisheries developing in both the Atlantic and the Gulf of Mexico (NMFS, 1993). Landings and commercial use of shark bycatch from the growing Atlantic and Gulf tuna and swordfish fisheries also became significant. The development of these fisheries is discussed in the following sections.

Minimal commercial landings of spiny dogfish were reported off the Northeastern coast from the 1930s through the mid 1970s with reported landings of less than 100 mt during most years prior to 1960; the dogfish liver oil boom that surged on the Pacific coast from 1937-1950 affected Atlantic fisheries only marginally. A foreign fishery developed for dogfish in the mid 1960s, with landings from1966 to 1977 averaging 13,000 mt annually, most of which were taken by the former USSR. Dogfish landings peaked from 1972 to 1974, then dropped sharply after 1978 following the declaration of the U.S. Economic Zone (U.S. EZ). Domestic landings averaged some 4,500 mt during the 1980s, then rose sharply in the late 1980s and early 1990s. The large-scale directed dogfish fishery that has developed in the 1990s is discussed in a separate section of this report.

Directed Shark Fisheries

Development of the Fishery

In the southeastern states, the directed shark fishery that emerged from the early 1980s to the early 1990s consisted primarily of boats of 40 to 55 feet employing longlines or gill nets. Gear and fishing methods developed during the emergence of a small-scale directed fishery on Florida's east coast from 1980 to 1984 is described in detail by Lawlor (1985). Major ports included Morehead City, North Carolina; Port Orange and Madeira Beach, Florida; and Bayou LaBatre, Alabama. Longline vessels typically employed monofilament lines at a depth of 120 feet or less, operating nearly year-round and, in some cases, following migrating sharks. The shark gill net fishery consisted of small (18-22 foot) boats operating in very shallow waters and estuaries from May through November, and a modern fleet of 36 to 55 foot boats targeting migrating sharks in coastal waters during the spring and fall (NMFS, 1993). Of commercial shark landings for the period 1979-1988, 86 percent came from the U.S. EZ (or beyond 200 miles), and only 14 percent came from state waters.

The number of commercial vessels in the Atlantic large coastal shark fishery increased from 42 in 1986 to a peak of 132 in 1989. Most of these vessels were pelagic or bottom longliners, with 10 to12 gillnet boats and 3 to 4 boats using both gillnets and longlines also targeting sharks. Annual shark landings from the Atlantic and Gulf (table

2) increased from a total of 128 mt round weight in 1979 to 524 mt in 1981; 1,048 mt in 1985; 3,374 mt in 1987; and 5,735 mt in 1988; peaking at 7,699 mt in 1989. Landings declined to 5,593 mt in 1991, and again rose to 6,316 mt in 1992 (NMFS, 1995). In 1989, approximately 86 percent of the shark catch was by longline, 9 percent by gill net, and the remainder by other gear (NMFS, 1993).

Since the early 1990s, several developments have combined to alter the southeastern shark fishery. Legislation in several coastal states, including Florida, South Carolina, and Louisiana, has prohibited gill netting within the 3-mile limit of state waters (9 miles for Florida), therefore, gill netters have been forced into deeper waters where their nets are less effective. In many cases, longlining is also prohibited in state waters. After 1989, several of the larger vessels left the fishery and in 1991, the total number of vessels fell to 96, while estimated commercial landings fell from 7,337 mt in 1989 to 5,548 mt in 1991. In 1992, a rise in fin and meat prices, anticipation of a fishery closure associated with the development of a management plan for Atlantic sharks, increased availability of fish, and displacement of vessels from other fisheries led to the re-entry of large gill net vessels and entry of additional boats into the directed shark fishery (NMFS, 1993). Landings jumped sharply to 9,251 mt in 1992, remaining fairly constant at that level through 1994.

A Fishery Management Plan for Sharks of the Atlantic Ocean (FMP) was implemented in 1993. The FMP applies to 73 species of shark, including 39 species in the management unit (tables 3 and 4). The FMP established annual permit requirements for vessels wishing to sell sharks, and set commercial quotas for species included in the large coastal and pelagic species groupings. The annual quotas are divided into semi-annual quotas of 1,218 mt and 290 mt, respectively; upon reaching the semiannual quotas, a notice of fishery closure is issued by NMFS. In 1994 and 1995, the annual large coastal commercial quota was raised slightly from 2,436 mt to 2,570 mt, while the pelagic commercial quota remained at 580 mt.

In 1993 and 1994, implementation of the semi-annual quotas led to derby-style fishing, with fishery closures imposed in mid May of 1993 and 1994 for the first season, and late July and early August of 1993 and 1994 for the second season. Associated problems included routine exceeding of the semi-annual quota prior to fishery closures; disruption of the fresh shark market; and waste and quality control problems. In order to extend the season and reduce such problems, a trip limit of 4,000 lb (1,814 kg) dressed weight was instituted in late 1994 (NMFS, Atlantic Shark Fisheries Final Rule, *Fed. Reg.* 59(200): 52453-52458).

As a result of the implementation of the shark FMP and other factors, total commercial shark landings dropped back to 5,046 mt in 1993 and 5,385 mt in 1994, with the Southeast region (south Atlantic and Gulf) contributing approximately 85 percent of the U.S. east coast shark catch (NMFS, 1995). However, largely as the result of speculative entry into the fishery, the number of permitted vessels in the shark fishery exceeded 1,400 in 1993--many more than actually participated in the fishery (NMFS, *Fed. Reg.* 58(168): 46153-46155).

The combination of semi-annual commercial quotas and vessel trip limits is likely to have affected the number and characteristics of vessels participating in the Atlantic shark fishery, although recent data on fleet composition are not available to support these conjectures. Many participants in the directed shark fishery fished year round prior to the implementation of the FMP. Before late 1994, the short fishing season and commercial quota created some disruption in the fleet, as vessels were required to pay overhead year round but were only able to participate in the fishery a few months during the year. The implementation of a trip limit improved this situation somewhat, and, due to reduced economic efficiency, had the added consequence of discouraging larger vessels from entering or remaining in the fishery. Reports from a number of sources suggest a reduction in the size of the active directed shark fleet.

Species Composition and Destination of the Catch

According to information compiled for the development of the Atlantic Shark Fishery Management Plan, the principal species reportedly taken in the directed longline fishery are sandbar *(Carcharinus plumbeus)*, blacktip *(C. limbatus)*, bull *(C. leucas)*, spinner *(C. brevipinna)*, dusky *(C. obscurus)*, bignose *(C. altimus)*, night *(C. signatus)*, lemon *(Negaprion brevirostris)*, tiger *(Galeocerdo cuvieri)*, sand tiger *(Odontaspis taurus)*, silky *(C. falciformis)*, scalloped hammerhead *(Sphyrna lewini)*, and great hammerhead *(S. mokarron)* sharks, but nurse *(Ginglymostoma cirratum)*, finetooth *(Carcharinus isodon)*, blacknose *(C. acronotus)*, and Atlantic sharpnose *(Rhizoprionodon terraenovae)* sharks are also taken (NMFS, 1993). The drift gillnet fishery targets schooling blacktip sharks (NMFS, 1993).

Since the implementation of the Atlantic Shark FMP, several attempts have been made to improve the reporting of catches and landings by species. The NMFS distributed materials designed to allow more accurate species identification by fishermen. Since then, species identification has improved and the proportion of unclassified sharks declined from 81.6 percent in 1992 to 67.7 percent in 1994 (table 5). In 1992, sandbar and blacktip sharks were the most common species reported in landings, accounting for 7.4 percent and 3.7 percent, respectively, of the identified catch. In 1993, sandbar sharks accounted for 8.5 percent of shark landings, blacktip sharks 5.1 percent, and hammerhead sharks 2.3 percent. In 1994, sandbar sharks accounted for 14.3 percent of commercial landings, hammerheads 7.1 percent, and blacktip 4.6 percent. Other species reported in commercial landings from 1992 to 1994 were thresher (*Alopias* spp.), white *(Carcharodon carcharias)*, dusky, tiger, lemon, Atlantic sharpnose, angel *(Squatina dumerili)*, bull, porbeagle, shortfin mako (Isurus oxyrinchus), finetooth, sand tiger, blacknose, silky, nurse, tope or soupfin *(Galeorhinus galeus)*, spinner, and blue *(Prionace glauca)* sharks (NMFS, 1995).

Although a mandatory observer program has not been established for the Atlantic and Gulf coast shark fisheries, observer data sets are available from voluntary observer programs, albeit for small sample sizes and with limited geographical coverage. One such observer data set is available from the Gulf of Mexico. From 1989 through 1991, observers recorded data from eight trips aboard five vessels in the Gulf of Mexico directed shark fishery off the coast of Louisiana; two of the vessels targeted sharks full time, and three part time (Russell, 1993). Data were recorded for 53 sets with a total of 17,404 sets, which produced 1,449 sharks or an average of 8.3 sharks per 100 hooks. The species composition of the catch was reported as follows: blacktip (674 or 46.5 percent), smooth dogfish (Mustelus canis) (389 or 26.8 percent), Atlantic sharpnose (204 or 14.1 percent), bull (45 or 3 percent), sandbar (41 or 2.8 percent), and spinner (39 or 2.7 percent), with the remainder composed of lemon, scalloped hammerhead, dusky, silky, shortfin mako, and unidentified sharks.

Observer program results from this Gulf of Mexico fishery indicated that blacktip (99 percent), bull (96 percent), spinner (78 percent), and sandbar sharks (76 percent) were nearly always retained. Small numbers of lemon, dusky, silky, and shortfin mako sharks were also retained for sale. Smooth dogfish (58 percent) and Atlantic sharpnose sharks (82 percent) were usually retained, but used as bait rather than sold for human consumption. Scalloped hammerhead sharks were typically finned and discarded. Few sharks were landed alive in this fishery, as short gangion lines (3.1 m) restricted mobility and, therefore, ventilation. The mortality rate of discarded sharks was 92.2 percent.

Another small voluntary observer program for the directed shark fishery was initiated in 1994 and funded by NMFS. Observer data in that year focused on North Carolina and the Florida Gulf coast; a third observer was added in 1995 to cover the Florida Atlantic coast (Gulf & South Atlantic Fisheries Development Foundation, 1996). The observer program covered 276 longline sets during 96 fishing trips. Vessels observed used monofilament bottom longlines ranging from 6 to 15 miles in length, with 50 to 100 lighter-weight monofilament gangions fished per mile. Fishing was conducted overnight, using 500 to 1,200 hooks for a period of 10 to 15 hours. Skates, sharks, and miscellaneous teleosts were used as bait.

Observers documented a total shark catch of 10,923 individuals over the two-year period, of which 7,764 were landed, corresponding to commercial landings of more than 115 mt (or approximately 2.3 percent of the total Atlantic commercial shark landings) during this period. The species composition of the observed catch varied significantly among regions and years, but two species--blacktip and sandbar sharks--contributed 60 to 75 percent of the total observed catch and 75 to 95 percent of the landings. Tiger sharks contributed another 11 percent of total catches, but were typically released and contributed less than 2 percent of landings. Catches were composed of 7,836 large coastal sharks of 18 species, and 3,037 small coastal sharks of four species. Catches and landings of species not included in these two groupings were negligible, consisting of 13 pelagic sharks (shortfin mako and bigeye thresher); 32 smooth dogfish, and 5 spiny dogfish. Overall, species from the large coastal grouping contributed 72 percent of catches and 77 percent of landings, while species from the small coastal grouping contributed 28 percent of catches and 23 percent of landings. Most catches and landings of small coastal species were comprised of Atlantic sharpnose shark (Gulf & South Atlantic Fisheries Development Foundation, 1996).

The observer program also documented considerable variation among the regions covered. Blacktip sharks were more abundant in nearshore waters of less than 10 fm in depth, while large sandbar sharks were more common on the mid-continental shelf in waters of 10 to 50 fm. The fishery in the South-Carolina-Georgia region occurred in shallower waters than other areas with catches dominated by blacktip sharks. Smaller numbers of dusky, silky, bull, scalloped hammerhead, great hammerhead, smooth hammerhead, lemon, and nurse sharks were observed, and catches of Atlantic sharpnose, blacknose, and smooth dogfish were also significant. The North Carolina fishery was conducted in deeper waters, with catches dominated by sandbar sharks; the majority of these were females. Smaller catches were observed of Atlantic sharpnose, dusky, blacktip, spinner, and scalloped hammerhead sharks. For Atlantic Florida, sandbar and blacktip sharks again dominated the catches, with smaller numbers of dusky, silky, bull, spinner, great and scalloped hammerhead, nurse, and sand tiger sharks. Most small coastal sharks recorded were caught in this region, and, unlike other regions, this catch was often landed. The Florida Gulf fishery caught and landed large numbers of sandbar sharks in 1994, but in 1995, effort shifted to blacktip sharks in nearshore waters. Smaller catches of silky, bull, Caribbean reef *(Carcharinus perezi)*, lemon, hammerhead, and nurse sharks also increased in 1995. A small bycatch of small coastal species was typically used for bait.

Of the large coastal catch, 75 to 80 percent was landed; 5 to 15 percent used for bait or discarded dead; and 10 to 20 percent released alive. Tiger, nurse, and sand tiger sharks were generally released alive. Of the catch of small coastal species, only about 1 percent were released alive, as these species were generally either landed or used as bait. The only observed destinations of the catch were meat, fins, and bait. Fin landings represented 4.5 percent of carcass weight for the Florida Gulf, 4.8 percent for North Carolina, and 4.9 percent for the South Atlantic (South Carolina to Georgia).

Incidental Shark Catch in Atlantic and Gulf Fisheries

Shark Bycatch in Tuna and Swordfish Fisheries

The U.S. pelagic longline fishery consists of a Gulf of Mexico yellowfin tuna fishery, in which a few vessels also participate in directed fisheries for swordfish, shrimp, shark, snapper, grouper. Others include a South Atlantic swordfish fishery that primarily targets swordfish year-round; a Mid-Atlantic and New England swordfish and bigeye tuna fishery, in which some vessels target sharks on a seasonal basis; the U.S. Atlantic distant water swordfish fishery; and the Caribbean Island tuna and swordfish fishery. The longline fishery primarily targets tuna, swordfish, and mahi mahi. However, some tuna and swordfish longline vessels target sharks--mako, thresher, and blue sharks, and, in some cases, porbeagle and coastal shark species--during peak or open seasons (NMFS, 1993; BWFA, 1995; Biedeman, pers. comm.).

In 1992, a scientific observer program was initiated for the large pelagic fisheries fleet in the Atlantic and Gulf of Mexico. Data collected by the NMFS Southeast Fisheries Science Center contained coverage primarily of the Southeastern U.S.waters of vessels targeting mostly swordfish or mahi mahi, with yellowfin tuna as a bycatch, and vessels operating in the Gulf of Mexico targeting primarily yellowfin tuna, with swordfish as a bycatch. Analysis of observer data gathered from 1,066 sets on 174 fishing trips in the Atlantic, Gulf, and Caribbean pelagic longline fishery during 1992-1994 indicates that about six species are marketable and tend to be retained: swordfish, yellowfin tuna, bigeye tuna, bluefin tuna, dolphin (mahi mahi), and shortfin mako. Together, these species comprised 55 percent of the total observed catch. Swordfish contributed the largest percentage (28 percent) of observed catches by number of fish, followed by sharks and rays (25 percent), tunas (22 percent), finfish (18 percent), and billfish (4 percent). The species composition changed significantly from 1992 to 1993. The proportion of swordfish increased from 25 percent in 1992 to 29 percent in 1994. Tuna fell from 28 percent of the catch in 1992 to 19 percent in 1993, then rose to 26 percent in 1994, while sharks and rays comprised 21 percent in 1992, 30 percent in 1993, and 18 percent in 1994 (Lee et al., 1995).

From 1992 to 1994, observers recorded a total capture of 6,778 sharks and 960 skates or rays. Blue sharks comprised nearly 40 percent of the shark bycatch, followed by silky (16 percent), Atlantic sharpnose (6 percent), dusky (5 percent), shortfin mako (4 percent), scalloped hammerhead (3 percent), sandbar (3 percent), and blacktip sharks (2 percent). Of total shark bycatch, approximately 64 percent were brought alongside the vessel alive, while nearly 36 percent were dead, and less than 1 percent were reported as damaged. Of the 3,574 blue sharks observed, 76 percent were alive, while 84 percent of sandbar, 68 percent of shortfin mako, 57 percent of dusky, 50 percent of Atlantic sharpnose, 42 percent of blacktip, 35 percent of silky sharks, and 34 percent of scalloped hammerheads captured were brought alongside alive and undamaged. The overall shark bycatch rate for all areas and all years was 6.36 sharks per set or 10.76 sharks per 1,000 hooks (Lee et al., 1995).

Shark bycatch by domestic Atlantic and Gulf tuna fisheries consists primarily of blue, porbeagle, and hammerhead sharks, with unidentified species forming a significant proportion of the catch. Observer data from the Gulf of Mexico tuna fishery reported that silky, spinner, blacktip, dusky, sandbar, and scalloped hammerhead sharks were the most common of the incidentally-caught shark species (Russell, 1993). In the swordfish fishery, mako and thresher are the predominant shark species caught incidentally; a large category of "unidentified" sharks is likely to consist of bignose, dusky, silky, and night sharks (NMFS, 1993). Small numbers of sharks are caught in the swordfish gillnet, tuna gillnet, and tuna pair trawl fisheries in the Atlantic, but longliners account for most shark bycatch (ICCAT, 1994).

Anderson (1985) estimated shark bycatch in the U.S. and Canadian Atlantic and Gulf swordfish longline fishery from 1962 to 1981 based on bycatch rates developed from 1979 observer data. This data indicated rates of 2.34 sharks caught for every swordfish for the area Maine to Virginia, 2.96 for North Carolina to Florida, and 2.13 in the Gulf of Mexico. In the waters from Maine to Virginia, shark bycatch by U.S. vessels is estimated to have totaled 29,451 mt during this period, with average annual catches of 1,472.5 mt. Catches from this region were highest from1974 to 1981, with a peak in 1987 of 8,672 mt. A Canadian swordfish longline fleet operated in this region from 1962 to 1970, with an estimated total shark bycatch of 4,136 mt; this fishery virtually ceased after 1970. Assuming a mean round weight of 41 kg, the estimated total number of sharks caught from 1962 to 1981 totaled 1,409,115, with an annual average of 70,456 sharks. The total number of swordfish caught during this period was estimated at 602,186 fish, with a total weight of 36,647 mt, giving a shark bycatch rate of 0.80 mt of shark for every 1 mt of swordfish caught.

Swordfish longlining from North Carolina to east Florida was negligible before 1976. From 1976 to 1981, the estimated shark bycatch for this region totaled 343,967 sharks, or estimating mean round weight of 42 kg, a total of 14,448 mt. Total swordfish catches during this period totaled 116,205 swordfish, or 6,085 mt, giving a shark bycatch rate of 2.37 mt of shark for every 1 mt of swordfish caught.

The swordfish longline fishery in the Gulf of Mexico (West Florida to Texas) was initiated in 1969. From 1969 to 1981, shark bycatch totaled 121,883 individuals or, assuming a mean round weight of 36 kg, 4,389 mt. Total swordfish catches for this period were 57,222 fish or 2,294 mt, giving a shark bycatch rate of 1.91 mt of sharks for every 1 mt of swordfish caught.

A federal Fishery Management Plan for swordfish was implemented in 1985 that established total allowable catch limits and required vessel and dealer permits and reporting. The number of vessels with federal permits to fish for Atlantic swordfish totaled 451 in 1985, increased to 752 in 1989, then declined to 655 in 1990 (NMFS, 1993). Some of the vessels from the Atlantic fishery moved their operations to the Pacific in 1989 and 1990. The number of permitted vessels has increased sharply since 1991--to 1,044 vessels in 1993, 1,134 vessels in 1994, and 1,210 in 1995. Much of this increase, however, is likely due to efforts by fishermen to establish a history in several different fisheries in response to a recent trend toward limited or controlled access in several Atlantic and Gulf fisheries. The number of vessels landing at least 1 swordfish from 1987 to 1995 totaled only 394 (NMFS, 1995). The number of vessels that landed at least one swordfish peaked in 1989 at 416; and declined by 1993 to 298 (Hoey et al., 1994). The domestic Total Allowable Catch (TAC) was set at 4,173 mt round weight (6.9 million pounds dressed weight) in 1991, and increased in 1992 to 4,572 mt round weight (7.56 million pounds dressed weight). Actual landings were 7.15 million pounds (dressed) in 1991, 6.38 million in 1992, 7.56 million in 1993, and 7.56 million in 1994. In 1993 and 1994, several vessels began to shift their operations from the Pacific back to the Atlantic (S. Pooley, pers. comm; WPRFMC, 1995)

Shark bycatch in the Atlantic and Gulf of Mexico swordfish fishery was calculated for 1992 from data provided in mandatory logbooks. Shark bycatch in the Grand Banks region totaled 48,369 sharks, of which 46,054 or 95 percent were blue sharks. Only 3 percent of blue shark bycatch was retained, while 14 percent was reportedly discarded dead and 83 percent discarded alive (ICCAT, 1994a). Assuming an average weight of 41 kg per shark (Anderson, 1985), total shark bycatch for this year would have been 1,983 mt.

The total shark bycatch for the Northeast coastal swordfish longline fishery for 1992 was 4,424 individuals, of which 3,013 or 68.12 percent were blue sharks. All of the blue shark bycatch was reportedly discarded, with 81 percent of the sharks discarded alive and 19 percent discarded dead. Smaller bycatch of dusky, blacktip, shortfin mako, silky, great hammerhead, spinner, bigeye thresher *(Alopias superciliosis)*, tiger, longfin mako (Isurus paucus), and scalloped hammerhead were also reported. Only shortfin mako (88 percent), longfin mako (50 percent), and dusky (59 percent) sharks tended to be retained (ICCAT, 1994a). Using an average weight of Northeast shark bycatch of 41 kg, from Anderson (1985), shark bycatch in the Northeast swordfish longline fishery would total 52.79 mt.

The Southeast coastal swordfish longline fleet reported in 1992 bycatch of 5,636 sharks, of which 1,035 or 18.36 percent were silky sharks, and 818 or 14.5 percent were blue sharks. Lesser numbers of blacktip, dusky, smooth hammerhead, night, great hammerhead, tiger, scalloped hammerhead, oceanic whitetip *(Carcharinus longimanus)*, shortfin mako, bigeye thresher, white, longfin mako, spinner, and common thresher (Alopias vulpinus) were also caught incidentally. Silky (53 percent), blacktip (68 percent), dusky (68 percent), night (55 percent), oceanic whitetip (44 percent), shortfin mako (91 percent), spinner (78 percent), and bignose (60 percent) were generally retained, while other species were usually discarded (ICCAT, 1994a). Assuming an average weight of 42 kg (Anderson, 1985), shark bycatch in the Southeast Atlantic swordfish longline fishery would have totaled 236.7 mt in 1992.

Shark bycatch in the Gulf of Mexico swordfish longline fishery for 1992 totaled 1,111 sharks, with blacktip, dusky, great hammerhead, night, shortfin mako, and silky sharks the most common species caught. Dusky, shortfin mako, silky, and unidentified sharks are often retained, as are smaller incidental catches of longfin mako, common thresher, and smooth hammerhead (ICCAT, 1994a). Assuming an average weight of 36 kg (Anderson, 1985), shark bycatch from swordfish longlining in the Gulf would have totaled 40 mt in 1992. Shark bycatch in the Caribbean totaled 1,734 sharks, consisting primarily of blue (797 or 46 percent), oceanic whitetip (390 or 22.5 percent), and unclassified (200 or 11.5 percent) sharks (ICCATa, 1994). Again assuming an average weight of 36 kg per shark, shark bycatch for the Caribbean would total 62.4 mt for 1992.

Total logbook-reported U.S. shark bycatch in the Atlantic, Gulf, and Caribbean swordfish longline fishery in 1992 was 61,274 individuals or 2,375 mt. Reported landings of swordfish by U.S. longliners in the North Atlantic totaled 48,369 individuals, or 4,124 mt, giving an overall ratio of .58 mt of sharks for every 1 mt of swordfish. This ratio is extremely low compared to the estimates provided by Anderson (1995). However, because of the significantly different methodologies used to develop them, the two data sets are not comparable. Furthermore, the lower bycatch rate obtained from 1992 logbook data may be due, at least in part, to gear modifications introduced by the Atlantic and Gulf longline fleet. Modified gear includes both lighter-weight hooks and single-strand monofilament leaders, which have been reported to increase the ability of large sharks to bite off the line (Biedeman, pers. comm.).

There is little information available to assess the impact of gear modifications in the swordfish longline fishery. Berkeley and Campos (1988), From 1981 to 1983, while conducting exploratory fishing to sample shark bycatch by commercial swordfish vessels along the Atlantic coast of Florida, Berkeley and Campos (1988) compared catch rates by single-strand, 250-pound test monofilament and multistrand, 500-pound stainless steel cable. They report that although many sharks escaped by biting through the monofilament, the number of sharks caught by monofilament was actually greater, although the difference was not statistically significant, while the catch of swordfish was only 43 percent as effective in catching swordfish. No further research of this nature was identified during the course of the TRAFFIC study.

The number of sharks reported as retained by the swordfish longline fishery in 1992 totaled approximately 1,975 for the Southeast, 414 for the Gulf of Mexico, 239 for the Caribbean, 440 for the Northeast Coastal, and 2,494 for the Grand Banks, or a grant total of 5,562 sharks. Using the estimated weights provided by Anderson, the volume of shark bycatch landed would total some 227 mt, with the Northeast and Grand Banks accounting for 120 mt, the Southeast 83 mt, and the Gulf and Caribbean 24 mt. Total retained bycatch accounts for roughly 10 percent (of total weight or total number of individuals) of shark bycatch. The proportion of sharks retained was highest for the Southeast, and lowest for the Northeast/Grand Banks.

Data on 1992 shark bycatch in the Atlantic, Gulf of Mexico, and Caribbean tuna fishery was also compiled from mandatory vessel logbook reports (ICCAT, 1994a, b). In that year, approximately 106,000 sharks were reported as caught incidentally by the U.S. large pelagic fleet, one third of the total catch reported by the fleet (ICCAT, 1994b). Shark bycatch in the tuna longline fishery totaled 26,202 sharks for the Northeast coastal region, 9,577 for the Grand Banks, 2,794 for the Southeast coastal region, 3,724 for the Gulf of Mexico, and 595 for the Caribbean (ICCAT, 1994a). Again, using the average weights provided by Anderson (1995), shark bycatch would total an estimated 1,467 mt for the Northeast/Grand Banks region, 117 mt for the Southeast, and 155 mt for the Gulf/Caribbean region, or a total of 1,739 mt of sharks caught incidentally in the Atlantic tuna longline fishery.

The shark species most commonly caught in the tuna fishery in the Northeast coastal region in 1992 was blue shark, contributing 18,619 individuals, or 71 percent of the total. Other significant bycatch species were dusky, shortfin mako, smooth hammerhead, bigeye thresher, silky, great hammerhead, blacktip, scalloped hammerhead, common thresher, longfin mako, and tiger sharks. Shortfin mako and longfin mako were frequently retained, while blue and hammerhead sharks were nearly always discarded (ICCAT, 1994a). In the Grand Banks region, blue shark bycatch totaled 8,820 individuals, or 92 percent of the shark bycatch. Significant quantities of shortfin mako and unclassified sharks were also caught. Again, shortfin and longfin mako tended to be retained, while blue sharks were nearly always discarded (ICCAT, 1994a).

In the Southeast coastal region, blacktip (23 percent), blue (22 percent), silky (20 percent), and dusky (8 percent) sharks were the most common shark species caught by the tuna fishery in 1992. Only smaller bycatch of shortfin mako, white, and night sharks tended to be retained frequently, while 22 percent of blacktip sharks and 1 percent of blue shark bycatch was retained (ICCAT, 1994a). For the Gulf of Mexico, blacktip (24 percent), unclassified (17 percent), dusky (8 percent), tiger (7 percent), and silky sharks (7 percent) were the most comon species caught incidentally in the tuna longline fishery. A high proportion of blacktip, dusky, unclassified, shortfin mako, smooth hammerhead, and scalloped hammerhead were retained. In the Caribbean, blue sharks contributed 39 percent of blue shark bycatch, and oceanic blacktip contributed 31 percent. Only less frequent bycatch of bignose, shortfin mako, and silky sharks tended to be retained (ICCAT, 1994a).

The proportion of shark bycatch reportedly retained by the Atlantic tuna longline fleet totaled 5,977 individuals in 1992: 2,272 in the Northeast Coastal region, 410 for the Grand Banks, 540 for the Southeast, 1,881 for the Gulf of Mexico, and 874 for the Caribbean. Using the same conversion factors as for the swordfish fishery, total retained bycatch by weight was approximately 110 mt for the Northeast and Grand Banks, 227 mt for the Southeast, and 99 mt for the Gulf and Caribbean, or a total of 436 mt. Commercial shark landings from the tuna fishery are therefore estimated at 25 percent by weight of total shark bycatch, with the proportion retained highest in the Gulf and Caribbean and lowest in the Northeast and Grand Banks.

The combined shark bycatch of the longline tuna and swordfish fisheries of the Atlantic coast of the United States is estimated at 4,114 mt in 1992, of which an estimated 663 mt, or 16 percent, was retained and presumably landed. Although the shark bycatch in the swordfish fishery is considerably higher than that in the tuna fishery, vessels targeting tuna landed roughly twice as many sharks. Overall, blue shark was the most common bycatch species, with a total of 79,432 individuals, or an estimated 3,251 mt, most of which were caught off the Grand Banks. Only 1,728 individuals, or an estimated 71 mt, were reported as retained. If blue sharks are removed from the analysis, bycatch of all other sharks totaled 863 mt, and the proportion retained increases to 69 percent.

Logbook reports for all areas combined give a total 1992 shark bycatch in the tuna and swordfish longline fisheries of 104,166 individuals, giving an overall bycatch rate of 9.05 sharks per set, or 17.09 sharks per 1,000 hooks. The bycatch rate for the Northeast is much higher, at 25.36 sharks per 1,000 hooks, compared to 5.99 sharks per 1,000 hooks for the Southeast. These catch rates appear consistent with the results of scientific observer sampling from 1992 to 1994, which derived a bycatch rate of 10.76 sharks per 1,000 hooks based on observations primarily from the Southeast, but also including trips off the Northeastern coast and Grand Banks.

Observer data from the Gulf of Mexico tuna longline fishery from 1988 to 1991 records a total capture of 516 sharks from 87 trips aboard 33 vessels, with a hooking rate of 0.3 sharks per 100 hooks (Russell, 1993). Bycatch was composed primarily of silky, spinner, blacktip, dusky, sandbar, and scalloped hammerhead sharks, with smaller numbers of bull, lemon, sand tiger, tiger, bigeye thresher, shortfin mako, longflin mako, and oceanic whitetip sharks. Observers reported an overall mortality rate for discarded sharks of 46.5 percent, varying by species and size. Small individuals, particularly blacktip, spinner, and silky sharks, tended to be landed dead; small spinner and silky sharks were typically finned and the carcass discarded. Medium to large mako sharks were usually retained for sale; small, unmarketable shortfin mako sharks were usually released alive. Very large individuals, particularly bull, tiger, dusky, and sand tiger sharks, were generally released alive; all tiger and lemon sharks were cut loose immediately. Medium to large dusky, blacktip, sandbar, and silky sharks were often shot, finned, and discarded, while scalloped hammerheads were often shot and discarded, and only occasionally finned. Shortfin mako, thresher, bigeye thresher, large blacktip, large silky, and large spinner sharks were usually retained for sale; blacktip, spinner, and dusky sharks combined contributed 51.7 percent of the retained catch.

The shooting and finning of sharks is considered a possible explanation why the 46.5 percent mortality rate for discarded sharks is considerably above mortality rates of 14.7 to 35 percent reported from observer records in previous years. The tendency for fishermen to kill sharks before discarding them is attributed in large part to the considerable damage they cause to hooked tunas and swordfish. Russell (1993) concludes that, although the then-pending Fishery Management Plan for Atlantic Sharks prohibits the landing of fins without the associated carcass, fishermen are likely to continue to kill sharks before discarding them, even if faced with significant penalties for this action, as extremely limited observer coverage would render such a measure unenforceable (Russell, 1993).

Shark Bycatch in Other Fisheries

In the Gulf of Mexico, shallow-water shrimp trawls catch large numbers of Atlantic sharpnose sharks and juveniles of other species. Some sharks are landed by this fishery, but mandatory use of turtle excluder devices (TEDs) to prevent capture of sea turtles is expected to reduce shark bycatch as well (NMFS, 1993). Additional shark bycatch occurs in the snapper-grouper fishery and is reported to account for a significant proportion of Louisiana shark landings (Horst, 1993) The Gulf of Mexico Fishery Management Council (1979, cited in Anderson (1985)) estimated total shark bycatch by the Gulf of Mexico shrimp fishery at 2,270 mt annually, with an additional bycatch of some 113 mt annually from the snapper-grouper fishery and other sources.

The New England multispecies gillnet fleet is reported to catch and land porbeagle, mako, and other sharks from July through September (NMFS, 1993). Vessel logbooks indicated total 1992 shark bycatch in the tuna and swordfish gillnet fisheries of 870 sharks, with the bulk of catches reported by vessels targeting swordfish. The primary species reported were blue, scalloped hammerhead, great hammerhead, thresher, mako, dusky, and unidentified sharks. Nearly all of the mako and thresher sharks caught were retained, while virtually all blue, hammerhead, and dusky sharks caught were discarded. No porbeagle sharks were reported as caught (ICCAT, 1994). Assuming an average weight per individual of 41 kg, 1992 shark bycatch would total 36 mt, of which 144 individuals or 6 mt were retained.

Tuna pair trawls operating off the Northeast coast also accounted for a minor bycatch of sharks. Data from vessel logbooks for 1992 indicated a total shark bycatch of 83 individuals, or an estimated 3 mt, consisting of blue, scalloped hammerhead, shortfin mako, dusky, smooth hammerhead, tiger, and unidentified sharks (ICCAT, 1994). Of these, only 9 mako sharks and 1 smooth hammerhead shark were reportedly retained, accounting for estimated landings of 0.4 mt.

Bycatch by Foreign Vessels in U.S. Waters

The shark bycatch by the Japanese tuna longline fishery operating in Atlantic and Gulf of Mexico waters was estimated by Anderson (1985) from 1960 to 1982, based on bycatch rates derived from Japanese vessel logbooks from 1978 to 1982. In the Atlantic, bycatch estimates averaged about 500 mt annually from 1960 to 1969, increased to an average of 1,113 mt per year from 1970 to 1979, and peaked in 1981 at 2,642 mt. In the Gulf of Mexico, estimated shark bycatch averaged 18 mt from 1963 to 1969, and 190 mt from 1970 to 1979, again peaking in 1981 at 619 mt. The Japanese Gulf of Mexico longline fishery ceased in 1982 (Russell, 1993).

Witzell (1985) analyzes shark bycatch in the Japanese tuna longline fishery in the Atlantic and Gulf of Mexico from 1978 to 1982 from data collected from Japanese vessel logbooks. Shark CPUE is 0.1335 sharks per 100 hooks for the Gulf of Mexico and 0.5988 for the Atlantic. The reported number of sharks caught ranged from 1,745 in 1980 to 7,609 in 1981. Based on average weights of 62.4 kg for the Atlantic and 80.4 kg in the Gulf of Mexico, the estimated total weights of shark bycatch per year range from 141.9 mt in 1980 to 619.1 mt in 1981; the average weights used are higher than real weights, therefore these figures are likely to be overestimates. Witzell notes that the percentage of sharks killed as reported by U.S. observers on Japanese vessels, is low, with 7.2 percent in the Atlantic and 14.7 percent in the Gulf of Mexico. These low mortality rates are attributed to provisions of the Fishery Conservation and Management Act of 1976, requiring foreign vessels fishing in U.S. waters to release all non-target species.

The estimates provided by Anderson (1985) and Witzell (1985) are considered to represent minimum shark bycatch from the Japanese longline fishery. They are based on vessel logbook reports, which are believed to significantly underreport bycatch species of no commercial value. Furthermore, it is probable that mortality rates reported change for vessels not carrying observers (Bonfil, 1994).

Hoff and Musick (1990) analyzed observer data from Japanese longline fishing operations in the Northwest Atlantic EZ to obtain shark bycatch estimates for 1982 and 1987. In 1982, Japanese vessels fished a total of 1,057 days, with a total estimated shark bycatch of 7,117 sharks, consisting mostly of blue sharks and significant quantities of hammerhead and mako. Fishing effort decreased by 1987 to a total of 537 fishing days, but shark bycatch increased to 8,330 individuals, again primarily blue sharks, but also including significant numbers of hammerhead, mako, porbeagle, and thresher sharks. Assuming an average weight per individual of 41 kg from Anderson (1985), 1982 and 1987 shark bycatch would total an estimated 292 mt and 342 mt, respectively.

Anderson (1985) also estimates shark bycatch in the the distant-water squid trawl fishery operating in the Northwest Atlantic EZ from 1965 to 1981. Bycatch rates developed from 1978 observer data were used to extrapolate from squid catches for other years. Estimated shark bycatch increased from 1 in 1965 to a peak of 266 in 1973, declining thereafter to 165 in 1981, with an annual average of 134 during the entire period. Observed bycatch in 1978 included great white, basking *(Cetorhinus maximus)*, shortfin mako, porbeagle, blacktip, sandbar, dusky, tiger, blue, hammerhead, and Atlantic angel sharks. Assuming an average weight per individual of 41 kg, shark bycatch is estimated to have averaged 5.5 mt per year during this period.

Recreational Fisheries

Sport fishing for sharks is increasing rapidly in the Atlantic and Gulf of Mexico, with most recreational fishing taking place from small and medium-size boats. More fishing and catches take place on private boats than on charter boats. Shark tournament fishing has also gained popularity since the early 1970s, with a total of about 65 such tournaments taking place on the Atlantic and Gulf coasts by the early 1990s. Mako, thresher, white, dusky, tiger, lemon, blacktip, hammerhead, and bull sharks are most the most highly-sought species in tournament fisheries because of their size and the difficulty involved in catching and landing them. Catch-and-release tournament and other recreational fishing is becoming increasingly widespread throughout the United States and many tournaments encourage tagging and releasing small sharks (NMFS, 1993).

Estimates of recreational catches of sharks are available from the annual Marine Recreational Fishery Statistics Survey (MRFSS) through 1991. These estimates are highly variable among the years surveyed. They cannot be used to assess trends, due to frequent changes in survey methodology and are subject to standard error estimates of up to 50 percent. They are also subject to frequent methodological errors, so should be interpreted with caution, particularly with regard to yearly trends (Hoff and Musick, 1990; NMFS, 1991). In addition, the database does not include information on Caribbean recreational landings; it provides incomplete data on the Northeast recreational fishery; and does not include Texas recreational fisheries after 1985 (NMFS, 1993).

Hoff and Musick (1990), analyzing this data for the period 1979-1987, reported an estimate of total Atlantic and Gulf recreational shark catches (excluding dogfish) of 306,211 mt, or an annual average of 34,023 mt; however, this figure does appear to be extremely high. The dominant species reported in recreational catches was shortfin mako, which was often sold to processors. Significant numbers of sandbar, blue, dusky, and sand tiger sharks also appearing in reported catches.

The National Marine Fisheries Service (1993) in the Atlantic Shark Fishery Management Plan reports estimated recreational landings of sharks other than dogfish (representing only sharks retained in the recreational fishery) totaling 52,371 mt during 1979-1989, or an average of 4,761 mt annually, with a high of 11,512 mt in 1979 to a low of 1,666 mt in 1989 (table 6). Landings are highest in the Mid-Atlantic Region (51 percent of the total), followed by the Gulf of Mexico (26 percent) and the South Atlantic (19 percent). From a review of MRFSS data and other sources (including Texas), NMFS (1993) estimated total recreational landings of shark species included in the management plan at 27,957 mt from 1979 to 1990, or an annual average of 2,330 mt. These estimates ranged from a low of 135 mt in 1979 to a high of 7,122 mt in 1989.

Casey and Hoey (1985) estimate recreational catches of large sharks by large offshore vessels (18-65 feet) for 1978 by combining the results of a recreational survey of this segment of the fishery with available data on average shark weights from tournament and research vessel catches. Although the estimate of total weight of large sharks caught (10,277 mt) is not comparable to the data sets discussed above due to methodological differences, the species composition from this segment of the fishery is of interest. For all fishing areas, the dominant species caught were blue sharks (42.7 percent), hammerhead sharks (10.2 percent), mako (7.8 percent), blacktip (6.9 percent), dusky (6.8 percent), white (2.3 percent), bull (2.1 percent), and tiger sharks (2.1 percent). Blue sharks were the dominant species in the North Atlantic (60.3 percent), while hammerhead and blacktip sharks predominated in both the South Atlantic (28.6 percent and 11.6 percent respectively) and the Gulf of Mexico (22.6 percent and 27.6 percent respectively).

Recent information is available on the importantance and economic value of recreational shark fisheries in the Gulf of Mexico. From a random survey of Gulf of Mexico charter boats during 1987-88, Holland et al. (1992) estimated that charter boats fishing all species made a total of 142,000 trips, carrying about 568,000 passengers in the Gulf of Mexico per year. A total of 510 charter boats reported targeting sharks, most based in Florida (481 or 94 percent), followed by Texas (12 boats) and Mississippi (10 boats). Most charter boats targeted several species, with Florida charter boats reporting an estimated 5.6 percent of their time targeting sharks; the authors derive an estimate of 4.9 percent of fishing time targeting sharks for all Gulf of Mexico recreational fisheries. Multiplying the total estimated economic value of the Gulf of Mexico charter boat fishery of $146 million by the effort estimate, the estimated total economic value of recreational shark fishing by Gulf of Mexico charter boats was $7.2 million.

Fisher and Ditton (1993) surveyed tournament shark anglers in the Gulf of Mexico with questionnaire items, including information on fishing experience, time spent fishing during a 12-month period, and time spent on recreational fishing. Anglers reported an average of 9 years experience in the shark fishery and an average of 58 days spent fishing during the year, while 25 percent of respondents indicated that sharks were their most preferred species. Most respondents (48 percent) reported typically fishing for sharks in the Gulf in waters of 10 miles or less from shore, while 6 percent reported fishing from shore, and 12 percent reported fishing in bays. Anglers caught an average of 4 sharks per day, with 1 shark retained. Total trip expenditures averaged $197 per person; this figure, extrapolated to all trips targeting sharks, was used to derive an estimated total economic value for the Gulf of Mexico recreational shark fishery of $42.4 million. Fisher and Ditton note that this figure likely underestimates total economic value, as trips not targeting sharks but catching sharks were not included. However, this bias may be offset by the fact that the population surveyed represents a specialized segment of the fishery, and not all trips targeting sharks are taken by components of this population.

The Atlantic Spiny Dogfish Fishery

Directed Fisheries

The New England and Mid-Atlantic dogfish fishery produced an average of approximately 4,500 mt annually during the 1980s, with most landings occuring in Massachusetts. Landings increased sharply in 1990 to 14,900 mt, peaking in 1993 at 22,400 mt (table 7). Both otter trawls and sink gill nets were used in the fishery, but, since the late 1980s, most of the catch has been taken by sink gill nets. The fishery expanded southward since 1989, with significant landings also occurring in the states of Maine, New Jersey, Maryland, Rhode Island, and North Carolina (Rago et al., 1994).

Two factors account for the rapid expansion of the spiny dogfish in the early 1990s. First, spiny dogfish biomass is estimated to have increased to four or five times the levels of the 1960s, as a result of reduced fishing effort following the cessation of foreign fishing in the late 1970s (Rago et al., 1994). Second, groundfish stocks traditionally supporting the New England fishery declined sharply due to overexploitation, leading to increased pressure on low value species such as dogfish and skates. For example, trawl survey catches on the Georges Bank changed from approximately 25 percent dogfish and skates in 1963 to 75 percent of these species in the late 1980s (NMFS, 1989).

Spiny dogfish in the Northwest Atlantic are believed to comprise a single stock that migrates seasonally between Mid-Atlantic and Canadian waters. The dogfish are concentrated off the U.S. Mid-Atlantic coast during winter and spring. They move north into Canadian waters and into bays and estuaries in the summer and remain in Canadian waters through the autumn. U.S. landings have historically occured primarily during the months of June through September, but are increasingly reported during fall and winter as well, as vessels follow the migrating stocks (Rago et al, 1994).

Spiny dogfish have an estimated life span of 50 years, with individuals of up to 70 years of age reported. Reproduction occurs offshore during winter, with females bearing an average of 6 live offspring per litter following a gestation period of 18 to 22 months. Females are significantly larger than males, measuring in length at maturity from 75 cm to maximum sizes of 125 cm and 10 kg. Spiny dogfish tend to school by size, with large mature individuals also tending to school by sex. In general, mature females predominate in inshore waters, while juveniles of both sexes predominate in offshore waters. The market is selective for specimens of 83 cm in length and 2.3 kg in weight, so that the fishery tends to target large mature females; more than 95 percent of sampled commercial landings consist of females (Nammack e al., 1985; Rago et al., 1994).

The life history of the spiny dogfish, the fact that the fishery targets mature females, and the intensification of the dogfish fishery in the early 1990s suggests the potential for a severe impact on dogfish stocks. Commercial U.S. landings from the Atlantic fishery, which reached 22,400 mt in 1993, remain below levels reached in the 1970s when the total of U.S. and foreign landings reached a peak at 25,600 mt in 1974. However, the dogfish fishery of the 1960s and 1970s was dominated by Soviet catches, which were taken for purposes of industrial processing and were, therefore, not size selective. Although data on dogfish bycatch and discards are not available for earlier years, a high rate of discards from the selective fishery of 1989 to the present suggests that total catches and fishing mortality are considerably higher than the volume reported in commercial landings (Rago et al, 1994; P. Rago, pers. comm.).

Observer data suggest that discards of dogfish from the directed gill net fishery for dogfish are relatively low, averaging some 13 percent by weight of the dogfish catch. Most dogfish discards occur when the fish are below market size. Smaller discards are attributed to poor quality, lack of a market, and damage due to predation by other species. The gillnet fishery directed at groundfish also catches significant volumes of dogfish and discards an average of 90 percent of the dogfish catch due to lack of a market or small size. Observer data from the otter trawl fishery, gathered primarily for trips directed on other species, suggests dogfish discard rates of 97 percent for the Georges Bank and Gulf of Maine. Higher bycatch occurs in the otter trawl fisheries in the New England-Mid Atlantic coastal region, averaging 3,500 to 5,200 lbs per trip, with over 99 percent of the dogfish caught discarded (Rago et al., 1994). Preliminary estimates of total dogfish discard for 1993 are 25,000 mt. Dogfish discard mortalities are estimated at 13,500 mt, with the largest proportion occuring in the trawl fisheries. Total fishing mortality in 1993 is therefore estimated to total approximately 36,000 mt.

Fishermen, processors, and distributors nearly universally report that dogfish stocks are already showing clear signs of decline (Rivlin, 1996). Analysis of landings data supports industry reports of a decline in the average size of landed dogfish; the average size of landed females has decreased by some 5 cm since 1982. Much of this decrease may be attributed to a shift from otter trawls to sink gill nets from the 1980s into the 1990s, as gill nets tend to select for larger specimens (Rago et al., 1994; P. Rago, pers. comm.). Analysis of landings per effort and biomass estimates developed from trawl surveys also support the perceived decline in stocks. Analysis of landings per day fished from 1976 to 1993 show a decline in Catchj Per Unit Effort (CPUE) since the intensification of fishing effort in 1990, suggesting a decline in the stocks--at least of mature females that are targeted by the fishery. Biomass estimates based on fishery independent surveys also suggest that the fishable stock of specimens greater of 80 cm or more in length peaked in 1989 at slightly below 300,000 mt, then declined slightly to 258,000 mt in 1994. The male component of the fishable stock has been stable since 1980, while the female component has been stable since 1990. Fishery independent data suggests that the average size of fishable stocks is declining at a rate of some 2 percent per year (Rago et al, 1994; NMFS/NEFSC 1994).

Recreational Fisheries

Rago et al. (1994) also estimate recreational dogfish catches and landings from 1979 to 1993. Total recreational catches increased from an average of 350 mt annually in 1979 and 1980 to 1,700 mt from 1989 to 1991, declining thereafter to 1,200 mt in 1993 (table 7). The bulk of recreational catches originate in the Northeast and Mid-Atlantic states, with less than 4 percent reported from the Southeastern states. Most dogfish are released, but 100 percent discard mortality is assumed due to mishandling by anglers. Recreational catches comprise roughly 8 percent of total spiny dogfish landings during this period, and are therefore insignificant in relation to commercial catches and landings.

PACIFIC COAST SHARK FISHERIES

Historical Background

Before the late 1930s, small scale shark fisheries supplied limited local markets for shark fillets and fish meal, while a significant ethnic market existed for the fins of soupfin sharks. In 1937, a new market developed for the livers of soupfin sharks for use in production of Vitamin A. The fishery peaked in 1939, with some 600 vessels in the California fishery producing 4,198 mt of soupfin sharks; smaller fisheries also operated in Oregon and Washington. Landings declined to 728 mt in 1946 as a result of overfishing, and, by 1950, landings had fallen to pre-1937 levels as a result of the development of synthetic substitutes and increased imports from Japan (NMFS, 1993). The shark liver oil boom also resulted in the expansion of the spiny dogfish fishery in Washington. During the 1940s, more than 250,000 mt of spiny dogfish were caught (Holts, 1988). The spiny dogfish fishery similarly collapsed in the early 1950s when synthetic substitutes were developed.

Both the soupfin and the spiny dogfish fisheries have persisted on a smaller scale. Since the 1970s, soupfin shark landings have averaged 68 to 114 mt , while the spiny dogfish fishery remains the largest shark fishery in the Pacific, with landings above 2,000 mt annually (Cailliet, 1992). Spiny dogfish consistently comprise the bulk of west coast landings. Following a peak of 4,337.5 mt in 1979, commercial landings fell to an average of 2,657.6 mt from 1980 to 1985 (Cailliet et al., 1992).

Demand for shark for domestic consumption began to increase on the Pacific coast in the mid 1970s. Market prices increased rapidly for thresher (*Alopias* spp.), Pacific angel *(Squatina californica)*, tope or soupfin *(Galeorhinus galeus)*, and shortfin mako, and efforts were made to market white, salmon *(Lamna ditropis)*, sevengill *(Notorynchus cepedianus)*, leopard *(Triakis semifasciata)*, spiny dogfish, and other shark species. West coast (California, Oregon, and Washington) shark landings rose from 104.3 mt in 1974 to 5,239.8 mt in 1979, then averaged 4,194.2 mt annually from 1980 to 1985 (Holts, 1988). Pacific coast shark landings have decreased since 1985, with two species--the common thresher and the Pacific angel shark--showing signs of decline (Cailliet, 1992).

Pacific Coast Directed Shark Fisheries

Pacific coast directed shark fisheries have consistently reported much lower landings than the Atlantic coast (table 8). Washington reports the highest commercial shark landings (table 9), consisting almost entirely of spiny dogfish, with small catches of blue, common thresher, and soupfin sharks (Cailliet, 1992). Oregon shark landings (table 10) are minimal and typically dominated by soupfin sharks, with the exception of 1988, when Oregon granted permits for an experimental fishery for common thresher sharks. Lesser volumes of bluntnose sixgill sharks *(Hexanchus griseus)* and spiny dogfish are also reported. Alaska landings rose significantly in the early 1990s, but little information is available on the fisheries or species composition of catch (table 11). California lands the widest diversity of shark species, with much of the commercial catch consisting of thresher and mako sharks (tables 12, 13).

The California Drift Gillnet Fishery for Swordfish, Thresher, and Mako.

The California drift gill net fishery began to develop in 1977, initially targeting the common thresher and shortfin mako. Swordfish almost immediately became a target species as well, with smaller incidental catch of bigeye thresher and pelagic thresher (Alopius pelagicus), tunas, and other species. Logbooks and landing receipts from all drift gill net vessels also record occasional landings of Pacific angel shark, blacktip shark, blue shark, cow sharks (Hexanchidae), spiny dogfish, dusky shark, hammerhead shark, leopard shark, salmon shark, sevengill shark, smoothound (*Mustelus* spp.), soupfin shark, and white shark; however, a 14 inch (35.6 cm) minimum mesh size mandated in 1982 for swordfish and shark fisheries generally restricts shark catch in this fishery to thresher, mako, and blue sharks, while vessels using 8 inch (20.3 cm) mesh to target other species are likely to take an incidental catch of smaller sharks, such as soupfin.

The fishery began in 1977 with 15 vessels, growing to more than 150 vessels by 1982 as growing market acceptance for shark meat resulted in an increase in ex-vessel prices from $0.13 per kg in 1977 to $0.33 per kg in 1980, and $0.73 per kg in 1986 (Stick et al., 1990). Hanan et al. (1993) provides a thorough description of the development of the fishery from 1980 through 1991. Drift gill net trips ranged from a single night to a month. As the fishery evolved, larger vessels began to enter the fishery and fishing effort moved northward and offshore. Nets used in the fishery ranged from 800 to 1000 fathoms in length, with a stretched mesh size of 13 to 19 inches (33 to 48.3 cm). Entangled sharks were removed from the net by cutting the fins off, then cleaned by removing the head and viscera and washing with sea water. Some skippers retained the shark fins for sale, but most did not. Blue sharks and pelagic stingrays *(Dasyatis violacea)* were the only chondrichthyan species commonly brought on board alive; blue sharks were usually clubbed to death immediately for the safety of the crew, then discarded. Many fishermen gradually shifted to a larger mesh size to reduce bycatch of juvenile blue sharks, typically adopting a mesh size of 18 to 22 inches (45.7 to 55.9 cm) (Stick et al., 1990).

In 1980, the drift gillnet fishery was made a limited entry fishery, with those already participating in the fishery allowed to continue. A mesh size restriction was set at 8 inches (20.3 cm) or larger, and a limit of 6000 feet (5486.5 m) net length established. Legislation passed in 1982 1) established a limit of 150 on the number of drift gill net permits issued; 2) increased the mesh size limit to 14 inches (35.6 cm); 3) set time and area closures to reduce interactions with marine mammals; 4) established a closure for the shark fishery February 1 to April 30; and 4) required that swordfish landings not exceed thresher and shortfin mako landings from1 May through 15 September (Hanan, 1993). Development of these management measures is discussed at length by Bedford (1987).

In 1985, new legislation eliminated the shark poundage landing requirement for swordfish, implemented new time and area closures, and prohibited drift gill nets within 25 nautical miles from 15 December through 31 January and within 75 miles from 1 June through 14 August. In 1986, the thresher shark fishing season was reduced to 30 days in May. Additional time and area closures were implemented in 1987 and, in 1988, a new requirement established that the pelvic fins of thresher sharks be left intact until after landing for purposes of sex determination. In 1989, new legislation prohibited drift gill nets within 75 nautical miles of shore from May 1 through 14 July, leaving in place the previous closure from February 1 through April 30; the closure was subsequently extended through 14 August. This provision further reduced landings by the directed shark fishery (Hanan, 1993).

From 1980-81 to 1990-91, an estimated total of 9,315 mt of swordfish were landed by the drift gill net fishery, or 931 mt annually. Swordfish landings increased from 321 mt in 1981 and 1982 to a peak of 1,537 mt in 1984 and 1985, then declined steadily to 683 mt in 1990 and 1991. Total estimated shark landings were 6,252 mt during this period, averaging 625 mt annually. Total shark landings from the drift gill net fishery fell from 1,233 mt in 1980 and 1981 to less than 300 mt in 1989 and 1990, with decreased effort and landings corresponding to regulatory developments during this period (Hanan et al., 1993). Common thresher shark was the dominant species in landings from 1981 through 1983, but was replaced by swordfish in subsequent seasons. After 1985, roughly half of thresher shark landings occurred during the shark season; the other half occurred in the fall and winter as a bycatch of the swordfish fishery (Holts, 1988; Cailliet, 1992). Thresher shark landings continued to decline in 1992 and 1993, dropping from 305 mt in 1989 to 187 mt in 1993 (Larson, 1994).

In 1982, Oregon and Washington began to issue experimental permits for thresher sharks. In 1982 and 1983, landings were recorded by only one vessel; no landings were recorded in 1985. However, fishing effort increased in 1986 and 1987, with landings of 293 mt by 37 vessels in 1986, and 111 mt by 29 vessels in 1987. Most of the permits for the experimental fishery were issued to California vessels moving northward following implementation of California regulations on the thresher shark fishery (Holts, 1988; Stick et al., 1990). Thresher landings in the northern states consisted mostly of large males, with an average dressed weight of more than 95 kg, while California landings consisted of fish with an average dressed weight of 18 kg and a nearly even sex ratio (Holts, 1988).

Prior to the 1987 season, more restrictive permit conditions were implemented, including a total thresher catch quota of 820,000 lbs (372 mt) dressed weight, a prohibition on fishing within 5 miles of shore, and a season extending from July through October. The opening of the 1988 fishing season was delayed until July 15 and fishing was prohibited within 20 miles of shore. No thresher permits were issued in 1989, due, in large part, to decreased interest in the fishery after 1986 and lack of involvement by Oregon and Washington fishermen (Stick et al., 1990).

All directed thresher fisheries were terminated by 1990, and a joint management plan was implemented by California, Oregon, and Washington in October, 1990. Both common threshers and mako sharks continue to be taken and sold as bycatch of the California drift gill net swordfish fishery, while blue sharks are typically discarded. The thresher fishery is open from May 1 through August 14, during which vessels participating in the directed fishery land approximately 907 mt daily. During the swordfish season (April 15 through January 31), bycatch of thresher sharks is likely to fall to an average of 5 to 10 percent of total catches, as market prices are considerably higher for swordfish, and low-cost imports of shark begin to increase during this period.

Common thresher sharks on the Pacific coast are believed to form a single stock that moves northward from Baja California, Mexico into southern California waters in early spring, continuing north to Canadian waters in late summer and fall. The high occurence of threshers taken off the coast of California with hooks from the Japanese tuna and billfish fishery indicates movement from distant southern or offshore areas. Little is known of stock status or movements for bigeye or pelagic threshers, although it is possible that pelagic thresher stocks are concentrated off central Baja California, with their occurence in more northern waters attributed to strong El Niño events (Hanan et al., 1993).

Most of the catch of common threshers by the swordfish drift gillnet fishery consists of immature fish averaging two years of age (Cailliet, 1992). Set net fisheries in southern California inshore waters have also taken a significant incidental catch of juvenile thresher sharks. Estimates of thresher shark bycatch based on observer data from 1983 to 1987 ranges from 500 to 3,200 fish annually (Stick et al., 1990), although this bycatch should be significantly reduced by the prohibition of gillnetting within 3 miles of shore. The Southern California Bight is likely to be an important nursery area for juvenile sharks, which remain in shallow nearshore areas and are seldom found north of Cape Mendocino, California. Mating occurs in summer, with common threshers giving birth in the spring, following a gestation period of 9 months (Hanan et al., 1993).

During the first two years of the fishery, landings of common thresher were concentrated in the months of May and June and occured primarily in the Southern California Bight. Following seasonal and area closures, the fishery moved northward and offshore, with increased catches of large mature males (Hanan et al., 1993). CPUE estimates since 1981 are highly variable with an overall declining trend, but are unreliable as many thresher shark catches are taken incidentally to the swordfish fishery. However, length frequency data taken from the fishery also reveals a decline in average length and increased occurrence of smaller fish, suggesting excessive harvest (Hanan et al., 1993; Stick et al., 1990). Mean alternate length from the California fishery decreased from 66 cm in 1981 to 56.2 cm in 1988 (Stick et al., 1990).

The California drift gill net fishery for swordfish and sharks is considered a Category I fishery under the federal Marine Mammal Protection Act of 1988, due to potential interaction with marine mammals such as harbor seal, sea lions, Northern elephant seal, and a number of cetacean species. Category I requires that participating vessels obtain an exemption to legally operate, maintain records of fishing effort and incidental catch, and carry observers when requested (Stick et al., 1990). A mandatory observer program was initiated in 1990 (Hanan et al., 1993).

The California Shortfin Mako Fishery

The shortfin mako fishery originated as an incidental catch of the California swordfish and thresher drift gill net fishery. In the mid 1980s, a directed longline fishery for shortfin mako also developed. The drift gill net shortfin mako catch peaked in 1982 at approximately 244 mt, then declined to 98 mt by 1985. Landings increased in 1986 and 1987 as a result of the directed longline fishery. Landings peaked in 1987 at over 272 mt, then declined again to less than 182 mt by 1989 (Cailliet, 1992). Both fisheries land primarily juvenile fish, ranging from one to three years of age (Cailliet, 1992; Holts, 1995).

In 1987, the California Department of Fish and Game prohibited the use of drift gillnet gear in state waters. In 1988, in response to applications by participating fishermen, California established an experimental longline fishery for shortfin mako and blue sharks (O'Brien and Sunada, 1994). In 1988 and 1989, the initial fishery consisted of 10 vessels, 9-15 meters in length, using 3-4 mile (4.8 to 6.4 km) stainless steel cable, buoyed at intervals of 75-90 m, with leaders and baited hooks attached. The number of permitted vessels was reduced to 6 in 1990, and 8 in 1991. During the second year of the fishery, stringent regulations were imposed on the fishery, including a total allowable catch of 240,000 lbs (109 mt), which was reduced in 1990 and 1991 to 175,000 lbs (79 mt). Vessels were required to carry on-board observers during 1988 and 1989 and to maintain logbooks during all years. In addition, permitted vessels were required to assist in efforts to reduce blue shark mortality, develop a market for blue shark bycatch, and participate in a shortfin mako tagging program. Although efforts to develop a market for blue shark were unsuccessful, blue shark mortality was reduced to 22 percent. However, the experimental fishery was terminated after the 1991 season due to fears that stocks would be negatively impacted by fisheries within coastal nursery areas (O'Brien and Sunada, 1994; Cailliet, 1992). Shortfin mako continues to be landed by the commercial gillnet fishery, with total landings by drift gill net, set gill net, and purse seine averaging 140 mt annually from 1980 to 1992 (O'Brien and Sunada, 1994).

According to observer data collected in 1988 and 1989, blue sharks made up 62 percent of the total catch, shortfin mako sharks 29 percent, with approximately 9 percent bycatch of pelagic stingrays. In accordance with catch quotas, landings of shortfin mako dropped from 122.2 mt in 1988 to 80.7 mt in 1989 and 79.0 mt in 1990. Landings fell to 50.1 mt in 1991 as a result of a drop in East Coast demand and increased imports. In 1989, efforts were made to market blue shark for meat, leather, and crab bait, but were unsuccessful. A minimum weight quota of 40,000 lbs (18.1 mt) of blue shark was required to be landed in 1990, but this quota was abandoned in 1991. As a result, no blue sharks were landed after 1990 (O'Brien and Sunada, 1994).

Movements of shortfin mako sharks in Pacific waters are not well known, although the size of fish caught in California waters suggests that southern California is also an important nursery area for this species. During most of the history of the directed fishery, the highest catches of shortfin mako were taken from July through September, with additional incidental catches in the thresher and swordfish fishery from May through January. The highest catches were reported within the Southern California Bight (Hanan et al., 1993).

The Blue Shark Fishery

The California experimental longline fishery for shortfin mako and blue sharks in 1988 to 1991 averaged catches of four blue sharks for each shortfin mako shark. Incidental mortality was reduced in this fishery through the development of a de-hooking tool to remove hooks from live sharks. In 1989, some 4 mt of blue shark were marketed, and in 1990, 20 mt were sold for jerky and fish and chips. However, most blue sharks continue to be discarded. A large bycatch also occurs in the drift gill net swordfish and thresher fishery off southern California, and in set net fisheries for Pacific angel shark and California halibut *(Paralichthys californicus)*. Holts (1988) reported that an estimated 300 mt of blue sharks may be caught incidentally in west coast fisheries, representing a decrease from previous years, due to the use of larger mesh nets. More recent mortality estimates are not available (Cailliet, 1992).

In 1995, Oregon instituted a Developing Fisheries Policy under which any species not included in an existing management plan requires a developing fisheries permit. Blue sharks have been listed in this category, and a total of five permits were issued for blue sharks as of early 1996 (M. Saelens, pers. comm.). According to preliminary landings data from the Oregon Dept. of Fish and Wildlife, however, commercial blue shark landings increased only slightly during from 0.06 in 1994 to 0.4 in 1995.

Little information is available on stock status and movements for the blue shark. However, southern California is known to be an important pupping and a nursery area for juvenile sharks. Mating occurs during late spring to early winter, with parturation occuring in early spring following a gestation of 9 to 12 months (Hanan et al., 1993).

The Pacific Angel Shark Fishery

Long considered a trash fish, with incidental catches by trammel nets and trawls in the California halibut fishery used for crab bait, the angel shark became the subject of a developing directed fishery in 1977. Following improvements in on-board and shoreside processing, a directed set net fishery for Pacific angel sharks began to develop in 1978 in southern California. The angel sharks were filleted, with the tail section cut for the fish and chips trade and odd pieces used to make angel shark jerky; the head and fins continued to be used as bait in the crab fishery (Richards, 1987).

Before 1982, 6 to8 vessels targeted angel sharks in California waters, but effort increased in 1982 due to the northern displacement of other species by the El Niño warming current. Market acceptance increased as a result of the decline in thresher shark fisheries and, by 1985, angel shark replaced thresher as the principal shark marketed locally. Vessels targeting angel shark during winter and spring months used large mesh (12-16 inch or 30.5-40.6 cm) gill nets. Most of the catch is reported as taken within one mile of shore in waters less than 20 m in depth, and only occasional landings have been reported north of California (Richards, 1987; Holts, 1988).

Landings of Pacific angel shark peaked in 1985 and 1986 at over 546 mt, then declined dramatically to 121.7 mt by 1989 as a result of both declining stocks and increased availability of lower cost imports (Cailliet, 1989). A minimum size limit of 107 mm for females and 102 mm for males was adopted in mid 1988, but the fishery continued to decline. The fishery was effectively ended in 1994 with the implementation of state Proposition 132, which prohibited the use of set gill nets within three miles of the coast (Cailliet, 1992; D. Holts, pers. comm.), although a small number of set gill net vessels continue to fish outside the 3-mile limit with a small incidental catch of angel sharks (L. Laughlin, pers. comm.).

The Soupfin Shark Fishery

Although the soupfin shark is sometimes targeted by the commercial fishery, this species is most frequently taken incidentally in other fisheries. Landings are highest during September through December, and typically occur within 5 miles of shore in waters less than 180 m in depth (Holts, 1988). Commercial west coast landings averaged approximately 91 mt annually from 1976 to 1989, with the exception of 1984, when 253.2 mt were taken (Cailliet, 1992). Landings were expected to decline after 1994 as a result of Proposition 132 (Cailliet, 1992).

The Leopard Shark Fishery

The leopard shark is typically caught as a bycatch of other net fisheries. Landings rose from 6.6 mt in 1976 to a peak of 45.4 mt in 1983, then declined to approximately 23 mt by 1989 (Cailliet, 1992). The prohibition of set gill nets in state waters within 3 miles of the coast is expected to further reduce leopard shark landings (Cailliet, 1992).

Salmon Shark

Salmon sharks are captured incidentally in troll, gillnet, and seine fisheries for salmon in Alaskan coastal waters. Since 1983, a number of Alaska fishermen have engaged in experimental directed fisheries for this species, with successful results from the marketing of both meat and fins. The Alaska Office of Commercial Fisheries Development in the early 1980s also financed an effort to develop the directed fishery and encouraged the marketing of meat, fins, hides, jaws, and blood serum (Paust and Smith, 1986; Paust, 1987). Although the salmon shark produces high quality meat and valuable fins, commercial landings remain extremely low as a result of limited onshore processing facilities. There were virtually no reported commercial landings of salmon shark in the Pacific from 1990 to 1995. However, some observers anticipate renewed interest in this species as the result of the decline of the Pacific coast salmon fishery in recent years.

The salmon shark, distributed roughly from Alaska to southern California, reaches a recorded maximum size of at least 3.1 m in length, with a weight of 363 kg, but may reach more than 3.7 m and weights of 454 kg. The reproductive and migratory behavior of the salmon shark are poorly known.

Shark Bycatch in Other Pacific Fisheries

The Eastern Tropical Pacific Tuna Purse Seine Fishery

Purse seine fisheries for yellowfin and other tunas in the Eastern Tropical Pacific (ETP) catch sharks incidentally, although there is little published information on bycatch rates and no information on discards or mortality rates (Bonfil, 1994). Au (1991), analyzing observer data from the U.S. fleet in 1974 and 1975, finds that sharks are the most common bycatch species of this fishery. Silky sharks were the most commonly reported species caught, with bycatch ranging from 1 to 500 per set in sets that caught them. Other species observed in order of occurrence were oceanic whitetip sharks; other carcharinids, including bull shark, blacktip shark, gray reef shark *(Carcharinus amblyrhynchos)*, and other unidentified species; hammerhead sharks (Sphyrnidae), thresher sharks, mackerel sharks (Lamnidae), blue sharks, and whale sharks *(Rhiniodon typus)* sharks. Manta rays *(Manta birostris)* and other skate and ray species were also caught incidentally in the fishery.

For purse seine sets off the coast of Central America, sharks were associated with approximately 40 percent of sets on logs, with the proportion of sharks caught ranging up to 90 percent per set. Sharks were associated with 21 percent of sets on fish schools, and 13 percent of sets on porpoise. Off the coast of Mexico, the presence of sharks in purse seine sets was less frequent, and appeared to occur most frequently in sets on porpoise (13 percent), infrequently in sets on tuna schools (6 percent), and rarely or not at all in sets on logs (0 percent observed).

In the Eastern Tropical Pacific (ETP), smaller yellowfin tuna tend to associate with logs in nearshore waters, while larger fish tend to associate with porpoise schools farther offshore. For this reason, in the 19502, the U.S. tuna fleet began to employ purse seines to encircle porpoise and tuna schools. Development of the backdown procedure to release entangled dolphins in the 1960s led to an increase in the size of the fleet and its movement farther offshore. The U.S. fleet peaked at some 150 vessels in the mid 1970s, dropping to 29 in the late 1980s, as industry restructuring led to many vessels being sold, reflagged, or transferred to Puerto Rico and American Samoa. From the late 1980s through the early 1990s, restrictions on dolphin mortality were tightened under the U.S. Marine Mammal Protection Act and the "dolphin-safe" policy was declared by U.S. tuna processors and retailers. As a result, most of the remainder of the fleet transferred to the Western Pacific, with most purse seine sets on tuna schools. By 1991, only five or six U.S. vessels fished full time in the ETP. This large-scale relocation was assisted by a 1987 agreement between the U.S. and the Foreign Fishery Agency of the South Pacific Forum, which provided for a U.S. transfer of $60 million in license fees, technical assistance, and aid; an extension of the agreement opened access to the remainder of the U.S. fleet. The ETP tuna purse seine fishery is now dominated by the Mexican fleet (Rose, 1993).

The Inter-American Tropical Tuna Commission (IATTC), an international body created to manage stocks of tuna and related species in the ETP, began in 1990 to conduct research trials with sets on Floating Aggregation Devices (FADS). Since then, they have routinely collected observer information on relative rates of bycatch of sharks and other species in log, school, and porpoise sets (IATTC, 1992). Beginning in late 1992, bycatch information began to be compiled in the IATTC's Bycatch Database, which contains data collected by IATTC observers aboard tuna purse seine vessels of 400 tons or more of the IATTC parties (Costa Rica, France, Japan, Nicaragua, Panama, U.S., Vanuatu, and Venezuela) (García, 1996).

Records from the Bycatch Database for 1993 and 1994 have been compiled by IATTC. These include a total of 17,968 sets occurring off Mexico and Central and South America, or 59 percent of total Eastern Pacific tuna purse seine sets. For observed sets, shark bycatch per set in 1993 was 1.819 for dolphin sets, 2.608 for school sets, and 19.889 for log sets. For 1994, these values are 0.333, 3.271, and 10.644, respectively. Bycatch of rays in 1993 was 0.155 per dolphin set, 1.146 for school sets, and 0.074 for log sets, with values for 1994 of 0.092, 0.832, and 0.067, respectively. Estimated total bycatches for these years, derived by multiplying observed bycatch per set by the total number of Eastern Pacific Ocean (EPO) sets, was 74,633 sharks and 7,685 rays in 1993, and 46,345 sharks and 5,044 rays in 1994. Log sets accounted for 63.5 percent of estimated total shark bycatch in 1993, and 59 percent in 1994, while school sets accounted for 83.7 percent of estimated total ray bycatch in 1993, and 82.5 percent in 1994.

Shark species commonly reported in the EPO tuna fishery are blacktip, whitetip, hammerhead, and silky shark. Blacktip sharks accounted for 56.3 percent of estimated total shark bycatch. Observed bycatch rates for this species in 1993 were 0.68 for dolphin sets, 2.168 for school sets, and 10.549 for log sets, while 1994 rates were 0.154, 2.087, and 5.612, respectively. Blacktip sharks larger than 150 cm contributed 76.6 percent of the bycatch in dolphin sets, 54.1 percent in school sets, and 25.7 percent in log sets, while small sharks (less than 90 cm) comprised 1.3 percent of the dolphin set bycatch, 1.36 percent of school set bycatch, and 24.7 percent of log set bycatch. For whitetip sharks, larger specimens were typically caught in log sets, followed by school and dolphin sets, while small sharks were most common in log sets, followed by dolphin and school sets. For silky sharks, large sharks predominated in school sets, followed by dolphin and log sets, while small sharks contributed 33.8 percent of the log set bycatch, 23.5 percent of dolphin set bycatch, and 15.8 percent of school set bycatch. Ray bycatch consisted of manta ray and other unidentified species. Large manta rays predominated in dolphin set bycatch, followed by log and school sets, while small specimens predominated in log sets, followed by dolphin and school sets (García, in litt., 1996).

The North Pacific High Seas Driftnet Fisheries

A North Pacific driftnet fishery for flying squid was developed in 1978 by Japan, with South Korea and Taiwan also entering the fishery soon thereafter. Other vessels from Japan and Taiwan targeted tunas and billfish in the large-mesh driftnet fishery. The large-scale driftnet fishery ended in 1992 as a result of the United Nations moratorium, which took effect on 31 December 1992.

Available data on shark bycatch in the North Pacific squid fishery is reviewed by Bonfil (1994). Observer program data report a 1990 bycatch of 89,551 sharks, of which 81,956 were blue sharks, 6,263 salmon sharks, and the remainder consisting of mako, thresher, and smaller numbers of spiny dogfish, white sharks, basking sharks, pygmy shark (Euprotomicrus bispinatus), and cookie cutter sharks (Isistius spp.). From effort statistics and observer data, Bonfil estimates a total shark bycatch in the fishery of nearly 2 million sharks, or an estimated 18,739 mt, of which 8,400 mt were taken by Japan, 9,000 mt by Taiwan, and 1,300 mt by Korea. Of the total, 1.8 million individuals, or 12,802 mt, consisted of juvenile blue sharks (1-2 years). Estimated shark bycatch is considerably higher in 1989 than in 1990; Northridge (1991) estimates total blue shark bycatch in the fishery at 2.44 million individuals. Bonfil (1994) estimates that 1,800,000 sharks were caught by the Japanese fleet in that year. The reported 1989 catch for Japan totaled only 237,734 individuals; it is unclear whether this figure represents landings, but, if so, it suggests shark discards of about 1,560,000 sharks, or 10,900 mt, in this fishery.

Observer data collected aboard Japanese vessels participating in the squid driftnet fishery from 1989 to 1991 recorded the presence of 13 elasmobranch species occuring as bycatch in the fishery, with blue shark and salmon shark the dominant species (McKinnell, 1993). According to this data, blue sharks of less than 1 m in length were typically discarded, while fish greater than 1 meter in length were finned and the carcass discarded. Salmon sharks and occasional bycatch of mako sharks were also retained. Both sharks fins and salmon and mako shark fillets were sold by the crew as an additional source of income (McKinnell, 1995).

Observer data from the South Korea squid driftnet fishery in 1991 recorded a total of 8,391 sharks caught incidentally by Korean vessels. Of these, 8,235 were blue sharks, 123 salmon sharks, 22 shortfin mako sharks, 5 cookie cutter sharks, 2 white sharks, one common thresher shark, and 3 unidentified sharks. In addition, a total of 5 pelagic stingrays were observed. Overall bycatch rates for blue sharks for all seasons and all fishing areas were 42.12 blue sharks per 1,000 poks (net panels) for operations in which blue sharks were caught, or 37.09 blue sharks per 1,000 poks for all fishing operations (Park et al., 1992).

Observer data are also available for the large mesh high seas drift net fishery for tunas and billfish. As larger mesh sizes used in this fishery permit escape by smaller bycatch species, estimates of shark bycatch in this fishery are considerably lower than for the squid fishery. Estimates for 1990 total 150,000 individuals, or 1,722 mt, of which 974 mt would have been taken by Japan, and 748 mt by Taiwan. Reported species in order of importance are blue, mako, cookie cutter, pygmy, salmon, white, thresher, basking, hammerhead, and spiny dogfish sharks (Bonfil, 1994).

Pacific Coast Recreational Fisheries

According to the Marine Recreational Fisheries Statistics Survey, total estimated Pacific coast recreational landings for all shark species averaged 182 mt annually from 1984 to 1989 (table 14). Spiny dogfish accounted for 35 percent of total recreational landings, with most landings occurring in Washington. Other shark species reported in recreational catches and landings during this period include spiny dogfish, bullhead (*Heterodontus* spp.), horn (*Heterodontus* spp.), bluntnose sixgill, sevengill, sand tiger, thresher, shortfin mako, soupfin, smoothound, blue, leopard, angel, and Pacific sleeper sharks *(Somniosus pacificus)* (NMFS, 1992b).

Sport fisheries for shortfin mako sharks became increasingly popular in California in the 1980s, with several annual tournaments targeting this species. Estimates from the Marine Recreational Fisheries Statistics Survey of recreational landings of shortfin mako are highly variable from year to year, but average 63 mt annually from 1980 to 1989. Estimated recreational landings account for 31 percent of total (commercial and recreational) shortfin mako landings during this period. After 1989, estimates of recreational catches are available only from commercial passenger vessels and do not include data from private vessels; these data report recreational landings of 4 mt in 1990, and 2 mt in 1991 and 1992 (O'Brien and Sunada, 1994). A small recreational hook and line fishery in southern California also targets juvenile thresher sharks (Stick et al., 1990).

The Pacific Spiny Dogfish Fishery

The Pacific coast dogfish fishery is concentrated in Washington (table 15). The dogfish fishery in Puget Sound is where most dogfish catches are taken by trawl, set net, and hook and line. Most catches by coastal fisheries are by trawl (B. Culver, pers. comm.; PCMFC, 1991 through 1994). Washington landings increased from 2,635.1 mt in 1976 to a peak of 4,279.7 mt in 1979, decreased to an average of 1,348.3 mt annually from 1985 to 1989, then rose again to an annual average of 2,396.9 mt from 1991 to 1994. The volume of spiny dogfish caught in Canadian (British Columbia) waters but landed in Washington ports increased steadily beginning in the late 1970s and, according to data presented by Cailliet (1992), represented more than half of Washington landings from 1985 to 1989. Oregon landings were less than 1 mt annually from 1985 to 1989, increasing to 65.9 mt in 1991; much of the dogfish catch is incidental and is landed in Washington (M. Saelens, pers. comm.). Alaska commercial dogfish landings averaged

4.1 mt from 1990 to 1994, then increased to 12.4 mt in 1995, with the bulk of catches taken by single otter trawl, mid-water trawl, and longline vessels. California landings have averaged less than 0.5 mt annually since 1988.

The Northeastern Pacific stock of spiny dogfish is distributed from Alaska to Baja California, but is most common in the waters off British Columbia, Canada, and Washington. Stock structure and movements are poorly known, but available information suggests seasonal north-south migration. Individuals tagged in the eastern Pacific have also been recaptured off the coast of Japan (Ketchen, 1986).

Pacific spiny dogfish tend to be longer-living, slower-growing, and larger than Atlantic stocks (Ketchen, 1986; Jensen, 1965; Nammack et al., 1985). Ketchen (1986) reports that the spiny dogfish breeds during the late fall and early winter, with a gestation period of two years. Females produce from 2 to 16 pups, with an average of 6 or 7. The estimated age at maturity is 24 years for females and 14 years for males. Females reach an average size of 94 centimeters (cm) at maturity, with a maximum of 130 cm at

WESTERN PACIFIC SHARK FISHERIES

Overview

The U.S. Western Pacific region includes Hawaii, the territories of American Samoa, Guam, the Northern Mariana Islands, and the islands and atolls of Baker, Howland, Jarvis, Johnston, Kingman, Palmyra, and Wake. There are currently no active directed coastal shark fisheries in the region (R. Schroeder, pers. comm.). Nearly all shark landings reported in the region in recent years were taken as bycatch by Hawaiian longline vessels targeting swordfish, tuna, and other pelagic species (table 8). Small commercial shark landings are reported for Guam and American Samoa; no shark landings are reported for the Northern Mariana Islands. Shark bycatch is also taken by U.S. and foreign purse seine and pole and line fisheries targeting tuna in the Western Pacific. Troll fisheries targeting albacore also catch and land small volumes of shark, while shark bycatch in the handline fishery is typically discarded (WPRFMC, 1995b).

The Development of Western Pacific Pelagic Fisheries

Prior to 1980, a significant foreign fishery for tuna, swordfish, and billfish operated within 200 miles of the coast of the western Pacific islands. Japanese vessels were most active in waters around Hawaii; they fished actively in waters around Guam after 1974, and were less active off the Northern Mariana Islands. Taiwanese and Korean longline vessels based in American Samoa fished in both Samoan waters and in waters off Hawaii. A Japanese drift gillnet fishery for marlin and swordfish operated just outside the 200-mile limit off Hawaii from the early 1970s to the early 1980s. Although U.S. Japanese, Korean, Taiwanese, Philippino, Soviet, and New Zealand purse seiners fished tuna throughout the Western Pacific during these years, no vessels were known to operate within U.S. waters (WPFMC, 1986).

In 1980, a Preliminary Management Plan for pelagic species, including swordfish, billfish, and pelagic sharks was implemented for the Western Pacific region economic zone. Although several hundred permit applications were received from Japanese, Taiwanese, and Korean vessels to fish within the U.S. EZ, no legal fishing occurred in the U.S. EZ after 1980. This was apparently due in part to a drop in tuna prices during the early 1980s that led to a reduction in all longline fleets in the Western Pacific, and their reluctance to carry U.S. observers as required under the Management Plan (WPFMC, 1986).

In 1987, the Western Pacific Regional Fishery Management Council implemented a final Fishery Management Plan for Pelagic Fisheries of the Western Pacific Region. The FMP was intended to facilitate foreign tuna fishing within the U.S. EZ, ban drift gillnet fishing, and regulate foreign fishery for non-tuna species in the U.S. EZ. The plan has, however, become increasingly important in data collection and monitoring programs for domestic fisheries. Initially covered by the management plan were billfishes (Istiophoridae), wahoo (Acanthocybium solanderi), mahi mahi (Coryphaena hippurus), and the following four families of shark species: requiem sharks (Carcharhinidae), thresher sharks (Alopiidae), mackerel sharks (Lamnidae), and hammerhead sharks (Sphyrnidae). Tuna and related species were incorporated in the FMP by an amendment in 1992 (WPRFMC, 1992a). A limited entry permit system was established for the fishery in December, 1990.

Hawaii Shark Fisheries

The Hawaiian longline fleet declined steadily from the 1940s until the late 1970s from 76 vessels in 1950 to 38 in 1960 and 24 in 1970, and reached an historic low of 17 vessels during 1975 and 1976. In the late 1970s, the fleet began to increase again with the entry of new, larger vessels (80-95 feet), that replaced the wooden sampan-style boats of the older Hawaiian fleet. Many of the new vessels relocated from the west coast and Alaska. By 1983, the fleet had grown to 32 vessels (WPFMC, 1986). From 1978 to 1983, sharks reportedly comprised an annual average of 37 percent of total catches by Hawaiian longline vessels. In the mid 1980s, consumption of shark meat increased rapidly as the product gained market acceptance. During most of these years, however, only mako, thresher, and white sharks were marketable in Hawaii, with other species discarded, not reported, or underreported (WPFMC, 1986).

The longline fleet continued to grow, with 40 to 50 vessels in 1987 and 80 vessels in 1989. In July, 1990, when the Council circulated a notice of possible implementation of limited entry rules, the fleet totaled 110 vessels. By December, 1990, when the control date was established, the fleet had grown to more than 150 vessels, with 40 to 50 of these targeting swordfish (WPRFMC, 1991). Much of this increase was due to the relocation of vessels from the depleted Atlantic swordfish fishery in the Atlantic and the yellowfin tuna fishery in the Gulf of Mexico. Hawaii commercial swordfish landings increased nearly threefold from 1988 to 1989, and, from 1989 to 1990, landings increased tenfold (WPRFMC, 1991b). By 1992, an increase in fishing effort on tuna by the longline, purse seine, and other fleets led to the incorporation of tuna in the Western Pacific FMP (WPRFMC, 1992a).

In 1991, approximately 43 percent of total longline fishing effort was directed at tuna, and 19 percent at swordfish. In 1992, these proportions were 45 percent and 24 percent, respectively. The number of Hawaii longline vessels targeting swordfish full time increased to 23 in 1991 and 27 in 1992, with an additional 39 vessels targeting swordfish part time. Swordfish longliners average 30 to 40 days at sea per trip, fishing up to 1,500 miles from Hawaii. The majority of the swordfish catch is therefore taken well outside the U.S. EZ. By contrast, tuna longliners average 7 to 10 days per trip and tend to fish closer to the islands. Logbook reports for 1991 through mid 1993 record a total swordfish catch of 65,691 fish in 1991, 73,841 fish in 1992, and 52,189 fish during the first half of 1993. The percentage of swordfish taken outside the EZ was 65 percent in 1991. Following area closures within the EZ, the percentage increased to 84 percent in 1992, and 80 percent from January to June 1993. In 1992, 70 percent of albacore, 45 percent of bigeye tuna, and 13 percent of yellowfin tuna were taken by longline vessels outside the EZ (WPRFMC, 1994a).

Total reported shark bycatch in Hawaiian longline fisheries totaled 71,063 fish in 1991, 96,073 fish in 1992, and 55,034 sharks during the first half of 1993, paralleling the increase in swordfish and tuna catches during this period. Shark catches outside the EZ accounted for 66.5 percent of the total in 1991, 78.6 percent in 1992, and 69.3 percent in the first half of 1993. Shark landings from the longline fishery totaled 90.7 mt in 1991, with a value of $100,000, and 254 mt in 1992, with a reported value of $350,000. Non-longline commercial landings totaled 10 mt in 1991 and 6.3 mt in 1992, and were valued at $4,003 and $3,645, respectively (WPRFMC, 1994a). Analysis of market data in 1991 and 1992 suggests that most sharks were landed whole in Hawaii and were destined for the local restaurant market (WPRFMC, 1994a).

Shark bycatch in the longline fishery consists primarily of blue, mako, and thresher sharks, the majority of which are probably caught as bycatch in the swordfish fishery. Relative market price and trip duration encourages high discards of sharks, as many fishermen are reluctant to store sharks with their swordfish catch because of the potential for spoiling the swordfish (S. Pooley, pers. comm.). According to 1991 observer data, blue sharks were the most important bycatch species in the fishery and were generally cut loose (WPRFMC, 1992b). During 1992, of 96,073 sharks caught by the longline fishery, only about 3,600 were retained (WPRFMC, 1994a).

A significant amount of finning was observed for the first time in the mid 1990s, with fins landed for export to Hong Kong, Korea, Taiwan, and China. The relative contributions of Hawaiian and foreign longline fleets to total shark fin landings is not entirely clear. Due to the small number of dealers handling shark fin, the volume of fins is subject to federal confidentiality rules and cannot be reported by weight. Instead, landed fins are converted to round weight in reported landings (S. Pooley, pers. comm.)

Reported commercial shark landings in Hawaii increased sharply in 1993 to 1,180.3 mt, with 1,174.8 mt landed by the longline fleet. However, most retained catches were landed as fins only, rather than whole carcasses. A total of 16,758 sharks were reportedly retained in 1993. Of these, approximately 14,500 were blue sharks for which only fins were retained. It is likely that improved reporting, as a result of mandatory logbook requirements, contributed to the apparent increase in shark landings after 1990, while much of the dramatic increase in shark fin landings in 1993 was reportedly due to a new estimate of whole weights represented by shark fin landings (WPRFMC, 1994b).

Hawaii shark landings fell to 816.5 mt in 1994, with 811.9 mt landed by the longline fleet, again with high landings of fins. The decrease in landings was undoubtedly related to a 47 percent decline in swordfish landings from 1993 levels. Beginning in 1994, a number of swordfish vessels that had shifted their operations from the Atlantic coast began to return to the Atlantic. Reasons for exiting the fishery included: high cost of operating from Hawaii, poor swordfish catch rates, anticipation of better fishing elsewhere, and the need to keep longline permits active elsewhere in the United States (e.g., in the Atlantic swordfish fishery following notice of proposed limited entry) (WPRFMC, 1995a). The exodus of swordfish vessels may also be due, at least in part, to a shift in relative market prices in favor of tuna. Swordfish landings are expected to continue to decline as vessels leave the fishery or direct greater effort toward tuna. As shark bycatch rates are significantly lower for the tuna fishery, shark landings are also expected to continue to drop (S. Pooley, pers. comm.).

Sharks are occasionally caught in the Hawaii day handline tuna fishery, representing less than 1 percent of total catches in 1979 and 1989, with catches of 0.1 mt and 2.2 mt, respectively (WPFMC, 1986). Shark bycatch in the growing tuna purse seine fishery is likely to be significant, but data on bycatch rates are not available.

Thresher and mako sharks are occasionally landed as whole carcasses by trollers, charter vessels, and other small fishing vessels. In previous years, such landings were more common, as shark meat was used to process fishcake. The decline in landings of whole sharks may be attributed to regulations restricting longline vessels to 25 miles or more offshore, which forced many small longline vessels to leave the fleet. Medium and large sized longliners operating further ofshore are more reluctant to store shark on board with other species during long trips, and typically discard the shark bycatch unless it is caught on the way into port (S. Pooley, pers. comm.).

Guam Shark Fisheries

Reported commercial shark landings in Guam totaled less than 1 mt in 1993, and increased to 2.3 mt in 1994. Most commercial catches of sharks and other species are taken in the troll fishery, which is simultaneously recreational, subsistence, and commercial. Reported commercial shark landings were less than 1 mt in most years since the early 1980s, with the exception of 1991 (3.7 mt) and 1994 (2.3 mt) (WPRFMC, 1986; WPRFMC, various years).

In the late 1980s, 22 U.S. and Korean purse seine vessels were based in Guam, with an additional 30 foreign longliners landing tuna and billfish for air transshipment to Japan for sale in sashimi markets (WPRFMC, 1990). By 1990, 219 Taiwanese and 114 Japanese vessels transshipped fish from Guam, and in 1991, three longline vessels shifted their operations from the Gulf of Mexico to Guam (WPRFMC, 1991c). In the early 1990s, many of the foreign longline vessels transshipping through Guam reportedly concentrated fishing effort on the boundary between the waters of Guam and the Federal States of Micronesia (WPRFMC, 1991c). Although it is likely that shark fins, and possibly meat, are also transshipped through Guam, no trade information is available.

American Samoa Fisheries

A small localized fishery in American Samoa reported average annual landings of less than 1 mt from 1988 to 1994. Reported landings increased in 1994 to 6 mt. This apparent increase, however, is likely to be the result of improved data collection in that year (WPRFMC, 1995a).

In the late 1980s, two tuna canneries in American Samoa processed landings by U.S. purse seiners of yellowfin and skipjack tuna, albacore tuna caught by U.S. troll vessels, and landings of albacore tuna offloaded by some 100 Taiwanese and 40 Korean longline vessels fishing in the Western Pacific (WPFMC, 1990). Again, although sharks are likely to be landed in American Samoa for reexport, no trade information is available to suggest possible volumes.

Recreational Fisheries

Very little information is available on recreational shark fisheries in the Western Pacific. Estimates of catches by charter vessels in 1982 totaled 159 mt, representing 2 percent of the number of fish caught, and 15.8 percent by weight of the recreational charter boat catch. Sharks also contributed 7 percent of revenues from fish sales by charter boats during that year (WPFMC, 1986).

Shark Control Programs

A series of six shark control programs were implemented in Hawaii between 1959 and 1976, consisting essentially of directed longline fisheries. A total for all programs of 4,668 sharks were caught at an estimated cost per shark of $39 to $283. Tiger sharks, most commonly responsible for attacks on humans, were the most frequent species caught, with a total of 554 individuals. Other species killed included blacktip, hammerhead, sixgill, prickly *(Echinorhinus cookei)*, white, blue, mako, gray reef *(Carcharinhus amblyrhynchos)*, Galapagos *(C. galapagensis)*, bignose, false catshark *(Pseudotriakis microdon)*, and silky sharks. A review of shark control programs is provided by Wetherbee et al. (1994).

CHONDRICHTHYAN MANAGEMENT AND CONSERVATION

Overview

In the United States, waters within the 3-mile territorial sea lie within the jurisdiction of coastal states. Management of marine resources in the federal waters of the United States is the responsibility of the National Marine Fisheries Service (NMFS) within the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce.

Fisheries management within the 200-mile Exclusive Economic Zone takes place under the authority of the Magnuson Fishery Conservation and Management Act. This act established eight regional fishery management councils, whose members are nominated by state governors and appointed by the U.S. Secretary of Commerce. Commercial fisheries are managed largely through Fishery Management Plans (FMPs), developed through consultations among NMFS, the regional councils, the interstate commissions, states, and other interested parties.

Marine waters under federal jurisdiction are divided into five large geographic regions: Northeast, Southeast, Alaska, Pacific, and Western Pacific. These regions correspond roughly to the location of NMFS regional offices: Northeast, Southeast, Alaska, Northeast, and Northwest. Regional Fishery Management Councils have been established for the New England, Middle Atlantic, South Atlantic, Gulf of Mexico, Caribbean, Pacific, North Pacific, and Western Pacific. The three interstate fisheries commissions are the Atlantic States Marine Fisheries Commission, the Gulf States Marine Fisheries Commission, and Pacific States Marine Fisheries Commission.

In addition, the United States is a party to a number of international treaties, conventions, and research organizations governing marine fisheries. These include the Inter-American Tropical Tuna Commission (IATTC) (Eastern Pacific), the International Convention for the Conservation of Atlantic Tunas (ICCAT), the International North Pacific Fisheries Commission and International Council for the Exploration of the Sea (ICES) (North Atlantic), and the Northwest Atlantic Fisheries Organization (NAFO).

Management and Conservation Measures in the Atlantic

Under a Preliminary Management Plan (PMP) for Atlantic Billfishes and Sharks published in 1978, a total of 1,500 mt of sharks was allocated for foreign fisheries in the U.S. EZ. Under the PMP, the Faroe Islands was the only country to receive permits under this allocation, and received an allocation of 500 mt of porbeagle sharks beginning in 1978. Actual landings were considerably below the allocation, totaling only 5 mt in 1980 and 100 mt in 1982, with no catch in 1983 or 1984 (Casey and Hoey, 1995).

Under the 1993 Fishery Management Plan, there is no allocation for foreign fisheries for sharks in the U.S. EZ. The 1993 Fishery Management Plan for Sharks of the

Atlantic Ocean applies to all sharks caught in U.S. waters, whether state, federal, or international. If fishing occurs exclusively in state waters, more restrictive state requirements may apply. The FMP requires any person selling a shark in or from the U.S. EZ to obtain an annual vessel permit, which is dependent on eligibility under earned income qualifications.

Vessel owners or operators who obtain a permit are required to maintain records of sales of sharks and submit related weighout slips. In addition, selected vessels are required to maintain and submit logbooks containing information on fishing gear and location, numbers of each species caught, and number of each species discarded. The FMP prohibits finning within the U.S. EZ or on board a permitted vessel, and requires that fins on board or offloaded do not exceed five percent of the weight of the carcasses. Transfers of sharks at sea are also prohibited. The FMP requires that permitted vessels must release any shark that is not retained in a manner that ensures maximum probability of survival, and requires that if caught by hook and line, the shark "must be released by cutting the line near the hook without removing the fish from the water." (50 CFR Ch. VI, §678; NMFS, Final rule and interim final rule for Atlantic sharks, *Fed. Reg.* 58(78): 21931-21949)

The FMP includes 39 species of sharks in a management unit. These are separated into three groups for assessment and regulatory purposes: large coastal (22 species), small coastal (7 species), and pelagic species (10 species). The FMP also includes 34 additional species, including dogfish, to which data collection requirements apply but for which commercial catch quotas have not been established. In 1993, the FMP established commercial quotas for the shark species included in the large coastal and pelagic categories. The annual quotas are divided into semi-annual quotas of 1,218 mt and 290 mt, respectively. Upon reaching the semiannual quotas, a notice of fishery closure is issued by NMFS.

The distinction among commercial, recreational, and incidental fisheries is not always clear. For example, some shark bycatch is likely to be reported in commercial landings and some recreational catch is likely to be sold in local markets. Beginning in the mid 1980s, this distinction may have become even less clear, as an increasing proportion of both recreational catches and swordfish and tuna longline shark catches were landed for commercial sale. The Atlantic Shark Fishery Management Plan, implemented in 1993, takes these changes into account by counting commercial landings from each of these fisheries against the commercial quota. The FMP does not, however, account for bycatch that is not landed, in particular, shark bycatch that normally would be landed, but must be discarded after the semiannual commercial quotas are reached.

Under the Shark FMP, both sales by commercial vessels and sales by licensed recreational vessels (under commercial permit) are counted toward the quota. Commercial vessels may not retain sharks included in the species group for which the quota has been reached, while recreational vessels are permitted to retain, but not to sell, sharks included in the species group for which the quota has been reached (50 CFR Ch.

VI, §678; NMFS, Final rule and interim final rule for Atlantic sharks, *Fed. Reg.* 58(78): 21931-21949)

Recreational shark fishing is also specifically covered under the FMP. Recreational charter and head boats are subject to a trip limit of 4 sharks from the large coastal and pelagic species groups combined, and a trip limit of 5 sharks per person per day for the small coastal species. Shark tournament operators are also required to maintain and submit records of catch and effort. Recreational vessels may retain species of sharks for which a commercial quota has been reached, however, the sale, purchase, trade, or barter of such sharks is prohibited.(50 CFR Ch. VI, §678; NMFS, Final rule and interim final rule for Atlantic sharks, *Fed. Reg.* 58(78): 21931-21949))

In 1993, an annual commercial quota of 2,436 mt, dressed weight was established for large coastal species, and an annual quota of 580 mt, dressed weight, for pelagic species. In 1994 and 1995, the large coastal commercial quota was raised slightly to 2,570 mt, while the pelagic commercial quota remained at 580 mt. In 1993 and 1994, implementation of the semi-annual quotas led to derby-style fishing, with fishery closures imposed in mid May of both years for the first season, and in late-July and early August for 1993 and 1994, respectively, for the second season. Associated problems included routine exceeding of the semi-annual quota prior to fishery closures; disruption of the fresh shark market; and waste and quality control problems. In order to extend the season and reduce such problems, a trip limit of 4,000 lb (1,814 kg), dressed weight was instituted in late 1994 (NMFS (1994), Atlantic Shark Fisheries Final Rule, *Fed. Reg.* 59(200): 52453-52458.

Several changes were made in the FMP implementing regulations in late 1994. These included a requirement that dealers obtain an annual permit to purchase sharks and provide semi-monthly reports to NMFS. These reports required documentation of the vessels from which sharks were received, dates of receipt, port and county where sharks were off-loaded, total weight by market category for shark and other species received with the shark, and price. The revised regulations further prohibited fishing by drift gillnet of 2.5 km or more in length and possession of sharks by vessels using or having such gear on board.

As of early 1996, the Atlantic shark fishery continued to be subject to open access, with more than 1,400 vessels permitted for a shark quota that could be caught by 40 vessels (NMFS (1993), *Fed. Reg.* 58(168): 46153-46155). A control date of February 22, 1994, for purposes of elegibility criteria for potential limitations on access to the fishery, was established to discourage speculative entries into the fishery (NMFS (1994), *Fed. Reg.* 59(35): 8458), but has not been successful. In 1995 and 1996, NMFS initiated a public consultation period for the development of limited access rules for the Atlantic shark fishery.

In addition, the Atlantic Shark FMP allows for the further development of both general and species-specific management measures, pending the collection of additional data on the species composition of catches and landings and status assessments. Preliminary conclusions of the voluntary observer program conducted in 1994 through 1996 include the finding that much of the nearshore catch consists of immature fish, with seasonal impacts on pregnant females, suggesting the possible development of area restrictions. The report also finds that the establishment of a minimum size limit of 140 cm (fork length) for sandbar shark landings would correspond to approximately a 10 percent reduction in landings, thereby allowing for gradual rebuilding of this stock (Gulf and South Atlantic Fisheries Development Foundation, 1996).

Apart from some improvements in species reporting, available information on the Atlantic directed shark fisheries remains limited. Reported landings records contain incomplete data on landings of fins. Carcass landing data are likely to be biased by the use of a standard conversion factor of 1.39 to convert all carcass weights for all species to live weights. Mandatory logbook reporting under the FMP remains incomplete because during the first two years of the FMP, not all shark fishermen were provided with shark logbooks (NMFS, 1994c). Information available to date through logbook reporting is not yet available publically. In addition, the FMP is not accompanied by a mandatory observer program for the directed shark fishery, so observer data sets are available only from voluntary observer programs with small sample sizes and limited geographical coverage.

Management and Conservation Measures in the Pacific

During the early 1980s, the Pacific Fisheries Management Council began work on the development of a Fisheries Management Plan for oceanic sharks and billfish. However, the Council determined that the fishery for these species was restricted to California. Since California had already enacted fishery management regulations, it was decided not to pursue the FMP (Stick et al., 1990).

A Thresher Shark Management Plan was published in 1990 by the Pacific Marine Fisheries Commission for California, Oregon, and Washington. The plan outlines available information on thresher shark biology, distribution, status, and fisheries. It also contains protocol for state management strategies and recommends a series of research measures to increase available information on fisheries data, such as sex ratio, length frequency, CPUE, stock identification, and age determination. A management panel was established with one member from each of the state agencies, assisted by an advisory panel of five members representing interests in the thresher shark resource and fisheries. An annual Pacific coast thresher shark harvest guideline of 750,000 lbs (340 mt) dressed weight was established. The management panel meets if this guideline is exceeded in order to evaluate the status of the resource and recommend management measures (Stick et al., 1990). However, the directed thresher shark fishery remains limited to California, with total Pacific coast landings remaining well under the harvest guideline since the publication of the Management Plan.

California has implemented a range of management and conservation measures for Pacific sharks and general fishery and gear restrictions limiting shark landings in the state (L. Laughlin, pers. comm.). Legislation passed in 1995 (effective 1 January 1996) attempts to prevent the practice of finning by prohibiting the possession of severed shark fins and tails aboard vessels at sea, except when they remain unaltered and the corresponding carcass is also in possession. The use of set gill nets is prohibited within the 3 mile limit of state waters. Drift gillnetting for shark and swordfish requires an annual permit; the number of vessel permits remains limited to 150. The fishery, which is closed February 1 through April 30 and restricted to outside 75 miles from May 1 through August 14, is restricted by a mesh size limit of 14 inches stretched length. Longline vessels are permitted only outside the 200 mile EZ. Commercial size limits are set for Pacific angel shark at 42 inches total length for females and 40 inches for males, or alternate lengths (first dorsal fin to tip of tail) of 15 and 14.5 inches respectively. Angel sharks taken by gill or trammel net must be landed with at least one pelvic fin and the tail fin attached. A size limit for leopard sharks in both the commercial and recreational fisheries is established at 36 inches total length.

State regulations prohibit the taking of white sharks except for educational and scientific purposes, although incidental catches may be landed with the pelvic fin intact and sold for scientific or display purposes. Also prohibited since 1993 are the taking or possession for commercial purposes of shark and ray egg cases and brown smoothound sharks for the aquaria trade.

California has also enacted regulations on recreational shark fisheries. A total bag and possession limit of 20 fish of all species applies to the recreational fishery. Individual bag limits are established for a number of species, including leopard shark (3), blue shark (2), thresher shark (2), shortfin mako (2), soupfin shark (1), sixgill shark (1), sevengill shark (1), and white sharks (0).

In the Western Pacific region, pelagic sharks are included in the management unit of the 1987 Fishery Management Plan for Pelagic Fisheries of the Western Pacific Region, incorporating Hawaii, Guam, American Samoa, and the Northern Mariana Islands. Catches and landings of pelagic sharks in this region occur primarily as bycatch in the Hawaii longline fishery. Shark management, therefore, benefits indirectly from limited entry into the longline fishery after 1990.

In 1990, in response to rapid growth in the Hawaii domestic longline fishery, the Council voted to request an emergency ruling establishing provisions for mandatory logbook and dealer reporting. The ruling required an annual permit for any vessel using longline gear or possessing, receiving, transshiping, or landing management unit species taken by longline gear . These measures were permanently incorporated by amendment into the FMP in 1991. Interim federal regulations became effective November 27, 1990. In December, 1990, the Council established an additional requirement for limited entry permits for the Hawaii longline fishery, granted on the basis of participation in the fishery prior to the control date of December 5, 1990. Permits are required for any vessel using longline gear to fish species included in the Pacific pelagic management unit within the U.S. EZ around Hawaii. The Council also established control dates of December 6, 1990 and January 1, 1991 for the longline fisheries in Guam and American Samoa, respectively (WPRFMC, 1991a; 50 CFR § 685, as amended).

In April, 1991, the Council requested an interim federal emergency rule establishing a longline closure area of 50 miles around the North West Hawaiian Islands as a result of marine mammal interactions; and an area of 50 miles around the islands of Maui and Hawaii counties, a 75 mile closure around the island of Oahu and the islands of Kauai County in, to prevent conflicts between longline fisheries and coastal fisheries. In Guam, longlining was prohibited within 50 miles of Guam's 100 fathom isobath (WPRFMC, 1991b). The emergency ruling, effective June 1991, established areas closed to longline fishing in waters surrounding Hawaii and Guam. Exemptions were made only for individuals who owned and operated a longline vessel in restricted waters prior to 1970 and harvested 80 percent or more of total landings in restricted waters in any five years after 1969. The area closures were incorporated by amendment to the FMP in October 1991 (WPRFMC, 1991c).

In 1994, an amended limited access program was adopted to replace the moratorium that expired in that year. Under the revised program, permits could be issued to all limited entry permit holders that made at least one landing in Hawaii ports of fish caught by longline during the moratorium. Individuals with limited access permits for vessels less than 40 feet long were exempted from the landing requirement to qualify for a new permit. Restrictions on permit transfers were eased to allow upgrading or replacement of vessels, subject to the qualification that the new vessel not exceed in size the largest vessel active during the moratorium (WPRFMC, 1994a).

Mandatory logbook requirements and collaborative efforts to improve data collection and reporting from pelagic fisheries have increased the availability of information on shark bycatch and status. However, to date, the FMP has not contributed significantly to research and management of pelagic sharks in the Western Pacific, primarily because few sharks have been landed from the fishery. In response to an apparent rise in shark fin landings in 1993 and 1994, the Western Pacific Regional Fisheries Management Council recommended increased efforts by NMFS to assess total catches, landings, and revenues related to shark fin landings.

As part of efforts to improve research effort in pelagic fisheries, the Pelagic Fisheries Research Program (PFRP) was established by the Council in 1992. In mid 1995, the PFRP provided support for a study to estimate bycatch and discards of sharks and other species by the Hawaiian longline fishery. The results of this research are not yet available.

DOMESTIC USE AND TRADE OF SHARKS AND SHARK PRODUCTS

Meat

Dogfish

Despite sporadic efforts to encourage popular acceptance of dogfish, there is virtually no domestic consumption of this product. During World War I, an effort was made to popularize the consumption of dogfish by labelling it "grayfish," which was offered in canned form until it became evident that corrosion of the can and decomposition made dogfish canning impractical. In the late 1950s, dogfish meat was landed in New England in significant quantities as part of an industrial fishery for meal and oil, with landings peaking in 1957 at 2,859 mt. In the 1960s, incidental catch of dogfish from otter trawls was reportedly marketed in small quantities for fish and chips and select ethnic markets (Jensen, 1965).

U.S. dogfish landings on both the Atlantic and Pacific coasts are therefore destined almost exclusively for export and account for the bulk of reported U.S. shark exports. Customs data record U.S. exports of dogfish and other sharks only for 1989 to 1995 (table 16), and begin to distinguish dogfish from other sharks only in 1995 (table 17). In that year, reported U.S. exports of dogfish totaled 8,092 mt, or 97 percent of total U.S. shark exports.

Reported U.S. imports of dogfish and other sharks are similarly combined until 1995 (table 18). Reported 1995 dogfish imports totaled 1,319 mt--nearly all from Canada, since Canadian catches are frequently landed in U.S. ports for processing (table 19). Small volumes of dogfish reportedly imported from Latin America likely include small shark species other than *Squalus acanthias*, such as narrownose smooth-hound (Mustelus *schmitti)*. Re-exports of dogfish totaling 12.5 mt were reported in 1995, with Canada the only reported destination (table 21).

Processers and wholesalers on both coasts report that Europe absorbs the bulk of the spiny dogfish produced in the U.S., with France, Germany, and the United Kingdom the most important consumers; smaller imports are reported by Belgium, Greece, Iceland, Italy, Netherlands, Norway, Portugal, and Spain. According to 1995 customs data, France alone accounts for 41 percent of U.S. dogfish exports, while France, Germany, and the UK together account for nearly 72 percent of reported U.S. dogfish exports.

Two products are exported for the European market. The "back," or "tube," is the main body of the fish and accounts for 28-30 percent of the total body weight. This product is exported to all European consumer countries for sale as fillets, steaks, portions, and fish and chips. The belly "flap," or "nape," accounts for an additional 7 percent of the round weight and is exported only to Germany, where it is smoked and sold as "schillerlochen." Atlantic coast processors report 1996 dogfish prices to fisherman of between \$0.05 to \$0.09/kg. Prices in Europe are approximately \$0.27 to \$0.36/kg for frozen backs and $0.68 to $1.36/kg for frozen belly flaps. A smaller volume of whole (headed and gutted, or H&G) frozen dogfish is exported to Japan, largely from the West coast.

European markets favor larger dogfish for production of backs and belly flaps. Fish of 2.3 kg or larger are sought for backs, while the German market favors belly flaps of 22.86 cm or more in length, requiring a fish of some 4 kg. Processors on the East coast typically require fish of at least 2.3 to 2.7 kg. However, as a result of the intensification of the fishery since 1989, the bulk of dogfish landings from the Atlantic now consists of fish of 1.8 to 2.3 kg, while large females of up to 10 kg are increasingly rare (McCarron and Wilson, 1994; Rivlin, 1996).

In late 1995, West coast processors were reportedly paying $0.09/kg for jumbo fish (16.8 kg and up), $0.32/kg for medium fish (14.5 to16.4 kg), and $0.05/kg for small fish below 14.5 kg. Small fish are primarily sold to scientific and laboratory suppliers. While most of the product is exported to Europe, at least one processor supplies dogfish to a Japanese company that makes kamaboko, a type of fish cake (Rivlin, 1995).

The West coast fishery, with far fewer landings, currently tends to merely supplement the Atlantic catch, especially during the winter months, and processing facilities for this fishery are currently extremely limited. It is possible, however, that given the larger average size of Pacific spiny dogfish and continuing declines in the average size of fish landed on the Atlantic, the West coast fishery may continue to expand. This trend may be further encouraged by the crisis affecting salmon fisheries since dogfish are caught by the same gear used in the salmon fishery, often rival salmon in price, and the fact that many salmon fishermen also have dogfish permits (K. Wolfe, pers. comm.). The dogfish fishery may also be affected by increased regulation of the Pacific groundfish fishery. A new groundfish management plan is scheduled for release by Washington in 1996.

Other Sharks

The popularity of shark meat for human consumption has increased considerably in the United States since the 1970s. This resulted in large part to a number efforts during the early to mid 1980s to increase market acceptance and improve processing and product quality (Cook, 1987; Otwell et al., 1985; Paust, 1986; Slosser, 1983). Particularly in coastal areas throughout the United States, shark fillets and steaks are widely offered in seafood restaurants, supermarkets, and seafood markets.

Shark species most preferred and highly valued for the production of meat for human consumption are the common pelagic species, shortfin mako, common thresher, and porbeagle. Ex-vessel prices for pelagic sharks remain lower than prices for swordfish, although prices may be comparable during specific seasons. Hanan et al. (1993) report that ex-vessel prices from 1980 through 1991 ranged from $0.45 to $0.90 per kg for shark, compared to $0.90 to $1.82 per lb for swordfish. However, there remains a considerable incentive to land pelagic sharks, as shark fisheries tend to become seasonally available as swordfish become less available. Furthermore, even during peak swordfish seasons, both fishermen and dealers report that interest in purchasing a vessel's catch is increased by the presence of other species, including sharks. Ex-vessel prices for shark are even more favorable when compared to tuna. This is reflected in the higher number of sharks generally retained by vessels targeting tuna than swordfish.

On both the Atlantic and the Pacific, these pelagic species are typically landed headed and gutted (H&G), with the fins removed. Landings by the longline pelagic fleet, along with the remainder of the vessel catch, are routinely purchased by wholesalers of sashimi-grade tuna and swordfish and sold fresh as whole carcasses, or as blocks or "clippers" to restaurants and retail dealers. Meat from this group of species is typically marketed in the same form as swordfish--as fresh steaks--although the marketing of packaged, frozen shark steaks is becoming increasingly common. Meat from species in the large coastal shark category, such as blacktip and sandbar shark, is considered of lower quality, and is typically sold in the form of fresh fillets and steaks in supermarkets and popular seafood restaurants. These species are also increasingly used for the manufacture of frozen packaged products, such as frozen shark fillets and frozen shark medallions.

Although production of most shark products continues to be poorly reported, the U.S. National Marine Fisheries Service has routinely compiled and published statistics on the production of fresh and frozen shark fillets and steaks in the United States since 1984. According to published figures, production of fillets and steaks increased from 3,514 mt in 1984 to 5,679 mt in 1993 (NMFS, Fisheries of the United States, various years) (table 22). Fillets account for the bulk of shark meat production--accounting for more than 95 percent of reported production in 1993. Reported values also reflect higher unit values for the more specialized sale of shark steaks. Although reported production of shark fillets and steaks appears high relative to U.S. landings, a significant proportion is likely to be accounted for by imports.

Customs data for imports and exports of shark are available only from 1989; furthermore, until 1995, the data combined dogfish with other sharks (tables 16, 18). In 1995, reported exports of fresh and frozen sharks other than dogfish totaled 246 mt--only 3 percent of total export of fresh and frozen shark (table 23). Reported re-exports totaled only 15.6 mt, with Hong Kong as the only reported destination (table 21). It is possible that shark exports prior to the implementation of the Atlantic Shark FMP in 1993 were somewhat higher than at present. Commercial quotas established under the FMP have reduced the supply available to the domestic market and, therefore, may have resulted in a reduction in the volume of exports.

Unfortunately, little information is available withs which to assess the species composition of reported exports of sharks other than dogfish. Interviews conducted during the course of the study suggested only one product likely to be reported in this category. Although blue shark has not gained market acceptance in the United States, both fishermen and dealers report that some is landed for export to Europe. It is also reported that blue shark is imported from Canada by U.S. processors and wholesalers for reexport to Europe.

U.S. shark meat imports (table 18) do not appear to have been greatly affected by the FMP. Total imports average some 2,600 mt annually, with the exception of 1993 when Canadian dogfish exports to the United States appear to have dropped temporarily. Again, data specifically for imports of sharks other than dogfish are available only for 1995. In that year, a total of 1,013 mt of shark other than dogfish were reported as imported into the United States, representing some 39 percent of total U.S. shark imports (table 24).

Reported imports for 1995 are dominated by frozen shark from Latin America--notably Ecuador, Costa Rica, and Mexico, and Canada. With regard to imports, industry interviews were able to provide a great deal of information on species composition. Mako, thresher, and porbeagle sharks are typically the only species for which the value of the meat is sufficiently high to make international trade viable, and importers nearly universally reported trading only in these species. Several dealers reported imports of mako and thresher sharks from Costa Rica, Ecuador, Mexico, and Peru, and of mako sharks from Suriname, while both dealer reports and available trade data suggest that U.S. imports from Chile consist almost entirely of mako sharks. Both the species composition of Canadian commercial landings as well as dealer interviews suggest that imports from Canada are composed of mako, thresher, porbeagle, and blue sharks. Very few additional species were reported in trade; one dealer interviewed reported importing oceanic whitetip shark from the Philippines, one reported importing blacktip shark from Costa Rica, and one reported importing mako shark from Japan.

Fins

Small-scale domestic production of shark fins has taken place in the U.S. for several decades, but, until the mid 1980s, shark fin prices provided little incentive for the development of directed shark fisheries or significant landings of incidental shark catch. Maximum ex-vessel prices for shark fins reportedly reached $3.40/kg in 1978, and $5.00/kg in 1983 (Ottwell et al., 1985). In the last ten years, however, ex-vessel prices for shark fins have increased by some 90 to 100 percent. In combination with increased popularity and value of shark meat for human consumption, the recent rise in world fin prices has been a major factor in the development of U.S. shark fisheries. To date, however, production and trade of shark fins in the United States remains virtually undocumented. The following discussion is therefore based heavily on available customs data and on information provided through interviews with dealers and fishermen.

Although significant domestic production of shark fins began relatively recently in the mid 1980s, the United States has apparently long served as both a consumer and a transshipment point for fins. U.S. customs data report dried fin imports averaging 54,135 kg from1972 to 1979. Imports from China, Hong Kong, Japan, Singapore, South Korea and Taiwan are presumably dried fins for consumption within the United States, and accounted for 25 percent of reported U.S. imports. Latin America and the Caribbean (Belize, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, Mexico, Netherlands Antilles-Aruba, Nicaragua, Peru, Venezuela) accounted for 73 percent of U.S. imports, with Mexico alone accounting for 78 percent of imports from this region and 57 percent of total U.S. imports.

U.S. reported imports of dried shark fins remained relatively stable until the mid 1980s, then rose sharply in 1986 (table 25). Imports averaged 53,498 kg annually from 1980 to 1985, rose to 97,221 in 1986, 174,132 kg in 1987, and 185,735 kg in 1988. From 1989 to 1993, imports averaged 227,206 kg annually, peaking in 1992 at 280,646 kg before dropping to 114,331 kg in 1994. Rising imports from Latin America and the Caribbean accounted for much of this increase, notably from Brazil, Costa Rica, Ecuador, El Salvador, Guatemala, Guyana, Mexico, Netherlands Antilles, Nicaragua, Panama, Peru, Trinidad and Tobago, Uruguay, and Venezuela, although significant imports of fins from Canada, Africa, and the Pacific also began to appear in the late 1980s and early 1990s.

Reported U.S. imports are significantly lower in volume than reported exports from Asia to the United States (table 26). For example, the volume of U.S. imports from Hong Kong reported by U.S. Customs averaged 7,619 kg annually from 1990 to 1994, while Hong Kong reported average annual exports to the United States during the same period of 21,532 kg. This apparent discrepancy may be due to errors in reporting--due to transshipment or time lag between exports and imports--but also may be due in part to different methods of reporting packaged processed fins destined for U.S. consumption.

Unfortunately, customs data are not available for U.S. fin exports as no classification has been established; also, there is no reliable information on U.S. fin production available. Although dried shark fin exports may be reported in U.S. customs as "Unspecified dried products," a review of trade volumes and countries of destination reported in this category suggests that products other than shark fins are also reported in significant quantities under this classification, thereby rendering it unusable for purposes of shark fin trade analysis. Hong Kong, China, and Singapore alone report combined total imports of shark fin from the United States, averaging 471,989 kg annually from 1991 to 1994 (table 27), likely representing the majority of total U.S. shark fin exports.

According to the National Marine Fisheries Service, reported domestic production of shark fins by U.S. seafood processing plants nationwide was minimal from 1984 through 1986, but rose from 11 mt in 1987 to 118 mt in 1989 (NMFS, 1993). Most shark fins pass directly from the fisherman to the dealer, rather than through processing plants, so these figures may significantly underestimate U.S. production.

Since the late 1980s, a significant but unknown proportion of U.S. production of shark fins is likely to be derived from the domestic spiny dogfish fishery. Both dogfish processors and fin dealers report that these fins are universally taken and have entered international trade for at least the last ten to twenty years. Indeed, the finning of dogfish is also reported to have occurred in the past, when prices for dogfish meat were too low to make it economically viable to land and process the entire fish. Only the pectoral and caudal fins are usable. Together they account for approximately 2.5 percent of the carcass weight, of which approximately 1.5 percent is the tail. Dogfish fins are classified as secondary fins and fishermen receive only about $0.90/kg, with retail prices reaching only about $6.80/kg.

Dogfish fins are typically exported frozen, although an increasing proportion is now being dried by dealers within the United States prior to export for secondary processing (B. Ross, pers. comm.). Canadian dogfish catches are also often landed and/or processed in the United States. An unknown proportion of fins from the Canadian catch are likely to be processed in and reexported from the United States. Unlike dogfish fins, fins from other shark species are most often imported, exported, and reexported in whole dried form for secondary processing, although some exports of frozen fins and fin needles are also likely to occur.

The United States is not merely a supplier and transshipment point for the shark fin trade; there is also significant and apparently growing domestic consumption of shark fins, particularly in urban areas with large populations of ethnic Chinese, such as New York, San Francisco, and Los Angeles. Market surveys and interviews of restaurants and herbal, pharmaceutical, and seafood retailers conducted by the author in ethnic centers in each of these cities during 1994-1996 suggested that most of the shark fin products consumed in the United States are imported as dried or processed fins, fin nets, or canned shark fin soup from Hong Kong, Japan, Korea, and Taiwan. Fins produced within the United States, rather than purchased domestically for processing and consumption, are typically exported frozen or dried to Asia for processing. Limited exceptions to this rule were found only in California, where a small number of trading and retail establishments have begun to import dried fins directly from Mexico and elsewhere in Latin America. The fins are for sale and consumption within the United States, as well as for reexport, and some restaurants have begun purchasing fresh and frozen fins from Mexico for the preparation of shark fin soup.

Marketing and trade of shark fins within the United States does not follow a standard pattern. Grading, species composition, pricing, suppliers, and destinations all tend to vary, both regionally and among individual companies and traders. Shark fins obtained from domestic fisheries may be purchased by processors and wholesalers of a variety of fisheries products, by agents of specialized shark fin trading companies, or by independent seafood dealers. Fishermen generally prefer to sell to specialized dealers who tend to offer more favorable prices. The fins can be purchased wet, frozen, or dried, but, except for dogfish fins, are typically exported in dried form; in some cases, the skin is removed before export. Hong Kong is by far the largest importer of U.S. shark fin exports and reexports. Much of the shark fin imported by Hong Kong is in turn shipped to China for labor-intensive processing. Much of the processed fin is consumed in China, the remainder returned to Hong Kong for domestic consumption or reexport.

Grading and pricing of shark fins also varies somewhat by region and by individual dealer, but general categories for common U.S. species are reported in table 28. The most valued species for their fins are sandbar, hammerhead, blacktip, dusky, tiger, bull, and silky sharks. Prices for shark fins are typically reported for the primary set only; ex-vessel prices for primary (dorsal, pectorals, caudal) wet fins of these species range from $2.27 to 2.73/kg for small fins and $8.64 to 12.27/kg for large fins; the average price is $6.36 to 7.27/kg. Ex-vessel prices for wet fins of dogfish and pelagic sharks are considerably lower, with an average price of $0.68 to $2.05/kg. The lower caudal (tail) fin of the shark is the most valuable, due to the density of fin needles and lack of platelets. For large coastal sharks, the caudal fin accounts for approximately 50 percent by weight of the primary fin set. Caudal fins are, therefore, often graded and priced in the next higher category than the remainder of the fin set. Ex-vessel prices for dried fins are roughly double those for wet fins, since dried fin volume is approximately 50 percent of wet fin weight. Wholesale and retail prices for dried shark fins are also considerably higher, reflecting both the loss of volume during drying and processing and shipment costs. In 1996, the highest retail price noted during market surveys was $126/kg for imported, dried fins with the skin removed.

There are several indications that U.S. production and trade of shark fins will continue to decline over the next two to three years. First, landings of dogfish and other sharks are likely to continue to decline as a result of management measures, overfishing, or both. Second, the rapid rise in ex-vessel prices in recent years, due at least in part to increased competition among dealers for supplies of unprocessed fins, has narrowed dealer margins at a rate higher than the apparent rise in retail prices. Ex-vessel prices for shark fins are, therefore, unlikely to continue to increase. Third, the climate of political instability and economic uncertainty accompanying the 1997 return of Hong Kong to the People's Republic of China is likely to continue to reduce demand for luxury items such as shark fin. Finally, while the sharp increase in shark fin value and production in the mid 1980s was the result of increased demand by the PRC, anti-corruption measures implemented in China during the mid 1990s are reported to have significantly reduced consumption of shark fins, and have made a corresponding impact on worldwide demand for shark fin.

Cartilage

The market for shark cartilage is generally reported to have developed only within the last five years, but shark cartilage capsules--and occasionally loose powder--are now found in almost any pharmacy or health products retail outlet in the United States. The number of companies actually manufacturing cartilage powder is limited to 4 or 5; these companies market their own brand names and/or supply ground cartilage to other pharmaceutical companies both within the U.S. and abroad.

As most sharks are landed as headed and gutted carcasses, the cartilage is not always sold directly by the fisherman, but is often collected by processors or retail outlets after filleting or processing. The cartilage is purchased wet, frozen, or dried by fish dealers, many of whom also trade in shark fins and other products. The dealers in turn supply cartilage manufacturers with the dried or frozen product. Although the vertebrae is the most common part of the shark used, manufacturers may also purchase heads, jaws, and "breast.". Many dogfish processors also sell cartilage directly to pharmaceutical companies. On the West coast, much of this product is obtained by boiling the heads and vertebrae; on the East coast, it may be more common to sell the vertebrae only, as dogfish heads are often used or sold as bait.

The price paid by dealers to domestic suppliers is approximately $0.45 to $0.90 per kg. Kreuzer and Ahmed (1993) estimate that shark bones [cartilage] contribute an average of 4 percent of body weight, although this proportion may be greater if cartilage other than the vertebrae is included. The value of the cartilage to fishermen is therefore relatively low, particularly if the cartilage is not purchased directly from the vessel. Furthermore, the cartilage is not as commonly retained as meat or fins, and many fishermen and processors report that they do not sell cartilage.

Although no trade statistics are available for shark cartilage, interviews within the industry suggest that much of the raw cartilage processed in the United States is imported. One dealer estimates that imports account for approximately 65 percent of the United States' supply. Much of the shark cartilage powder bottled in the United States is reportedly imported from Japan and at least two brand names are marketed as Japanese shark cartilage; one advertises that the cartilage is obtained from shark fins. Another U.S.-based manufacturer has established a processing facility in Australia for cartilage marketed within the United States.

Although detailed market information on shark cartilage was generally difficult to obtain from pharmaceutical companies, one major manufacturer reported that their supply was obtained overseas, shipped to an overseas processing plant, imported into the United States in the form of dried chips and further processed. Approximately 5 to 10 percent of the unbranded bulk material is exported to foreign processors for bottling, while the remainder is bottled by the manufacturer and marketed within the United States. It is then exported to some 35 countries worldwide, including North and South America, Europe, Africa, Asia, and the Pacific.

Skins and Leather

U.S. markets for shark leather emerged in the 1930s as a result of the development of a chemical tanning process by Ocean Leather of New Jersey. Currently, there is only one manufacturer of shark leather in the United States. In previous years, this tannery purchased raw skins from U.S. suppliers, but, due to the difficulty of processing, the company now purchases crusted skins from a single supplier in Mexico. Tiger shark is the preferred species for production of leather, but the skins of dusky, blacktip, whitetip, and occasionally nurse shark, are also considered suitable for tanning. Processing requires skins of sharks of 1.5 m or greater in length.

The principal demand for shark leather in the United States is for the manufacture of cowboy boots in Texas, with smaller sales to manufacturers of leather goods, particularly watch straps and belts, in the United States, Europe, and Asia. The popularity of Western boots has declined since the 1980s, therefore, tanning of shark skins within the United States has reportedly fallen off sharply. Shark leather continues to be imported from a number of sources by brokers and leather goods manufacturers.

Available trade data are inadequate to determine the sources and species most important to the production and trade of shark leather. The United States imported over $3.5 million of shark skin from 1978 to 1987, primarily from Mexico, but also from other countries such as France and Japan. Customs data from 1984 to 1990 report average annual imports of 11,984 whole skins, rising from 1,189 skins in 1984 to a peak of 36,818 skins in 1989. Imports from Mexico likely consisted of a mix of raw, crusted, and tanned skins, while imports from other sources probably included only tanned leather. In 1989, U.S. custom commodities were revised and shark skin was no longer included in its own commodity code (Gaski, 1991). After 1989, the only data available on U.S. trade in shark skins and leather are those reported by the U.S. Fish and Wildlife Service; these data are likely to significantly underestimate volumes in trade, and report all trade of shark skins under a single species code of "tiger shark". Moreover, inconsistent units of measure make it difficult to assess the volume of skins traded.

During the 1980s, a significant trade of shark skins occurred across the U.S.-Mexico border as shark skins were imported and cut by U.S. companies, exported to Mexico for assembly into Western boots and other products, and then reexported from Mexico to the United States. FWS data, although likely to significantly underestimate volumes in trade, reported total U.S. shark skin imports from Mexico from 1987 to 1990 as follows: 69,283 skins, 38,380 partial skins, and an additional 715 square meters, 65 meters, and 413 kg of skins; 192,430 pairs of shoes and boots; 22,335 small leather products; and 26 large leather products. Reported U.S. exports of shark skins, leather, and leather goods to Mexico during the same period totaled 2,528 skins, 15,916 partial skins, and 120 square meters of skin; 11,202 pairs of shoes and boots; 11,699 small leather products; and 1,134 unidentified products (Rose, 1991). Although Mexico is known to be a major supplier of shark skins to the United States, the nature of the trade and the fact that U.S. exports are more commonly underreported than imports make it difficult to determine what proportion of these skins and leather products originated in Mexico.

Liver Oil

Shark liver and body oils have long been used for pharmaceutical and industrial purposes. On the Atlantic coast, as early as the late 19th century, a handline fishery for dogfish exclusively for liver oil for tanning and curing leather existed in Massachusetts, while a reduction plant in Maine processed dogfish for oil and guano. After World War II, dogfish liver oil was used as a rubber extender, and the body oils used in the tanning of leather (Jensen, 1965). On the Pacific coast, a market developed in 1930s for the livers of soupfin and spiny dogfish sharks for use in production of Vitamin A, but, as a result of the development of synthetic substitutes, the fisheries in California and Washington collapsed in the 1950s.

Currently, a limited market remains for shark liver oil, most commonly in capsule form as a health supplement. Liver oil is also used in a small number of hand cremes and other cosmetic products, and as an ingredient in Preparation H®, an over-the-counter hemorrhoid ointment. The livers of deep water shark species (600 to 1,000 m) contain the chemical compound squalene, which is used in the manufacture of lubricants, bacteriocides, pharmaceuticals, and cosmetics. Squalene is included as a non-active ingredient in pharmaceutical applications because it imparts increased skin permeability, while squalane, a compound produced by hydrogenating squalene, is miscible with natural skin oils and is therefore useful as a skin moisturizer. Diacyl glyceryl ethers, another chemical compound found in shark liver oils, is reported to be effective in the healing of wounds, as well as supposedly having bacteriostatic action and protecting against radiation (Summers and Wong, 1992; Buranudeen and Richards-Rajadurai, 1986).

In 1993, the chemical compound squalamine was isolated from dogfish. Studies conducted in the United States since 1993 suggest that the chemical is effective against bacterial infection and acts against viruses, including HIV. Magainin Pharmaceuticals of Pennsylvania, in collaboration with the National Institutes of Health, is currently testing the use of squalamine for potential use in the treatment of several sexually transmitted diseases, including herpes, gonorrhoea, and chlamydia (Mestel, 1995). In 1996, researchers at Johns Hopkins Medical Institute reported that in preliminary tests using laboratory animals, synthetic squalamine appeared to slow the process of vascularization in solid brain tumors, suggesting that squalamine may be useful in the treatment of cancer (Altman, 1996).

Although fishermen report that livers from the soupfin shark continue to be marketed in California, U.S. production of shark liver oil appears to be limited. Fisheries dealers and processors report that shark liver oil was produced in the past, but that shark livers are now rarely taken because they are "messy," difficult to process, and have a strong odor. No data are available regarding the production or export of shark liver oil; however, given limited U.S. landings of deep water shark species and low international prices for shark liver oil in recent years, it does not appear likely that shark liver oil continues to be processed within the United States in significant quantities.

Shark liver oil capsules are manufactured in the United States and are available on the domestic market and abroad to a limited extent, however, recent customs data are not available to determine the quantity of imports. U.S. customs data for U.S. imports of shark liver oil available from 1972 to 1986 report sporadic imports of small volumes of shark liver oil, totaling 43,116 kg over the entire period (table 29).

Fishmeal and Other Uses of Processing Wastes

Several attempts have been made to utilize waste products from dogfish and other shark species. In the 1960s and 1970s, following the Pacific dogfish liver oil boom of the World War II era, research was conducted on use of dogfish waste in salmon feed (Rivlin, 1995). More recently, research has been carried out by Northeastern universities on the use of dogfish wastes as an ingredient in fish feed (Anon., 1995). To date, however, efforts to develop industrial uses for dogfish waste have been unsuccessful. This is due to the high urea content of the carcass and heavy water content, which makes it unsuitable for use in meal-based feeds or fertilizer for agricultural use (Anon., 1986).

Sharks as Bait

In many areas, small sharks that are unmarketable are not discarded, but instead are used as bait, often in shark fisheries themselves. For example, in the Gulf of Mexico directed shark fishery, large numbers of small Atlantic sharpnose sharks caught incidentally are almost always retained as bait by the same vessel. In the southeastern United States, restrictions on gillnet fisheries have led to shortages of baitfish, so fishers increasingly purchase spiny dogfish heads from northeastern fisheries.

Shark Teeth, Jaws, and other Curios

Shark teeth and jaws are widely used in local curio trades, and are available throughout coastal areas of the United States. In some cases, these consist of fossilized shark teeth that are collected along the shoreline. Preserved shark foetuses appear in the curio trade in the southern U.S. These markets generally appear to be limited to coastal tourist areas and are primarily opportunistic.

Aquarium Specimens

Shark displays in public aquaria are increasingly popular in the United States. Nurse sharks are frequently maintained as live specimens in public aquaria, and, in some areas of the United States, juveniles may be captured for sale to private hobbyists. Live catshark (Scyliorhinidae) juveniles and egg cases were also observed to be imported from Indonesia for sale to private aquarists.

CONCLUSIONS AND NATIONAL RECOMMENDATIONS

U.S. shark landings are derived from both directed fisheries and incidental catch,and are reported primarily for the southeastern United States. The low relative value of chondrichthyans compared to many target species, such as tunas and billfish, has discouraged the development of directed shark fisheries for species other than spiny dogfish outside the southeastern United States. Elsewhere, shark stocks are affected primarily by incidental fisheries, which are characterized by high rates of shark discards, in order to conserve limited cargo space.

The Impact of Trade

Meat and fins are the primary products of U.S. shark fisheries, both directed and incidental, although products such as skins, liver oil, and cartilage also contribute to the fisheries' value in some areas. Shark meat is increasingly important in U.S. domestic consumption and exports, although available production and trade data do not provide consistent reports by product form (e.g., carcass, fillet, steak), and, therefore, are not sufficiently precise to indicate the relative importance of trade for species other than spiny dogfish.

In recent years, as the value of fins has risen rapidly compared to meat prices, the practice of "finning," or removing a shark's fins and discarding its carcass, has been raised as an important issue in shark management and conservation. The Atlantic Shark FMP was developed partly as a result of the rapid growth in commercial landings from the directed shark fishery, and partly because of reports of widespread finning, particularly in pelagic fisheries. Unfortunately, available data do not shed much light on the extent to which finning occurred prior to the FMP, and consequently do not allow an assessment of the impact of measures to prevent it. Federal statistics appear to have reported commercial landings of shark fins only sporadically during the last ten years. In all years for which fin landings are reported, they remain well below 5 percent of estimated landings reported in terms of shark whole weights.

Limited data is also available with which to assess the current importance of finning in U.S. shark fisheries. Federal landings data appear to include landings of shark fins only sporadically, and conversion factors for fin and carcass weights are not sufficiently precise to allow an accurate estimate of their relative importance in landings. Furthermore, aggregate data do not reveal the extent to which both carcasses and fins may be retained at varying rates for different species. Given the limitations of available landings data, information on the volume of shark fin exports is especially critical, but the United States has not yet established a customs commodity code for shark fin exports, so such data are not available. However, limited data sets are available for the development of some tentative assessments.

For example, Florida--the most important shark fishing state on the Atlantic coast--has reported shark fin landings consistently since 1986 (table 30). These data, however, appear only sporadically in federal reports and are not consistent with federal landings data, due to editing by NMFS. Directed shark fisheries targeting primarily blacktip and sandbar sharks emerged on a significant scale in the mid 1980s in Florida, with reported landings of shark fins accounting for only a minor proportion of both total landings and value of the fishery until the late 1980s and early 1990s. Landings of fins, as well as carcasses, rose rapidly in 1989, although the relative value of fin landings remained well below that of carcass value until 1992. In that year, a sharp rise in the unit value of shark fins occurred, with the total value of fin landings reported as nearly double that of carcass value, a situation that continued through 1995. Fin landings as a proportion of carcass weight also peaked in 1992 at 4.3 percent, but even then remained within the 5 percent limit established under the Shark FMP, and carcass value remains an important proportion of the overall value of the fishery. It therefore appears likely that the practice of finning occurred to only a limited extent in Florida's directed coastal shark fishery.

Data available from incidental shark fisheries suggest a very different context. Logbook data for 1992 from the Atlantic and Gulf tuna and swordfish fleets alone reported total estimated shark catches of 4,114 mt, of which only 663 mt consisting of a handful of marketable species were retained. Total Atlantic and Gulf reported shark landings for that year were 10,280 mt, while total landings of species included in the 1993 shark FMP are limited to 3,150 mt annually. Neither logbook nor observer data are available from these fisheries to suggest the extent to which finning occurred prior to the implementation of the 1993 Management Plan. However, roughly one third to two-thirds of discarded sharks were reported dead or damaged when discarded, so that discards from this incidental fishery contribute significantly to total shark mortality regardless of the extent to which finning occurs.

In general, the results of TRAFFIC research suggest that the species most likely to be finned and discarded include species captured in large numbers in offshore and distant water fisheries, species with high-value fins, and species for which the meat and other products are not marketable. Finning generally appears to occur more frequently in incidental fisheries. Although finning may also occur in directed shark fisheries, the economic viability of directed fisheries often depends on the marketing of both meat and fins and, in some cases, additional products, such as skins, livers, and cartilage.

Assuming that the logbook and observer data examined in previous sections accurately reflect shark bycatch, landings, and discards, they suggest that for much of the pelagic fleet in the Atlantic, and to the extent that finning did occur, it was likely to have involved primarily blue sharks. Blue sharks are typically discarded due to limited consumer demand for their meat, however, the fins have significant commercial value. The meat of mako, porbeagle, and thresher has considerable commercial value, while their fins are of low quality; these species are generally landed. Of the species included in the Atlantic FMP large coastal grouping, several have commercially valuable meat. Species such as sandbar and blacktip sharks also have top grade fins, so that unit values of fins relative to meat tend to favor the former. However, the directed shark fisheries account for the bulk of commercial landings of these species, and the economic viability of the directed fisheries continues to depend on the sale of both meat and fins.

Shark Management and Conservation Measures

The effectiveness with which federal, regional, and state management measures have addressed the increasing importance of shark meat and fin production in U.S. fisheries has varied. On the Pacific coast, relatively minor landings of sharks, the limited number of species included in existing shark fisheries, and the concentration of shark fisheries in California have simplified the task of fisheries management for the Atlantic. California has engaged in research, data collection, and fishery management for targeted shark species since 1980. Regional management plans for the Atlantic and Gulf states were not implemented until 1993 and approximately two-thirds of shark landings for this region remain unidentified to species. On both coasts, restrictions on directed fisheries and total landings have not been accompanied by measures to reduce the volume of incidental catch, which remains a significant source of mortality. In addition, the impacts of recreational fisheries on both coasts remain poorly documented. In the Western Pacific, specific management measures for sharks have not been implemented, although regulation of the growing tuna and swordfish fisheries places limitations on this primary source of shark mortality.

The Atlantic Shark Fishery Management Plan of 1993 was developed in response to evidence of stock declines for a number of shark species in the Atlantic and Gulf fisheries. However, reliable data on which to base a realistic management program for rebuilding shark stocks is lacking. Fishery independent data, such as that from research or exploratory cruises, is generally unavailable. Assessments of trends in stock abundance have relied heavily on estimates of catch per unit effort (CPUE) derived from fishery dependent data sets. Annual Stock Assessment Workshops (SAWs) held under the FMP, in reviewing logbook, observer, and research data from a number of sources, have concluded that catch rates for shark stocks as a whole, and for select species for which data are available (Atlantic sharpnose, dusky, sandbar, hammerheads, tiger, mako, blue, and thresher sharks), suggest a consistently declining trend from the 1970s to the mid 1980s. These estimates indicate that abundance of many species and species groups could have declined by 40 to 75 percent during this period, while catch rates for large coastal species are estimated to have dropped by 65 to 85 percent. Available data also suggest continued decline from the mid 1980s to the early 1990s (NMFS, 1994e and 1995c).

CPUE data, however, are highly dependent on a number of factors other than stock abundance, and are therefore imprecise. Fisheries are highly dynamic and differences or fluctuations in factors such as experience and skill of captains and crew, gear types, fishing areas, stock movements, and environmental conditions, also affect CPUE. For species such as sharks that are often caught incidentally, part time, or seasonally, CPUE is an even less reliable of abundance than for targeted fisheries. First, CPUE for bycatch species can vary according to the species targeted, as different target species are associated with different gears, fishing areas, etc. Many fisheries, such as longline fisheries for swordfish, tunas, and related species, are multispecies fisheries for which target species may vary not only from year to year, but also from within years. The distribution of many shark species is extremely discontinuous over both space and time, due for example to seasonal migrations or movements related to different life stages.

Furthermore, calculations of CPUE are typically based on data from observer programs, mandatory logbooks, or research cruises. Each of these sources is particularly limited for bycatch species, since not only fishing effort, but also data collection, tend to be incidental to the target species. Observer programs and exploratory fishing cruises from which CPUE is calculated are frequently conducted over small areas and/or during relatively short periods of time, are discontinuous, and often result in small sample sizes, so may not be representative or easily extrapolated (Bonfil, 1994; Witzell, 1985). Although logbook data from swordfish vessels has been available since 1986, this data has not yet been analyzed by federal agencies.

The FMP will greatly assist the collection and analysis of reliable data. Much of this data, however, will not become available in an analyzable form for several years. Mandatory logbook reporting under the FMP has not provided a sufficiently long time series to analyze trends in abundance since the implementation of the Management Plan, and during the first two years of the FMP, not all shark fishermen were provided with shark logbooks (NMFS, 1994c). A small scientific observer program was initiated in 1994, but has limited area and fishery coverage. Given the limitations of available data, it is believed that evidence of trends in abundance for years following implementation of the FMP will not be available for at least a decade (NMFS, 1995). Therefore, although initial plans to implement a gradual annual increase in catch quotas have been suspended, species-specific management measures such as quotas and size limits have not yet been developed.

The implementation of the Atlantic Shark FMP is likely to have a significant impact on shark landings and discards by the longline tuna and swordfish fleets, as well as directed fisheries. The 590 mt commercial quota for the pelagic shark category appears consistent with the retained bycatch of sharks other than blue shark for the longline fishery. However, many longline vessels are active year-round, while the semi-annual commercial quotas for these species are typically reached early in each season, due to commercial catches by the directed fishery. One would, therefore, expect regulatory shark discards to have increased during 1993 and 1994. After 1994, the commercial trip limit served to extend the season, potentially enabling the longline fleet to contribute a greater proportion of commercial shark landings.

Both the development of species-specific management measures and an adequate understanding of the role of trade in driving fisheries development depend on the availability of accurate data on domestic production of sharks and shark products. The accuracy of such data in turn require a number of improvements in data collection. This could be accomplished through the expansion of observer program coverage, implementation and expansion of dockside monitoring programs, and processor surveys.

These research methods should also be used to obtain more accurate conversion factors for carcass and fin weight, by species or species groupings.

Current management measures for sharks in the United States are focused primarily on directed fisheries, neglecting important impacts by incidental and recreational fisheries. Improved data collection for incidental and recreational fisheries and exploration of mechanisms to reduce shark bycatch are also necessary for the effectiveness of any stock management and conservation measures, and should be enhanced within existing management plans.

Spiny Dogfish Fisheries and Trade

Management measures on both the Atlantic and the Pacific coasts also exclude spiny dogfish--by far the most important species in total U.S. shark landings, and already showing clear signs of decline on the Atlantic. Spiny dogfish are also included within the purview of the Atlantic Shark Fishery Management Plan, but are not included within species classifications for which commercial landing quotas have been established. The Mid-Atlantic and New England Fishery Management Councils have proposed the joint development of a management plan specifically for this species in response to rapidly intensifying fishing pressure and evidence that stock decline has already begun, or is imminent. Development of a such a management plan, once initiated, is estimated to require some two years of planning, preparation, and public comment before implementation. However, the crisis in New England groundfish fisheries has resulted in work on the dogfish management plan being postponed indefinitely. The situation is further complicated the fact that dogfish are considered a nuisance in other fisheries due to their destruction of nets and consumption of both bait and catch, and by speculation that reducing the population of dogfish, which feeds on groundfish, will favor the recovery of groundfish stocks.

Spiny dogfish landings on the Atlantic coast are driven almost entirely by export markets in Europe. The rapid increase in landings since the early 1990s has already led to evidence of stock declines. Although the development of a management plan for spiny dogfish has been delayed by a general crisis in groundfish fisheries in the region, prompt action to freeze landings at current levels while a management plan is in preparation appears warranted. In addition, as existing evidence suggests that a single stock of spiny dogfish migrates between the United States and Canada, with landings increasing in Canada as well, cooperative research and management efforts are recommended.

The Role of the United States in World Trade

Limitations in data collection and management for shark fisheries in the United States hinder not only domestic management, but also international management of an increasingly important global fishery. The United States is an important consumer of shark meat, not only from domestic production, but also from imports from a number of countries, particularly in Latin America. The United States is a critical regional transshipment point for shark fins destined for Hong Kong and elsewhere in Asia, again consisting largely of fins supplied by Latin American fisheries, and also fins imported from Africa and worldwide. Although markets for shark cartilage and cartilage products are poorly understood, several of the world's largest traders and processors of cartilage are based in the United States and obtain the bulk of their raw material from foreign fisheries. Despite the importance of the U.S. in world markets for these products, domestic research on trade and marketing remain extremely limited.

Improvements in the collection and reporting of trade data are clearly needed, with emphasis on collection and reporting of data on U.S. exports and re-exports of shark fins. Customs classifications that distinguish dried and fresh/frozen fins are needed to accurately relate trade data to domestic production.

Table 1. U.S. Domestic Commercial Landings of Dogfish and Other Sharks (MT), 1977-1994

Year	Dogfish	Other Sharks	Total Sharks
1977	3,142.5	572.4	3,714.9
1978	3,624.7	790.2	4,414.9
1979	8,763.0	1,508.2	10,271.2
1980	7,601.8	2,034.8	9,636.6
1981	8,343.5	2,215.8	10,559.3
1982	8,807.0	2,334.2	11,141.2
1983	6,555.8	2,131.9	8,687.7
1984	2,753.8	2,307.4	5,061.2
1985	5,244.9	2,554.2	7,799.1
1986	5,041.3	2,688.9	7,730.2
1987	6,426.1	3,476.8	9,902.9
1988	4,567.7	6,621.6	11,189.3
1989	5,807.9	7,790.1	13,598.0
1990	16,235.6	6,810.3	23,045.9
1991	15,592.9	5,729.4	21,322.3
1992	19,199.4	7,631.3	26,830.7
1993	22,754.2	6,957.3	29,711.5
1994	21,241.5	7,436.3	28,677.8

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, *Fisheries of the United States* (Washington, D.C.: Government Printing Office), 1977-1994.

Table 2. U.S. Atlantic and Gulf States Commercial Landings of Sharks and Shark Fins (Mt^1), 1985-1995

State	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995[2]
Southeast (Total)[3]	954.8	1,604.6	3,202.0	5,529.8	7,337.0 (7.5)	5,540.2 (21.9)	5,548.3 (119.7)	9,251.0 (119.3)	8,114.6 (68.9)	9,306.6 (77.0)	3,013.0 (259.6)
Alabama	28.9	213.1	565.5	313.9	823.1	650.6	486.3	240.8	26.4	176.6	14.1
Florida	713.7	1,145.0	2,198.2	2,527.9	3,243.9	3,369.7	2,859.1 (102.7)	2,482.9 (105.3)	1,605.2 (25.2)	2,096.6 (68.9)	2,284.0 (202.3)
Georgia	3.6	3.1	13.4	5.1	2.6	67.5	3.5	11.5	34.9	69.9 (1.1)	21.5 (0.1)
Louisiana	29.1	72.5	261.3	2,028.0	2,540.5	870.7 (21.9)	1,105.2 (17.0)	1,706.5 (14.0)	1,213.5 (10.4)	798.0 (4.4)	564.8 (25.4)
Mississippi	2.1	10.6	74.5	129.6	60.2	20.3	53.7	10.8	3.4	1.5	2.1
North Carolina	52.9	59.7	119.9	286.4	460.4 (7.5)	428.6	940.3	4,493.8 (0.1)	5,047.2 (0.1)	5,908.2	--
South Carolina	32.3	43.8	82.1	193.0	170.9	85.7	74.7	268.9	170.5	124.2 (0.1)	119.7 (0.0)
Texas	88.7	51.8	5.2	32.5	28.1	21.3	15.6	31.1	13.3	35.2	--
Unknown	--	5.0	5.2	13.5	7.3	25.8	9.9	4.7	0.3	96.3 (2.6)	6.9 (0.5)
Northeast (Total)[3]	238.5	291.2	334.3	364.1	332.1 (1.6)	367.8 (2.1)	818.8 (4.9)	1,029.3 (11.6)	937.0 (17.0)	565.6 (15.3)	n.a.
Connecticut	.7	.9	12.0	4.4	2.9	4.5	1.1	1.9 (0.0)	2.1	2.7	n.a.
Delaware	3.9	1.8	5.1	3.4	0	5.4	7.7	3.3	3.0	5.9	n.a.
Maine	18.4	14.3	39.9	59.3	67.8	62.9	185.3	81.7	153.7	128.2	n.a.

					(0.3)	(1.1)	(0.4)	(0.6)	(3.6)	(3.6)	
Maryland	32.6	18.6	19.0	19.8	21.5	18.6	101.8 (1.5)	94.3 (0.7)	310.7 (4.6)	23.6 (0.9)	n.a.
Massachusetts	35.7	50.0	63.8	58.6	76.0	60.6	45.7	56.4	57.4	49.0 (0.0)	n.a.
New Hampshire	0	0.4	0.8	2.9	1.5	1.3	4.1	2.7	3.1	5.2 (0.0)	n.a.
New Jersey	69.2	99.6	99.2	138.2	109.3 (0.7)	101.8 (0.3)	265.4 (1.8)	403.7 (6.7)	311.8 (7.5)	264.5 (5.0)	n.a.
New York	46.7	75.5	75.3	42.4	9.5 (0.1)	16.5	33.7	87.4 (0.6)	31.4 (0.5)	26.7 (0.8)	n.a.
Rhode Island	16.4	20.9	15.6	11.3	20.8 (0.5)	21.5 (0.1)	13.8 (0.1)	22.5 (0.2)	7.7 (0.6)	9.7 (0.2)	n.a.
Virginia	14.9	9.2	17.3	23.8	22.8	74.7 (0.6)	160.2 (1.1)	275.4 (2.9)	56.1 (0.7)	50.1 (4.7)	n.a.

[1]Dressed weight has been converted to whole weight using a conversion factor of 1.39 for all species. Landed fin weights are not reported for all states or for all years; where available, they are included in parentheses and include both dried and fresh/frozen fins. Landed fin weights are not converted to live weight before adding to totals, as fins are considered accounted for in converting carcass weight to live weight; reported fin weights are therefore considered to be duplicated in the landings data. Data for the Northeast do not include landings of spiny dogfish.

[2]1995 data are incomplete

[3]Totals may reflect error due to rounding.

Table 3. Shark Species included in the Management Unit of the Fishery Management Plan for Sharks of the Atlantic Ocean

Large Coastal Species

Basking sharks -- Cetorhinidae
- Basking shark, *Cetorhinus maximus*

Hammerhead sharks -- Sphyrnidae
- Great hammerhead, *Sphyrna mokarran*
- Scalloped hammerhead, *Sphyrna lewini*
- Smooth hammerhead, *Sphyrna zygaena*

Mackerel sharks -- Lamnidae
- White shark, *Carcharodon carcharias*

Nurse sharks -- Ginglymostomatidae
- Nurse shark, *Ginglymostoma cirratum*

Requiem sharks -- Carcharhinidae
- Bignose shark, *Carcharinus altimus*
- Blacktip shark, *Carcharinus limbatus*
- Bull shark, *Carcharinus leucas*
- Caribbean reef shark, *Carcharinus perezi*
- Dusky shark, *Carcharinus obscurus*
- Galapagos shark, *Carcharinus galapagensis*
- Lemon shark, *Negaprion brevirostris*
- Narrowtooth shark, *Carcharinus brachyurus*
- Night shark, *Carcharinus signatus*
- Sandbar shark, *Carcharinus plumbeus*
- Silky shark, *Carcharinus falciformis*
- Spinner shark, *Carcharinus brevipinna*
- Tiger shark, *Galeocerdo cuvieri*

Sand tiger sharks -- Odontaspididae
- Bigeye sand tiger, *Odontaspis noronhai*
- Sand tiger shark, *Odontaspis taurus*

Whale sharks -- Rhincodontidae
- Whale shark, *Rhiniodon typus*

Small coastal species

Angel sharks -- Squatinidae
- Atlantic angel shark, *Squatina dumerili*

Hammerhead sharks -- Sphyrnidae
- Bonnethead, *Sphyrna tiburo*

Requiem sharks -- Carcharinidae
- Atlantic sharpnose shark, *Rhizoprionodon terraenovae*
- Blacknose shark, *Carcharinus acronotus*
- Caribbean sharpnose shark, *Rhizoprionodon porosus*
- Finetooth shark, *Carcharinus isodon*
- Smalltail shark, *Carcharinus porosus*

Pelagic species

Cow sharks -- Hexanchidae
- Bigeye sixgill shark, *Hexanchus vitulus*
- Sevengill shark, *Heptranchias perlo*
- Sixgill shark, *Hexanchus griseus*

Mackerel sharks -- Lamnidae
- Longfin mako, *Isurus paucus*
- Porbeagle shark, *Lamna nasus*
- Shortfin mako, *Isurus oxyrinchus*

Requiem sharks -- Carcharinidae
- Blue shark, *Prionace glauca*
- Oceanic whitetip shark, *Carcharinus longimanus*

Thresher sharks -- Alopiidae
- Bigeye thresher, *Alopias superciliosus*
- Thresher shark, *Alopias vulpinus*

Source: 50 CFR Ch. VI (10-1-93 Edition), §678

Table 4. Shark Species Included for Data Reporting in the Fishery Management Plan for Atlantic Sharks

Cat sharks -- Scyliorhinidae	
	Iceland cat shark, *Apristurus laurussoni*
	Smallfin cat shark, *Apristurus pervipinnis*
	Deepwater cat shark, *Apristurus profundorum*
	Broadgill cat shark, *Apristurus riveri*
	Marbled cat shark, *Galeus arae*
	Blotched cat shark, *Scyliorhinus meadi*
	Chain dogfish, *Scyliorhinus retifer*
	Dwarf catshark, *Scyliorhinus torrei*
Dogfish sharks -- Squalidae	
	Japanese gulper shark, *Centrophorus acuus*
	Gulper shark, *Centrophorus granulosus*
	Little gulper shark, *Centrophorus uyato*
	Kitefin shark, *Dalatias licha*
	Flatnose gulper shark, *Deania profundorum*
	Portuguese shark, *Centroscymnus coelolepis*
	Greenland shark, *Somniosus microcephalus*
	Lined lanternshark, *Etmopterus bullisi*
	Broadband dogfish, *Etmopterus gracilispinnis*
	Caribbean lanternshark, *Etmopterus hillianus*
Dogfish sharks -- Squalidae (continued)	
	Great lanternshark, *Etmopterus princeps*
	Smooth lanternshark, *Etmopterus pusillus*
	Fringefin lanternshark, *Etmopterus schultzi*
	Green lanternshark, *Etmopterus virens*
	Cookiecutter shark, *Isistius brasiliensis*
	Bigtooth cookiecutter, *Isistius plutodus*
	Smallmouth velvet dogfish, *Scymnodon obscurus*
	Pygmy shark, *Saualiolus laticaudus*
	Roughskin spiny dogfish, *Squalus asper*
	Blainville's dogfish, *Squalus blainvillei*
	Spiny dogfish, *Squalus acanthias*
	Cuban dogfish, *Squalus cubensis*
	Bramble Shark, *Echinorhinus brucus*
Sawsharks -- Pristiophoridae	
	American sawshark, *Pristiophorus schroederi*
Smoothound sharks -- Triakiidae	
	Florida smoothound, *Mustelus norrisi*
	Smooth dogfish, *Mustelus canis*

Source: NMFS (1993), Fishery Management Plan for Sharks of the Atlantic Ocean.

Table 5. U.S. Atlantic and Gulf Commercial Landings of Sharks other than Dogfish (mt), by Species, 1992-1995

Year	Species	Southeast	Northeast	Total
1992	Bignose	0	8.4	8.4
	Blacktip	169.9	64.3	234.2
	Blue	0.0	0.4	0.4
	Bull	2.7	0.1	2.7
	Dogfish, unclassified	3,916.8	n.a.	n.a.
	Dusky	19.5	69.8	89.4
	Hammerhead	50.9	23.2	74.0
	Lemon	0.5	0.0	0.5
	Mako, Longfin	2.5	12.3	14.9
	Mako, Shortfin	90.9	65.1	156.0
	Mako, unclassified	0.0	63.3	63.3
	Porbeagle	0.0	12.8	12.8
	Sandbar	415.2	55.0	470.3
	Sand Tiger	0.1	5.4	5.5
	Soupfin	0.0	0.0	0.0
	Spinner	0.0	0.0	0.0
	Thresher, Bigeye	0.0	2.0	2.0
	Thresher, Unclassified	15.5	27.3	42.8
	Tiger	2.9	1.0	4.0
	White	0.0	0.1	0.1
	Unclassified Sharks	4,573.3	580.9	5,154.2
1993	Atlantic sharpnose	4.6	0.3	4.9
	Blacknose	0.0	0.0	0.0
	Blacktip	221.1	37.7	258.8
	Blue	0.0	3.2	3.2
	Bull	0.7	0.0	0.7
	Dogfish, unclassified	3,994.4	n.a.	n.a.
	Dusky	15.2	21.4	36.6

	Hammerhead	91.8	22.1	113.9
1993 cont'd	Lemon	0.6	0.0	0.6
	Mako, Longfin	2.0	0.5	2.5
	Mako, Shortfin	192.6	74.3	266.9
	Mako, unclassified	0.0	82.5	82.5
	Porbeagle	0.0	39.0	39.0
	Sandbar	395.3	31.7	427.1
	Sand Tiger	3.3	4.9	8.2
	Silky	3.1	0.0	3.1
	Thresher	9.7	9.9	19.6
	Tiger	5.8	1.0	6.8
	White	0.1	0.0	0.1
	Unclassified Sharks	3,174.3	608.5	3,782.8
1994	Atlantic sharpnose	9.0	0.0	9.0
	Blacknose	3.9	0.0	3.9
	Blacktip	241.6	6.7	248.4
	Blue	0.0	0.2	0.2
	Bull	1.7	0.1	1.8
	Dogfish, unclassified	4,480.5	n.a.	n.a.
	Dusky	32.8	20.4	53.3
	Finetooth	0.3	0.0	0.3
	Hammerhead	378.6	5.8	384.4
	Lemon	1.0	0.0	1.0
	Mako, Longfin	0.8	5.4	6.1
	Mako, Shortfin	44.9	65.9	110.8
	Mako, unclassified	0.0	83.6	83.6
	Nurse	0.0	0.1	0.1
	Pacific angel	0.5	0.0	0.5
	Porbeagle	0.2	2.5	2.7
	Sandbar	745.7	24.1	769.8
	Sand Tiger	2.2	6.4	8.6
	Silky	5.7	0.2	5.9

	Thresher	10.6	23.1	33.8
1994 cont'd	Tiger	15.3	1.8	17.1
	White	0.1	0.0	0.1
	Unclassified Sharks	3,331.1	313.0	3,644.1
1995	Atlantic sharpnose	3.2	n.a.	n.a.
	Blacknose	22.2	n.a.	n.a.
	Blacktip	210.2	n.a.	n.a.
	Blue	0.1	n.a.	n.a.
	Bull	6.4	n.a.	n.a.
	Dogfish, spiny	0.7	n.a.	n.a.
	Dogfish, unclassified	0.1	n.a.	n.a.
	Dusky	23.0	n.a.	n.a.
	Finetooth	0.4	n.a.	n.a.
	Hammerhead	162.5	n.a.	n.a.
	Lemon	5.9	n.a.	n.a.
	Mako, Longfin	0.1	n.a.	n.a.
	Mako, Shortfin	41.8	n.a.	n.a.
	Mako, unclassified	0.0	n.a.	n.a.
	Nurse	0.0	n.a.	n.a.
	Pacific angel	0.0	n.a.	n.a
	Porbeagle	0.2	n.a.	n.a.
	Sandbar	810.3	n.a.	n.a.
	Sand Tiger	1.5	n.a.	n.a.
	Silky	9.3	n.a.	n.a.
	Thresher	4.9	n.a.	n.a.
	Tiger	4.1	n.a.	n.a.
	White	0.0	n.a.	n.a.
	Unclassified Sharks	1,705.9	n.a.	n.a.

Table 6. Atlantic and Gulf Recreational Shark Landings (MT), 1979-1989

Year	North Atlantic	Mid Atlantic	South Atlantic	Gulf of Mexico	Total
1979	--	10,925	218	369	11,512
1980	--	240	1,966	1,005	3,210
1981	275	420	1,132	7,604	9,431
1982	--	1,252	688	660	2,599
1983	1,415	1,304	2,574	234	5,527
1984	--	1,408	349	115	1,975
1985	--	2,165	1,521	1,618	5,305
1986	--	2,943	692	608	4,243
1987	--	3,563	451	156	4,175
1988	--	1,530	318	813	2,728
1989	--	1,000	231	228	1,666
Total	1,690	26,750	10,140	13,410	52,371

Source: National Marine Fisheries Service (1993), Fishery Management Plan for Sharks of the Atlantic Ocean (compiled from Marine Recreational Fishery Statistics Survey, Atlantic and Gulf Coasts, various years).

Table 7. Total Spiny Dogfish Landings (mt) in the Western Atlantic (NAFO Subareas 2-6), 1960-1993

Year	US	Canada	USSR	Other Foreign	US Recreational	Total
1960	455	--	--	64	na	519
1961	438	--	--	--	na	438
1962	296	--	--	--	na	296
1963	--	--	--	1	na	1
1964	102	--	--	16	na	118
1965	181	9	188	10	na	388
1966	261	39	9,389	--	na	9,689
1967	90	--	2,436	--	na	2,526
1968	158	--	4,404	--	621	5,183
1969	112	--	8,827	363	453	9,755
1970	3	19	4,924	716	705	6,367
1971	<1	4	10,802	764	561	12,131
1972	9	3	23,302	689	820	24,823
1973	16	20	14,219	4,574	890	19,719
1974	102	36	20,444	4,069	969	25,620
1975	168	1	22,331	192	789	23,481
1976	549	3	16,681	107	707	18,047
1977	929	1	6,942	257	563	8,692
1978	852	84	577	45	700	2,258
1979	4,751	1,331	105	82	426	6,695
1980	4,171	670	351	248	284	5,723
1981	6,865	564	516	458	1,856	10,257
1982	6,633	953	27	337	700	8,647
1983	4,906	--	359	105	745	6,115
1984	4,451	4	291	100	663	5,509
1985	4,031	13	694	318	1,591	6,647
1986	2,665	21	214	154	1,438	4,492
1987	2,735	280	116	23	1,053	4,207
1988	3,257	--	574	73	1,336	5,103
1989	4,603	166	169	87	1,829	6,854
1990	14,870	1,316	383	10	1,662	18,222
1991	13,353	292	218	16	1,677	15,831
1992	17,160	829	26	41	1,197	19,012
1993	20,360	*1,000	--	--	1,212	22,572

*Estimated

Source: Rago et al., 1994

Table 8. U.S. Pacific Coast Shark Landings, 1987-1994 (round weight, MT)

State	1987	1988	1989	1990	1991	1992	1993	1994
Pacific Coast Total	2,868.9	2,479.7	2,176.7	2,137.6	3,102.5	2,705.3	2,637.9	2,864.4
Alaska	33.7	21.6	29.0	34.7	192.7	235.3	249.2	130.2
California	1,135.5	810.1	723.7	717.9	681.1	417.3	347.9	382.7
Oregon	55.8	42.3	3.4	9.2	68.3	57.9	37.4	70.9
Washington	1,643.9	1,605.7	1,420.6	1,385.0	2,160.4	1,976.8	2,003.4	2,280.6
West. Pacific Total	0.4	45.8	93.5	103.2	105.9	261.8	1,181.0	824.8
American Samoa	n.a.	0.3	2.0	0.9	1.5	0.6	0.3	6.0
Guam	0.4	0.0	0.8	1.0	3.7	0.8	0.4	2.3
Hawaii	0	45.4	90.7	90.7	101.3	260.4	1,180.3	816.5
Northern Marianas	--	--	--	--	--	--	--	--

Source: Alaska: Alaska Department of Fish and Game. Other Pacific Coast: 1990-1994 from NMFS, Southwest Fisheries Science Center; 1987-1989 from Caillet et al. (1992). Western Pacific: Western Pacific Regional Fishery Management Council Annual Reports, 1988-1994.

Table 9. Washington Commercial Shark Landings (MT), 1990-1994

Species	1990	1991	1992	1993	1994
Blue	0.0	0.0	0.0	0.0	0.0
Soupfin	0.6	0.5	0.3	0.5	0.3
Thresher	0.0	0.1	0.5	0.3	0.1
Unspecified	0.1	4.0	2.7	0.1	0.0
Dogfish	1,384.2	2,155.3	1,974.4	2,499.2	2,958.7
Total	1,385.0	2,157.9	1,977.9	2,500.1	2,959.2

Source: Southwest Fisheries Science Center

Table 10. Oregon Commercial Shark Landings (MT), 1990-1994

Species	1990	1991	1992	1993	1994
Blue	0.0	0.0	0.1	0.2	0.1
Soupfin	1.7	2.1	2.1	1.9	1.3
Thresher	0.3	0.0	0.6	0.3	0.0
Unspecified	0.1	0.2	0.0	0.3	0.1
Dogfish	7.1	65.9	55.1	34.8	69.3
Total	9.2	68.2	57.8	37.4	70.7

Source: Southwest Fisheries Science Center

Table 11. Alaska Commercial Shark Landings (MT), 1990-1995

Species	1990	1991	1992	1993	1994	1995
Salmon	--	0.2	0.1	--	0.0	0.0
Unspecified	30.7	189.8	230.2	241.3	129.3	170.6
Dogfish	4.0	2.7	5.0	7.9	0.9	12.4
Total	34.7	192.7	235.3	249.2	130.2	183.0

Source: Alaska Department of Fish and Game

Table 12. California Commercial Shark Landings (MT), 1970-1994

Year	Shortfin Mako	Common Thresher	Blue	Other	Total
1970	0.4	9.8	0.1	180.3	190.6
1971	2.7	3.1	0.6	166.3	172.7
1972	0.1	2.5	0.1	179.0	181.8
1973	0.4	2.6	0.4	186.5	189.9
1974	3.2	4.2	0.0	218.1	225.5
1975	4.5	17.1	0.2	210.6	232.5
1976	1.0	21.3	4.5	364.2	391.0
1977	9.0	58.7	44.6	515.1	627.5
1978	12.4	137.0	16.3	625.6	791.3
1979	16.0	333.7	39.3	651.5	1,040.5
1980	70.4	819.0	87.1	785.9	1,762.5
1981	125.8	895.2	92.1	637.6	1,750.7
1982	242.1	1087.1	26.2	561.4	1,916.8
1983	149.8	783.0	6.3	477.5	1,416.7
1984	110.1	752.4	1.8	581.1	1,445.4
1985	102.8	698.8	1.1	889.9	1,692.5
1986	214.8	275.1	1.5	789.4	1,280.9
1987	277.6	238.1	1.5	618.3	1,135.5
1988	221.9	243.4	3.2	341.6	810.1
1989	176.1	294.8	6.1	246.7	723.7
1990	261.7	209.3	19.8	227.1	717.9
1991	146.1	343.9	0.5	190.6	681.1
1992	96.0	178.6	0.9	141.8	417.3
1993	78.6	140.8	0.2	128.3	347.9
1994	87.5	193.9	11.3	90.1	382.7

Source: NMFS, Southwest Fisheries Science Center.

Table 13. California Commercial Landings of Sharks and Related Species (MT), 1990-1994

Species	1990	1991	1992	1993	1994
Pacific Angel	113.8	82.4	56.1	29.4	10.5
Basking	--	--	--	4.1	--
Blacktip	--	--	--	0.7	1.2
Blue	19.8	0.5	0.9	0.2	11.3
Cow	0.05	10.0	0.01	0.02	0.06
Dusky	--	--	0.2	0.02	--
Great white	0.1	0.05	0.4	0.0	0.2
Hammerhead	0.9	0.02	2.3	0.4	0.3
Horn	0.06	--	0.0	--	--
Leopard	18.7	21.7	18.6	21.8	12.5
Mako, Shortfin	261.8	146.1	96.0	78.6	87.5
Salmon	--	0.01	--	9.3	0.08
Sevengill	--	0.0	0.03	--	0.02
Sixgill	0.5	0.01	--	0.07	0.4
Smoothound, Brown	5.7	4.7	4.6	3.1	1.8
Smoothound, Grey	0.3	0.03	0.04	--	0.02
Soupfin	57.0	47.6	43.1	31.3	35.9
Spiny Dogfish	3.1	0.7	0.9	2.8	0.6
Swell	--	--	--	--	0.4
Thresher, Bigeye	17.9	18.6	12.3	24.6	21.7
Thresher, Common	209.4	343.9	178.7	140.8	193.9
Thresher, Pelagic	0.8	--	0.3	0.2	0.1
Unspecified	8.2	4.8	2.9	4.1	4.5
Total Sharks	718.1	681.2	417.4	348.0	382.8
Guitarfish	--	--	18.0	13.4	4.8
Hagfish	1,969.7	137.5	18.3	0.3	0.1
Bat Ray	--	--	--	1.9	0.06
Electric Ray	--	--	--	0.02	0.5
Skate	65.2	51.4	70.5	31.9	41.9
Stingray	--	--	0.02	0.06	0.2

Source: NMFS, Southwest Fisheries Science Center.

Table 14. Estimated Pacific Coast Recreational Shark Landings (MT), 1984-1989

Year	Dogfish	Other Sharks	Total
1984	83	450	534
1985	159	520	679
1986	449	456	905
1987	564	1,161	1,725
1988	670	935	1,605
1989	323	364	687

Note: Totals may not add due to rounding

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (1992b), Marine Recreational Fishery Statistics Survey, Pacific Coast, 1987-1989.

Table 15. Pacific Coast Spiny Dogfish Landings (MT), 1970-1994

Year	Alaska	California	Oregon	Washington	Total
1970		--	8	61	69
1971		--	2	12	14
1972		--	n.a.	20	20
1973		--	n.a.	6	6
1974		n.a.	11	749	760
1975		n.a.	10	508	518
1976		10	6	2635	2,651
1977		174	122	2,462	2,938
1978		200	59	2,759	3,018
1979		53	344	4,284	4,681
1980		7	135	3,232	3,374
1981		7	--	2,185	2,192
1982		3	--	2,032	2,035
1983		25	--	2,423	2,448
1984		8	--	3,461	3,469
1985	0	5	--	1,287	1,292
1986	0	4	0	2,333	2,337
1987	33	24	0	3,668	3,725
1988	19	2	0	3,399	3,420
1989	5	2	0	2,948	2,955
1990	4	3	7	1,384	1,394
1991	3	1	66	2,155	2,225
1992	5	1	55	1,974	2,035
1993	8	3	35	2,499	2,545
1994	1	1	69	2,959	3,030

Note: "--" = 0; "0" = <1; n.a. = not available

Source: California, Oregon, and Washington: 1990-1994 from NMFS, Southwest Fisheries Science Center; 1987-1989 from Caillet et al., 1992; 1970-1986 from Holts, 1988. Alaska, 1991-1994: Alaska Department of Fish and Game.

Table 16. U.S. Exports of Dogfish and Other Sharks, Fresh or Frozen (MT), 1989-1995

Destination	Year							
	1989	1990	1991	1992	1993	1994	1995	Total
Australia	--	--	--	--	--	--	13	13
Belgium	59	62	100	524	184	384	465	1,778
Canada	52	520	450	529	675	782	1,519	4,527
Costa Rica	--	--	--	--	--	--	26	26
Denmark	--	--	--	--	2	2	--	4
France	218	974	1,114	2,630	2,944	3,013	3,443	14,336
Germany	19	356	514	575	582	841	1,572	4,459
Greece	32	57	98	60	308	295	158	1,008
Hong Kong	--	7	12	28	--	95	111	253
Iceland	--	--	--	--	--	--	172	172
Ireland	--	12	9	--	--	--	--	21
Italy	--	75	235	323	161	206	258	1,258
Japan	14	193	331	269	230	615	215	1,867
Luxembourg	--	--	--	--	--	4	--	4
Mexico	36	2	37	134	400	314	56	979
Netherlands	--	0	11	66	23	144	28	272
Norway	--	--	--	20	10	20	46	96
Portugal	--	--	--	44	71	178	17	310
Singapore	--	--	--	--	--	--	13	13
South Korea	--	42	--	--	--	40	1	83
Spain	--	25	216	377	218	302	4	1,142
Sweden	--	--	--	0	--	2	--	2
Switzerland	--	--	--	--	--	3	--	3
Thailand	35	311	262	302	511	358	128	1,907
Turkey	--	--	--	3	2	0	--	5
United Kingdom	7	376	320	785	633	668	900	3,689
Venezuela	--	--	4	--	--	--	8	12
Total	474	3,013	3,708	6,668	6,954	8,266	8,338	37,421

Note: Totals may not add due to rounding.

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Table 17. U.S. Exports of Fresh and Frozen Dogfish (MT), 1995

Country	Fresh	Frozen	Total
Australia	--	13.22	13.22
Belgium	138.28	307.37	445.65
Canada	546.63	213.12	759.75
Costa Rica	--	25.91	25.91
France	1,931.23	1,426.64	3,357.87
Germany	112.02	1,439.26	1,551.28
Greece	19.37	74.93	94.30
Hong Kong	24.36	31.20	55.56
Iceland	--	172.34	172.34
Italy	23.98	233.67	257.65
Japan	58.35	139.64	197.99
Korea	1.17	--	1.17
Mexico	24.62	23.64	48.26
Netherlands	13.10	14.70	27.80
Norway	--	46.26	46.26
Portugal	--	13.51	13.51
Singapore	--	13.46	13.46
Spain	--	4.09	4.09
Thailand	--	98.89	98.89
United Kingdom	333.73	566.01	899.74
Venezuela	--	7.52	7.52
Total	3,226.83	4,865.37	8,092.20

Note: Totals may not add due to rounding.

Source: National Marine Fisheries Service.

Table 18. U.S. Imports of Dogfish and Other Sharks, Fresh or Frozen (MT), 1989-1995

Country of Origin	Year							
	1989	1990	1991	1992	1993	1994	1995	Total
Argentina	--	--	--	--	2	--	--	2
Bahamas	--	--	--	--	18	--	--	18
Bangladesh	--	--	--	0	--	--	--	0
Barbados	--	0	--	--	--	--	--	0
Brazil	--	--	--	--	1	2	--	3
Canada	1,508	1,754	1,428	1,064	634	1,352	1,445	9,185
Chile	24	40	8	--	49	21	30	172
Christmas Is.	--	--	--	0	--	--	--	0
Colombia	--	--	1	1	3	--	--	5
Costa Rica	393	410	442	356	370	318	293	2,582
Dominican Republic	--	1	--	--	--	--	--	1
Ecuador	151	318	431	341	190	409	272	2,112
El Salvador	--	--	1	--	1	--	--	2
Guatemala	--	--	1	5	--	--	--	6
Guyana	--	--	--	0	--	0	--	0
Honduras	--	--	--	--	2	3	--	5
Hong Kong	91	19	0	1	0	2	--	113
India	--	--	5	6	--	--	--	11
Italy	--	0	--	--	--	--	--	0
Jamaica		1	--	--	--	--	--	1
Japan	3	1	0	--	--	3	3	10
Malaysia	--	--	--	0	--	--	--	0
Mexico	281	176	233	461	619	681	268	2,719
Morocco	--	--	--	--	0	--	--	0
Netherlands Antilles	--	--	1	--	--	--	--	1
Nicaragua	--	--	1	9	--	61	--	71
Panama	--	--	--	--	--	1	1	2
Peru	1	10	--	2	--	23	1	37
Philippines	13	--	--	--	--	--	8	21

Portugal	3	3	1	9	5	4	0	25
Singapore	--	--	1	--	--	--	--	1
South Korea	--	--	--	--	38	--	--	38
Spain	--	1	--	1	--	--	--	2
St. Vincent-Grenadine	--	--	--	1	--	--	--	1
Switzerland	0	--	--	--	--	--	--	0
Taiwan	--	--	--	1	--	--	--	1
Thailand	--	--	1	--	--	--	--	1
Trinidad &Tobago	2	14	21	--	--	3	--	40
United Kingdom	15	--	--	--	--	--	9	24
Uruguay	1	--	--	--	--	7	1	9
Venezuela	--	5	4	1	5	3	0	18
Total	2,486	2,753	2,578	2,259	1,936	2,895	2,621	17,528

Note: "--" = 0; "0" = <1. Totals may not add due to rounding.

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Table 19. U.S. Imports of Fresh and Frozen Dogfish (MT), 1995

Country	Fresh	Frozen	Total
Canada	1,252.71	7.90	1,260.61
Costa Rica	33.09	--	33.09
Ecuador	8.55	--	8.55
Mexico	8.00	--	8.00
United Kingdom	--	8.56	8.56
Venezuela	0.38	--	0.38
Total	1,302.73	16.46	1,319.19

Source: National Marine Fisheries Service

Table 20. U.S. Reexports of Dogfish and Other Sharks, Fresh and Frozen (MT), 1989-1995

Country of Destination	1989	1990	1991	1992	1993	1994	1995
Canada	--	--	--	--	--	11.1	12.4
Germany	--	--	--	19.8	--	--	--
Hong Kong	43.4	5.2	--	10.2	2.9	--	15.6
Mexico	--	--	--	--	22.6	--	--
Peru	--	10.5	--	--	--	--	--
Singapore	--	--	--	--	0.1	--	--
Thailand	--	--	--	18.3	--	--	--
Total	43.4	15.7	--	48.3	25.6	11.1	28.0

Source: National Marine Fisheries Service

Table 21. U.S. Reexports of Dogfish and Other Sharks, By Product (MT), 1995

Country of Destination	Dogfish, Fresh	Dogfish, Frozen	Other Sharks, Fresh	Other Sharks, Frozen
Canada	7.1	5.4	--	--
Hong Kong	--	--	--	15.6

Source: National Marine Fisheries Service

Table 22. Reported U.S. Production of Fresh and Frozen Shark Steaks and Fillets, 1984-1994

Year	Volume (MT)		Value ($1,000)*	
	Fillets	Steaks	Fillets	Steaks
1984	3,455	59	4,278	161
1985	2,921	59	4,004	132
1986	2,047	n.a.	2,818	n.a.
1987	4,489	100	18,267	469
1988	2,413	255	5,123	1,425
1989	2,586	324	7,501	1,774
1990	4,743	808	17,127	3,708
1991	4,164	688	11,301	2,903
1992	4,025	526	11,932	1,943
1993	5,297	223	11,083	992
1994	6,603	66	15,177	267

*Nominal dollars

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Fisheries of the United States, various years.

Table 23. U.S. Exports of Fresh and Frozen Sharks other than Dogfish (MT), 1995

Country	Fresh	Frozen	Total
Australia	--	0.19	0.19
Belgium	--	19.18	19.18
France	18.73	66.01	84.74
Germany	--	20.25	20.25
Greece	45.31	18.15	63.46
Japan	--	17.35	17.35
Mexico	4.70	3.38	8.08
Portugal	--	3.52	3.52
Thailand	29.02	--	29.02
Total	97.76	148.03	245.79

Source: National Marine Fisheries Service

Table 24. U.S. Imports of Fresh and Frozen Sharks other than Dogfish (MT), 1995

Country	Fresh	Frozen	Total
Canada	168.50	15.81	184.31
Chile	29.73	--	29.73
Costa Rica	259.77	--	259.77
Ecuador	263.55	--	263.55
Japan	--	3.13	3.13
Mexico	258.05	1.99	260.04
Panama	0.92	--	0.92
Peru	1.44	--	1.44
Philippines	--	8.36	8.36
Portugal	0.45	--	0.45
Uruguay	0.99	--	0.99
Total	983.40	29.29	1,012.69

Source: National Marine Fisheries Service

Table 25. U.S. Imports of Dried Shark Fins (kg), 1980-1995

Country	Year															
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Antigua & Barbuda	--	--	--	--	--	--	--	--	--	--	--	--	307	--	--	--
Argentina	--	--	--	--	--	--	--	690	698	--	--	--	--	--	2592	--
Australia	--	--	--	--	--	--	--	--	--	50	--	162	--	92	881	235
Bahamas	--	--	--	--	--	--	--	--	--	--	--	--	--	486	--	--
Bangladesh	--	--	--	--	1000	--	--	--	--	643	--	--	162	--	--	--
Belgium	--	113	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Belize	--	--	--	--	--	--	--	--	--	120	--	--	--	--	--	--
Brazil	121	--	--	51	1506	--	--	1079	765	1151	2847	4981	4913	10329	5728	4105
Canada	--	--	--	1066	--	--	--	--	1764	52359	--	8520	24055	1814	10480	16468
Cayman Is.	--	--	--	--	--	--	--	--	41	--	--	--	--	--	--	--
Central African Republic	--	--	--	--	--	--	--	--	--	--	--	--	274	--	--	--
Chile	318	--	--	610	638	840	--	241	--	685	664	1442	--	70	--	--
China	732	231	870	1521	1410	1460	204	232	68	99	415	227	2724	607	1036	--
Colombia	--	--	--	--	--	975	1071	177	--	940	500	997	--	6200	6161	6385
Costa Rica	--	27	47	435	--	1685	2976	4119	17021	10296	11464	15228	20800	10956	5612	6496
Dominican Republic	140	--	--	54	--	--	--	--	510	--	--	--	--	32	--	--
Ecuador	181	1627	3505	3268	1654	1135	4123	12898	13688	9798	12968	20562	19469	16500	11695	6679
Country	Year															
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995

El Salvador	1221	186	--	254	177	1851	1227	15386	3021	663	3227	9491	8111	5127	6779	9113
Fiji	--	--	--	--	--	--	--	--	--	--	--	--	45	1860	1099	--
France	--	--	--	--	--	--	--	--	4922	--	--	10550	4443	--	--	--
French Pacific Is.	--	--	--	--	--	--	--	17885	17296	--	--	--	--	--	--	--
French Polynesia	--	--	--	--	--	--	--	--	--	1628	921	685	1120	214	526	1401
Gambia	--	--	--	--	--	--	--	--	--	--	3031	900	--	635	--	44
Ghana	--	--	--	--	--	--	--	--	--	140	450	239	230	--	429	1189
Guatemala	1700	2914	1446	2979	3287	1077	2417	2204	4199	1810	3575	10476	11175	9197	7977	3823
Guyana	--	375	--	--	--	350	680	--	--	347	1112	1271	15158	16803	1630	3472
Honduras	--	--	--	--	--	--	--	--	--	--	--	227	496	108	171	--
Hong Kong	5085	4214	7645	5446	11003	3494	7941	9274	5633	16808	5583	3734	7228	11493	10057	39824
Iceland	--	--	--	--	--	--	--	--	--	--	--	--	--	--	89	--
India	--	--	--	--	--	--	--	--	--	--	--	351	100	--	--	--
Indonesia	139	--	144	--	--	--	165	1085	1014	1131	250	21	256	298	--	424
Italy	--	--	--	--	--	--	--	899	1223	--	--	116	--	--	60	--
Ivory Coast	--	--	--	--	--	--	--	--	--	--	--	--	667	--	--	--
Japan	2369	3956	10426	8335	6431	10365	10292	9319	6828	11457	6723	7622	25639	1201	1863	1052
Kiribati	--	--	--	--	--	--	--	--	--	--	--	--	327	255	--	--
Liberia	--	--	--	--	--	--	--	--	--	220	--	--	--	--	--	--

Country	**Year**															
	1980	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Madagascar	--	--	--	--	--	--	--	--	--	--	--	--	--	421	20	--
Malaysia	--	45	--	--	--	--	227	--	--	6648	9979	--	417	--	--	--
Marshall Is.	--	--	--	--	--	--	--	--	--	--	--	--	--	1331	3048	--

Mexico	15193	11601	18282	25334	19537	15066	11309	16771	42806	42022	44247	39812	44056	30001	9265	17853
Namibia	--	--	--	73	--	--	--	--	--	--	--	--	--	--	--	--
Netherlands	--	--	--	--	--	--	--	--	1190	--	--	--	--	--	--	--
Netherlands Antilles	--	526	--	--	454	--	--	--	--	985	2670	8602	11874	12144	9688	--
New Zealand	--	--	--	390	--	--	--	--	--	--	--	--	--	--	600	10
Nicaragua	--	661	580	--	714	--	--	--	--	--	347	1371	2179	3265	1476	4273
Nigeria	--	--	--	--	--	--	--	--	--	177	--	--	--	--	--	--
Norway	363	119	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Oman	--	--	--	--	--	--	--	150	--	354	631	--	--	--	--	--
Other Pacific Is.	--	--	--	288	5	--	--	80	--	--	--	--	--	--	--	--
Pakistan	--	--	--	--	--	--	--	--	--	--	362	--	--	--	--	--
Panama	--	1039	1071	--	1895	4716	7853	5320	19795	21705	17903	7352	13125	13149	8916	6282
Peru	5259	5843	14192	12654	10740	10465	27575	32334	1555	4081	1311	7407	2734	2146	--	213
Philippines	100	--	--	--	--	--	--	7136	--	--	--	--	1685	--	--	--
Portugal	--	--	--	--	--	--	--	--	--	--	--	1712	--	45	--	--
Saudi Arabia	--	--	--	--	--	--	--	--	--	--	--	--	--	1023	--	--
Senegal	34	--	--	--	--	--	--	--	--	2914	6852	7706	717	--	--	--
Country	**Year**															
	1980	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Sierra Leone	--	--	--	--	--	--	--	--	--	--	--	--	1985	48	--	--
Singapore	--	1089	--	--	--	--	60	--	77	100	362	100	3637	8796	604	7047
South Africa	1018	--	190	--	--	--	--	284	--	--	--	--	--	--	--	--

South Korea	193	136	--	190	226	409	317	318	2254	507	159	181	187	980	--	--
S. Pacific Is.	--	--	--	--	--	--	822	--	--	--	--	--	--	--	--	--
Spain	--	--	--	1150	--	--	--	647	358	--	5328	3967	13637	258	810	--
Sri Lanka	9	--	--	--	--	--	--	--	--	1884	--	--	--	--	--	--
Suriname	182	--	--	--	--	--	--	--	--	540	834	1452	--	--	83	667
Taiwan	--	--	20	428	--	--	--	--	--	65	4153	10739	555	3600	--	--
Thailand	--	--	--	--	--	--	--	--	--	--	300	300	140	--	843	--
Trinidad & Tobago	738	--	--	--	--	--	--	--	--	2184	3282	12939	7039	3752	2325	4589
U.A.E.	--	--	--	--	--	--	--	--	90	190	--	--	365	--	--	21
United Kingdom	--	--	--	--	--	416	--	--	--	--	--	--	--	--	--	--
Uruguay	--	--	--	--	--	455	--	--	--	--	36	2074	8276	20690	826	--
Venezuela	--	--	892	--	2040	8800	17537	35604	38465	24761	39282	37939	20129	6347	962	570
W. Samoa	1081	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Yemen	--	--	--	--	--	--	--	--	454	424	--	--	--	--	--	--
Total	36289	34589	59310	64526	62717	63559	97221	174132	185735	219886	191768	241455	280646	202273	114331	142235

Source: National Marine Fisheries Service, from U.S. Customs

Table 26. Reported Asian Exports of Shark Fins to the U.S. (Kg), 1984 - 1995

Year	Hong Kong	China	Singapore	S. Korea	Japan	Total[1]
1984	24,598					
1985	21,316					
1986	18,291					
1987	28,874					
1988	14,679					
1989	20,736					
1990	14,115		2,000	295		
1991	11,221		1,000	45		12,266
1992	22,827	9,812	8,000	45	322	41,006
1993	23,627	575		0	337	24,539
1994	35,871	2,162	6,000	0	0	44,033
1995			10,000			

[1]Totals in parentheses are reported by Dockerty (1992), and are based on review of customs data from Hong Kong, Indonesia, Japan, Malaysia, Singapore, Sri Lanka, South Korea, Taiwan, and Thailand.

Source: Customs data from countries listed, reported in Phipps et al. (1996); Dockerty (1992).

Table 27. Reported Asian Imports of Shark Fins from the U.S. (Kg), 1984 - 1995

Year	Hong Kong	China	Singapore	S. Korea	Taiwan	Total[1]
1984	70,920					(71,009)
1985	74,559					(74,559)
1986	53,783					(53,783)
1987	140,998					(150,008)
1988	261,435				1,908	(278,220)
1989	229,360					(247,904)
1990	318,551		3,000	9,300		(332,015)
1991	413,108		5,000	0		418,108
1992	478,682	36,903	6,000	0		521,585
1993	445,061	0	4,000	0		449,061
1994	417,813	44,387	37,000	0		499,200
1995			34,000			

[1]Totals in parentheses are reported by Dockerty (1992), and are based on review of customs data from Hong Kong, Indonesia, Japan, Malaysia, Singapore, Sri Lanka, South Korea, Taiwan, and Thailand.

Source: Customs data from countries listed, reported in Phipps et al. (1996); Dockerty (1992).

Table 28. Ranking of Common U.S. Shark Species by Market Preference for Fins

(A)	(B)	(C)	(D)	(E)
Sandbar Hammerhead Blacktip*	Dusky Tiger Blacktip* Bull Silky Atlantic sharpnose*	Lemon Whitetip Sand tiger Atlantic sharpnose*	Mako Porbeagle Blue Thresher Dogfish* Atlantic sharpnose*	Dogfish* Atlantic sharpnose* Secondary/chip fins

*Species are listed in more than one category to reflect differing dealer reports and/or reports that quality varies by region or other factors.

Source: Dealer interviews

Table 29. U.S. Imports of Shark Liver Oil (Kg), 1972-1986

Year	Canada	Japan	Mexico	Norway	Switzerland
1972	--	4,500	--	--	--
1973	28,077	--	--	--	--
1974	--	--	--	--	--
1975	--	--	--	--	--
1976	--	180	--	--	--
1977	--	--	--	--	--
1978	--	--	--	--	270
1979	--	3,600	--	--	50
1980	--	--	--	--	--
1981	--	--	--	--	--
1982	--	--	771	--	--
1983	--	23	--	--	--
1984	--	--	--	380	--
1985	--	5,265	--	--	--
1986	--	--	--	--	--
Total	28,077	13,568	771	380	320

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Table 30. Florida Shark Landings by Volume, Value, and Number of Trips Reporting Landings, 1975, 1980, and 1984-1995

Year	Total Landings (Mt.)		Total Trips		Average Price (US$/Kg)		Est. Total Value ($1,000)	
	Shark	Fins	Shark	Fins	Shark	Fins	Shark	Fins
1975	8.3	n.a.	n.a.	n.a.	0.09	n.a.	1.6	n.a.
1980	130.4	n.a.	n.a.	n.a.	0.88	n.a.	115.4	n.a.
1984	618.0	n.a.	n.a.	n.a.	0.92	n.a.	565.7	n.a.
1985	713.4	n.a.	n.a.	n.a.	1.05	n.a.	751.8	n.a.
1986	1,185.5	9.5	7,924	397	0.73	18.43	870.9	175.3
1987	2,175.8	19.2	10,563	664	0.75	14.20	1,647.2	273.4
1988	2,487.5	38.4	10,037	942	0.68	15.21	1,718.1	585.3
1989	3,149.1	98.8	9,999	1,702	0.86	19.11	2,708.9	1,889.6
1990	3,264.9	96.8	10,826	1,638	0.82	20.68	2,681.3	2,002.2
1991	2,869.0	102.7	9,093	1,734	1.06	17.90	3,029.4	1,838.1
1992	2,619.7	111.4	7,677	1,929	0.75	40.21	1,966.4	4,479.3
1993	1,623.5	58.4	4,245	1,141	0.82	36.42	1,316.8	2,128.4
1994	2,192.7	71.4	5,190	2,026	0.88	40.83	1,946.4	2,916.5
1995	2,510.5	89.7	4,487	2,243	0.75	40.67	1,953.4	3,737.7

Source: Florida Department of Natural Resources, Division of Marine Resources.

References

Altman, Lawrence K. 1996. Shark Substance Found to Limit Tumor Growth. *The New York Times*, May 1, 1996: 15.

Anderson, Emory D. 1985. Analysis of Various Sources of Pelagic Shark Catches in the Northwest and Western Central Atlantic Ocean and Gulf of Mexico with Comments on Catches of Other Large Pelagics. Pp. 1-22. In: *Shark Catches from Selected Fisheries Off the U.S. East Coast*, NOAA Technical Report NMFS 31. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Anonymous, 1986. VIMS Documents Dogfish Economics. *Captain's Log* 7(6): 1-2.

Anonymous, 1995. Dogfish processing waste in salmon diets. *INFOFISH International* (March): 60.

Au, David W. 1991. Polyspecific Nature of Tuna Schools: Shark, Dolphin, and Seabird Associates. Fishery Bulletin 89: 343-354.

Bedford, Dennis W. 1987. Shark Management: A Case History--the California pelagic shark and swordfish fishery. In: S. Cook, ed., *Sharks: An Inquiry into the Biology, Behavior, Fisheries, and Use*. Proceedings of a Conference, October 13-15, 1985, Portland, Oregon. EM 8330. Oregon State University Extension Service.

Berkeley, Steven A. and Wilfredo L. Campos. 1988. Relative Abundance and Fishery Potential of Pelagic Sharks Along Florida's East Coast. *Marine Fisheries Review* 50(1): 9-16.

Bonfil, Ramón. 1994. *Overview of World Elasmobranch Fisheries*. FAO Fisheries Technical Paper, No. 341. United Nations Food and Agriculture Organization, Rome.

Branstetter, Steven and George Burgess. 1995. "Fishery-Dependent Monitoring of Shark Fishing Efforts in the Southeast U.S." Presentation at the 125th Annual Meeting of the American Fisheries Society, Tampa, Florida, August 27-31, 1995.

Blue Water Fishermen's Association (BWFA). 1995. "Basic Description of the Components in the U.S. Atlantic Pelagic Longline Fishery." Unpublished document.

Buranudeen, F. and P. N. Richards-Rajadurai. 1986. Squalene. *INFOFISH International*.

Cailliet, G. M., D. B. Holts, and D. Bedford. 1992. A Review of the Commercial Fisheries for Sharks on the West Coast of the United States, pp. 13-29. In: Julian Pepperell, John West, and Peter Woon, eds., *Shark Conservation*. Proceedings of an International Workshop on the Conservation of lasmobranchs held at Taronga Zoo, Sydney, Australia, February 24, 1991. Sydney: Conservation Research Centre.

Casey, John G. and John J. Hoey. 1985. Estimated Catches of Large Sharks by U.S. Recreational Fishermen in the Atlantic and Gulf of Mexico. In: *Shark Catches From Selected Fisheries Off the U.S. East Coast*, NOAA Technical Report NMFS 31, pp. 15-19. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Washington, D.C.

S. Cook, ed. 1987. *Sharks: An Inquiry into Biology, Behavior, Fisheries, and Use*. Proceedings of a Conference, Portland, Oregon, October 13-15, 1985. EM 8330/March 1987. Oregon State University Extension Service, Portland.

Culver, Brian. 1986. Personal communication by telephone, January 31. Resource Manager, Marine Resources Division, Washington Department of Fish and Wildlife, Montesano, Washington.

Dockerty, T. 1992. *International Trade in Shark Fins.* Wildlife Conservation Monitoring Centre, Wildlife Trade Monitoring Unit, Cambridge. Unpublished report.

Fisher, Mark R. and Robert B. Ditton. 1993. A Social and Economic Characterization of the U.S. Gulf of Mexico Recreational Shark Fishery. *Marine Fisheries Review* 55(3): 21-27.

Fishery Conservation and Management Act (1976), retitled through amendment in 1980 to the "Magnuson Fishery Conservation and Management Act." 50 CFR Ch. VI (10-1-93 Edition): §678.1-10, §678.20-27.

García, Marco A. 1996. In litt: Associate Scientist, Inter-American Tropical Tuna Commission, La Jolla, California. March 1996.

Gaski, Andrea L. 1991. *Exotic Leathers and the Texas (Cowboy) Boot Industry.* Unpublished report, TRAFFIC USA, Washington, D.C.

Gulf and South Atlantic Fisheries Development Foundation, Inc. 1996. *Commercial Shark Fishery Observer Program. Final Report,* MARFIN Award NA47FF0008, "Characterization and comparisons of the directed commercial shark fishery in the eastern Gulf of Mexico and off North Carolina through an observer program," supplemented with Interim Report, S-K Award NA57FD0067, "An expansion of an observer program to characterize and compare the southeast U.S. directed shark fishery to include the east coast of Florida."

Hanan, Doyle A., David B. Holts, and Atilio L. Coan, Jr. 1993. The California Drift Gill Net Fishery for Sharks and Swordfish, 1981-82 through 1990-1991. *Fish Bulletin* 175: 1-95.

Hoey, J.J., A. R. Bertolino, J. Cramer, and C.W. Rogers. 1995. Recent Trends in the U.S. Atlantic Longline Fishery. In ICCAT, *Collective Volume of Scientific Papers,* Vol. XLIV (3): 248-261.

Hoff, Thomas B. and J.A. Musick. 1990. Western North Atlantic Shark-Fishery Management Problems and Informational Requirements. pp. 455-472. In: Harold L. Pratt, Jr., Samuel H. Gruber, and Toru Taniuchi, eds., *Elasmobranchs as Living Resources: Advances in the Biology, Ecology, Systematics, and the Status of the Fisheries.* Proceedings of the 2nd U.S.-Japan Workshop, Honolulu, December 9-14, 1987. NOAA Technical Report NMFS 90. U.S. Department of Commerce.

Holland, Stephen M., Robert B. Ditton, and Duane A. Gill. 1992. The U.S. Gulf of Mexico Charter Boat Industry: Activity Centers, Species Targeted, and Fisheries Management Options. *Marine Fisheries Review* 54(2): 21-27.

Holts, David B. 1988. Review of U.S. West Coast Commercial Shark Fisheries. *Marine Fisheries Review* 50(1): 1-8.

Holts, David B. 1995. "Pelagic Shark Fisheries in the Eastern North Pacific." Presentation at the 125th Annual Meeting of the American Fisheries Society, Tampa, Florida, August 27-31, 1995.

Holts, David B. 1996. Personal communication by telephone, January 18. National Marine Fisheries Service, Southwest Fisheries Science Center. Horst, Jerald. 1993. *Louisiana Seafood Products Handbook.* The Louisiana Seafood Promotion and Marketing Board.

Inter-American Tropical Tuna Commission (IATTC). 1992. *Annual Report of the Inter-American Tropical Tuna Commission*. La Jolla, California.

International Commission for the Conservation of Atlantic Tunas (ICCAT). 1994a. Summary of the Survey on Tuna Fisheries By-Catches, 1993. In: *Collective Volume of Scientific Papers* XLII (2): 442-453.

International Commission for the Conservation of Atlantic Tunas (ICCAT). 1994b. *Report for Biennial Period, 1992-1993*, Part II (1993). Madrid, Spain.

Jensen, Albert C. 1965. Life History of the Spiny Dogfish. *Fishery Bulletin* 65(3): 527-554.

Ketchen, K.S. 1986. *The Spiny Dogfish (Squalus acanthias) in the Northeast Pacific and a History of its Utilization*. Canadian Special Publication of Fisheries and Aquatic Sciences 88. Department of Fisheries and Oceans, Ottawa.

Kreuzer, Rudolf and Rashid Ahmed. 1978. *Shark Utilization and Marketing*. Food and Agriculture Organization of the United Nations, Rome.

Larson, Mary L. 1994. *California Commercial Thresher Shark Landings--1993*. Unpublished report, California Department of Fish and Game.

Laughlin, Leeanne M. 1996. Personal communication by telephone January 17. In litt: January 19. Marine Biologist, California Department of Fish and Game.

Lawlor, Frank J., III. 1985. Shark Fishing Methods and Gear. In: Otwell, W. Steven, Frank J. Lawlor III, Jeffrey A. Fisher, George H. Burgess, Jr., Fred J. Prochaska, and John M. Stevely, *Manual on Shark Fishing*. Florida Sea Grant Report No. 73. Florida Sea Grant College, February 1985.

Lee, Dennis W., Cheryl J. Brown, and Tracey L. Jordan. 1995. *SEFSC Pelagic Longline Observer rogram Data Summary for 1992-1994*. NOAA Technical Memorandum NMFS-SEFC-373: 19 p. ontribution MIA-95/96/01 from the Southeast Fisheries Science Center, Miami Laboratory, ceanic Pelagic Division.

Mestel, Rosie. 1995. Shark extract takes a bite out of sexual diseases. *New Scientist* (2 December).

McCarron, David and James A. Wilson. 1994. *Processed New England Dogfish: Export and Domestic arket Opportunities*. Northern New England Product Development and Marketing Center, Food roducts Initiative Staff Paper, F.I. 004. University of Maine, Orono.

McKinnell, Skip. 1995. "Shark Bycatch in the Pacific Driftnet Fisheries." Presentation at the 125th Annual eeting of the American Fisheries Society, Tampa, Florida, August 27-31, 1995.

Nammack, Marta F., J. A. Musick, and J. A. Colvocoresses. 1985. *Life History of Spiny Dogfish off the ortheastern United States*. Transactions of the American Fisheries Society 114: 367-376.

Northridge, Simon P. 1991. *Driftnet Fisheries and their Impacts on Non-Target Species: A Worldwide Review*. FAO Fisheries Technical Paper, No. 320. Rome.

O'Brien, John W. and John S. Sunada. 1994. *A Review of the Southern California Experimental Drift Longline Fishery for Sharks, 1988-1991*. CalCOFI Reports (35): 222-229.

Otwell, W. Steven, Frank J. Lawlor III, Jeffrey A. Fisher, George H. Burgess, Jr., Fred J. Prochaska, and John M. Stevely. 1985. *Manual on Shark Fishing.* Florida Sea Grant Report No. 73. Florida Sea Grant College, February 1985.

Pacific States Marine Fisheries Commission (PSMFC). 1995. *47th Annual Report of the Pacific States Marine Fisheries Commission for the Year 1994.*

Pacific States Marine Fisheries Commission (PSMFC). 1994. *46th Annual Report of the Pacific States Marine Fisheries Commission for the Year 1993.*

Pacific States Marine Fisheries Commission (PSMFC). 1993. *45th Annual Report of the Pacific States Marine Fisheries Commission for the Year 1992.*

Pacific States Marine Fisheries Commission (PSMFC). 1992. *44th Annual Report of the Pacific States Marine Fisheries Commission for the Year 1991.*

Park, J. S., Y. Gong, J. U. Lee, Y. S. Kim, S. J. Hwang, M. Dahlberg, L. Jones, S. Fitzgerald, M. Seki, and P. Gould. 1992. *1991 Observations of the Republic of Korea High Seas Squid Driftnet Fishery in the North Pacific Ocean.* Joint Report of Republic of Korea National Fisheries Research and Development Agency, United States National Marine Fisheries Service, and United States Fish and Wildlife Service.

Paust, Brian. 1987. The Developing Alaska Salmon Shark Fishery. In: S. Cook, ed., *Sharks: An Inquiry into Biology, Behavior, Fisheries, and Use.* Proceedings of a Conference, Portland, Oregon, October 13-15, 1985. EM 8330/March 1987. Oregon State University Extension Service, Portland.

Paust, Brian and Ronald Smith. 1986. *Salmon Shark Manual.* AK-SG-86-01. Alaska Sea Grant College Program, University of Alaska, Fairbanks.

Pooley, Samuel. 1996. Personal communication by telephone, January. Industry Economist, NMFS, Southwest Fisheries Science Center, Honolulu Laboratory, Honolulu, Hawaii.

Rago, P. J. 1996. Personal communication by telephone, February. Interview, March 11. NMFS, Northeast Fisheries Science Center..

Rago, P. J., K. A. Sosebee, J. K. T. Brodziak, S. A. Murawski, and E. D. Anderson. 1994. *Distribution and Dynamics of Northwest Atlantic Spiny Dogfish (Squalus acanthias).* Northeast Fisheries Science Center Reference Document 94-19 (Draft).

Richards, John B. 1987. Developing a Localized Fishery: The Pacific Angel Shark. In: S. Cook, ed., *Sharks: An Inquiry into Biology, Behavior, Fisheries, and Use.* Proceedings of a Conference, October 13-15, 1985, Portland Oregon. EM 8330. Oregon State University Extension Service.

Rivlin, Michael. 1995. West Coast dogfish find new respect. *National Fisherman.* (October): 34-36.

Rivlin, Michael. 1996. Northeast 'dog catchers' scratch for a future. *National Fisherman* (February): 15-17, 76.

Rose, Debra A. 1991. *A North American Free Trade Agreement: The Impacts on Wildlife Trade,* Vols. 1 and 2. TRAFFIC USA, Washington, D.C.

Ross, Bob. 1996. Personal communication by telephone, 12 April. Trade Specialist, National Marine Fisheries Service, Gloucester, Massachussetts..

Russell, Sandra J. 1993. Shark Bycatch in the Northern Gulf of Mexico Tuna Longline Fishery, 1988-91, with Observations on the Nearshore Directed Shark Fishery. In Steven Branstetter, ed. *Conservation Biology of Elasmobranchs*, pp. 19-29. NOAA Technical Report NMFS 115. U.S. Department of Commerce. September.

Saelens, Mark. 1996. Personal communication by telephone, January 31. Technical Services Supervisor, Marine Finfish, Oregon Department of Fish and Game, Newport, Oregon.

Schroeder, Robert E. 1995. Personal communication to C. Robbins, TRAFFIC USA , January. Senior Scientist, Western Pacific Fishery Management Council.

Schwartz, Frank J. and George H. Burgess. 1975. *Sharks of North Carolina and Adjacent Waters*. Information Series, North Carolina Department of Natural and Economic Resources, Division of Marine Fisheries.

Slosser, Virginia. 1983. *A Study of U.S. Shark Markets*. National Marine Fisheries Service, St. Petersburg, Florida.

Stick, Kurt, Gene Fleming, Al Millikan, Larry Hreha, and David Hanson. 1990. *Interjurisdictional Fishery Management Plan for Thresher Shark off the Coasts of California, Oregon and Washington*. Pacific States Marine Fisheries Commission. Portland, Oregon.

Summers, Graeme and Ron Wong. 1992. Cosmetic Products from Semi-Refined Shark Liver Oil. *INFOFISH International* 2: 55-58.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 1987. Pelagic Fisheries of the Western Pacific Region. 50 CFR § 685. 52 *Federal Register* 5987 (February 17, 1987).

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Center. 1989. *Status of the Fishery Resources Off the Northeastern United States for 1989*. NOAA Technical Memorandum NMFS-F/NEC-72.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 1991. *Marine Recreational Fishery Statistics Survey, Atlantic and Gulf Coasts, 1987-1989*. Current Fisheries Statistics Number 8904. Silver Spring, MD.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 1992a. *Marine Recreational Fishery Statistics Survey, Atlantic and Gulf Coasts, 1990-1991*. Current Fisheries Statistics Number 9204. Silver Spring, MD.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 1992b. *Marine Recreational Fishery Statistics Survey, Pacific Coast, 1987-1989*. Current Fisheries Statistics Number 9205. Silver Spring, MD.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS). 1993. *Fishery Management Plan for Sharks of the Atlantic Ocean*. Silver Spring, MD, NMFS.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 1993. Fishery Conservation and Management; Foreign Fishing; Atlantic Sharks. *Federal Register* (April 26), 58(78): 21931-21949.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 1993. Atlantic Shark Fisheries. *Federal Register* (May 10), 58(88): 27482-3.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 1993. Atlantic Shark Fisheries. *Federal Register* (July 27), 58(142): 40076.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 1993. Atlantic Shark, Tuna and Swordfish Fisheries. *Federal Register* September 1), 58(168): 46153-5.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 1993. Atlantic Shark Fisheries. *Federal Register* (December 28), 58(247): 68556.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 1994a. Atlantic Shark Fisheries. *Federal Register* (February 22), 59(35): 8458.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 1994b. Atlantic Shark Fisheries. *Federal Register* (May 16), 59(93): 25350.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS). 1994c. Atlantic Shark Fisheries. *Federal Register* (August 1), 59(146): 38943.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS). 1994d. Atlantic Shark Fisheries. *Federal Register* October 18), 59(200): 52453-52458.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS). 1994e. Report of the Shark Evaluation Workshop, March 14-18, 1994, Miami, FL. Unpublished.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 1995a. Atlantic Shark Fisheries; Semiannual Quotas for Large Coastal and Pelagic Sharks. *Federal Register* (May 2), 60(84): 21468.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 1995b. Atlantic Shark Fisheries; Large Coastal Closure Notice. *Federal Register* (September 22), 60(184): 49235.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 1995c. 1995 *Shark Evaluation Annual Report.* April 1995. Unpublished.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS). 1995. Options for Establishing an Interim Permit Moratorium and Eligibility Criteria for the Atlantic Swordfish Fishery. Supplement to the Concept Paper "Towards Rationalization of Fisheries for Atlantic Highly Migratory Species." Silver Spring, MD., July 25, 1995.

U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center. 1994. Report of the 18th Northeast Regional Stock Assessment Workshop (18th SAW): Stock Assessment Review Committee (SARC) Concensus Summary of Assessments. Northeast Fisheries Science Center Reference Document 94/xx. Draft.

Western Pacific Regional Fishery Management Council. 1986. *Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region*. Western Pacific Regional Fishery Management Council, Honolulu Hawaii, July 1986.

Western Pacific Regional Fishery Management Council. 1989. *Pelagic Fisheries of the Western Pacific Region: Covering 1988 and Earlier Years*. Western Pacific Regional Fishery Management Council, Honolulu, Hawaii, December 1989.

Western Pacific Regional Fishery Management Council. 1990a. *Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region: Amendment 1 and Environmental Assessment*. Western Pacific Regional Fishery Management Council, Honolulu Hawaii, November 21, 1990.

Western Pacific Regional Fishery Management Council. 1990b. *Pelagic Fisheries of the Western Pacific Region: 1989 Annual Report*. Western Pacific Regional Fishery Management Council, Honolulu, Hawaii, August 1990.

Western Pacific Regional Fishery Management Council. 1991a. *Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region: Amendment 2 and Environmental Assessment*. Western Pacific Regional Fishery Management Council, Honolulu, Hawaii, February 1991.

Western Pacific Regional Fishery Management Council. 1991b. *Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region: Amendment 4*. Western Pacific Regional Fishery Management Council, Honolulu, Hawaii, June 1991.

Western Pacific Regional Fishery Management Council. 1991c. *Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region: Amendment 5*. Western Pacific Regional Fishery Management Council, Honolulu, Hawaii, October 7, 1991.

Western Pacific Regional Fishery Management Council. 1991d. *Pelagic Fisheries of the Western Pacific Region: 1990 Annual Report*. Western Pacific Regional Fishery Management Council, Honolulu, Hawaii, August 1991.

Western Pacific Regional Fishery Management Council. 1992a. *Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region: Amendment 6*. Western Pacific Regional Fishery Management Council, Honolulu, Hawaii, April 30, 1992.

Western Pacific Regional Fishery Management Council. 1992b. *Pelagic Fisheries of the Western Pacific Region: 1991 Annual Report*. Western Pacific Regional Fishery Management Council, Honolulu, Hawaii, August 1992.

Western Pacific Regional Fishery Management Council. 1993. *Pelagic Fisheries of the Western Pacific Region: 1992 Annual Report*. Western Pacific Regional Fishery Management Council, Honolulu, Hawaii, October 1993.

Western Pacific Regional Fishery Management Council. 1994a. *Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region: Amendment 6*. Western Pacific Regional Fishery Management Council, Honolulu, Hawaii, January 14, 1994.

Western Pacific Regional Fishery Management Council. 1994b. Pelagic Fisheries of the Western Pacific Region: 1993 Annual Report. Western Pacific Regional Fishery Management Council, Honolulu, Hawaii, August 1994.

Western Pacific Regional Fishery Management Council. 1995a. *Pelagic Fisheries of the Western Pacific Region: 1994 Annual Report.* Western Pacific Regional Fishery Management Council, Honolulu, Hawaii, August 1995.

Western Pacific Regional Fishery Management Council. 1995b. *Pelagic Fishing Methods in the Pacific.* 16 pp.

Wetherbee, Bradley M., Christopher G. Lowe, and Gerald L. Crow. 1994. A Review of Shark Control in Hawaii with Recommendations for Future Research. *Pacific Science* 48(2): 95-115.

Witzell, W. N. 1985. The Incidental Capture of Sharks in the Atlantic United States Fishery Conservation Zone Reported by the Japanese Tuna Longline Fleet. In: *Shark Catches From Selected Fisheries off the U.S. East Coast.* NOAA Technical Report NMFS 31. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Wolfe, Keith. 1996. Personal communication by telephone, January. Washington Department of Fish and Wildlife, Olympia, Washington.

GENERAL RECOMMENDATIONS[2]

The following recommendations address two specific issues that TRAFIC deems essential for the conservation and management of sharks. These are 1) the development and compilation of specific and consistent data to monitor the catch, landings, and trade of sharks; and the establishment of scientifically-based global endeavor to ensure sustainable offtake of these species for the future.

Meeting future data needs

1. The FAO Code of Conduct for Responsible Fisheries (1995) notes in its Article 12.1 that "states should recognize that responsible fisheries require the availability of a sound scientific basis to assist fisheries managers and other interested parties in making decisions." This statement is of great relevance in relation to shark fisheries and the inadequacy or paucity of data necessary for adequate management.

> ***Recommendation*:** All nations, particularly those that have expressed concern about the status and trade of sharks, should apply the principles and standards of the Code of Conduct for Responsible Fisheries that address fisheries research and data collection (Articles 7.4 and 12).

2. International bodies such as FAO, ICCAT, and ICES currently provide the most readily available sources of regional and global data on chondrichthyan catches, landings, production, and trade. These data are extremely problematic as a result of inconsistent recording and reporting methods and because of wide variations in the monitoring and reporting capabilities of the countries providing data.

Improved data collection and reporting depends in large part on increased national capacity to monitor chondrichthyan fisheries. However, international organizations, such as FAO, can assist this process by reviewing sources of error and bias in current reporting; developing and disseminating standardized guidelines for data collection and reporting; and, in consultation with other relevant fisheries and trade specialists, recommending species and species groups that should be reported separately in production and trade data.

> ***Recommendation*:** International fisheries agencies, including FAO; regional fisheries development agencies, such as ICCAT and OLDEPESCA; and national fisheries agencies should initiate or improve the collection of taxa-specific data on shark fisheries to species level wherever possible. Data could be compiled by using one or more of the following methods:

[2] These recommendations are excerpted from Rose (1996) published by TRAFFIC International.

i) The compilation of catch and landing data at the genus or species level may be improved by adopting or adapting either the TRAFFIC list of commonly exploited sharks (see Rose 1996) or the IUCN Shark Specialist Group's list of sharks that are vulnerable to overexploitation and possibly subject to trade, or by compiling a comparable list of some 30 to 40 species to target for improved data collection.

ii) As an alternative to genus or species-specific data, the compilation of data at a higher taxonomic level could be initiated.This could be more easily achieved through the differentiation of external physical characteristics such as number of fins and gill slits.

iii) Nations or agencies lacking the capability to immediately initiate reporting at the level of species, genus, or order should initiate reporting as shark, ray, skate, or chimaera.

> ***Recommendation*:** Once an initial species list is compiled and improved data collection initiated, FAO and other relevant fisheries agencies should actively review and periodically modify the list by adding or eliminating species, so that species lists are specific to a geographic region, consist of sharks commonly fished in that region, and/or include species of concern to that region.
>
> ***Recommendation*:** To assist in the compilation of data on catches and landings, the FAO should produce an expanded list of FAO species codes for national and international reporting.
>
> ***Recommendation*:** All catch and landing data should be compiled by oceanic catch area, as largely defined by FAO or more strictly defined or limited by regional or national fisheries agencies.
>
> ***Recommendation*:** Catch and landing data should be collected for commercial, subsistence, and recreational fisheries.

3. At the national level, identification of chondrichthyan species poses an especially pressing problem for both fisheries management and monitoring of markets and trade. Training in species identification for fishermen, personnel of fisheries management agencies, inspectors charged with enforcing health and sanitary codes, customs officials, and others involved in reporting catches, landings, and trade may significantly improve the quality and content of fisheries and trade data. The FAO and other inter-governmental and international bodies can assist this process by contributing to the production and dissemination of species identification materials.

> ***Recommendation*:** In order to assist fisheries agencies and fishermen in the compilation of species-specific catch and landing data, FAO should develop an

elementary, user-friendly, and simply-illustrated identification manual for commonly fished species. This identification guide could be adopted or modified by national and regional fisheries agencies for use by relevant agencies and in specific fisheries and/or fleets.

4. Significant improvements are needed in the general reporting of chondrichthyan catches and landings at the national level if related fisheries, markets, and trade are to be understood and effectively managed. The implementation of mandatory logbook reporting of the volume, species composition, and destination of catches and landings; mandatory or voluntary observer programs; dockside monitoring programs; and fisheries processor surveys are among the many useful measures for improving data collection. Programs such as these may contribute significantly, not only to available information on chondrichthyan catches and landings, but also to the availability of incidental market and other information needed to accurately interpret trends in fishing effort and in catches and landings.

***Recommendation*:** General data collection efforts through logbook reporting, dockside monitoring prgrams, processor surveys, and other related effort should be initiated or improved in artesanal, subsistence, and recreational, as well as large-scale commercial fisheries. Such monitoring programs should be mandated for domestic vessels fishing in national, foreign, and international waters, and to foreign vessels operating in national waters or landing their catch in domestic ports. Resulting data should be published routinely or otherwise made available to researchers, in order to assist current efforts to document and analyze trends in fisheries and stock abundance.

***Recommendation*:** Documentation of chondrichthyan bycatch should be a priority for efforts to improve fisheries data collection and monitoring at the national, regional, and international levels.

5. In many cases, the uses and value of chondrichthyan resources remain largely undocumented, not only in in national fisheries and production statistics, but also in customs data. Important fishing, processing, and trading nations, in particular, should consider the usefulness of creating tariff classifications for shark fins; meat of dogfish, other sharks, and skates and rays; and possibly shark and ray skins and leather and shark liver oil.

***Recommendation*:** In cooperation with national customs authorities, national fisheries agencies should begin to report nationally or regionally important shark trade through pre-existing harmonized customs codes for raw or semi-processed shark, shark fins, and shark oil.

***Recommendation*:** National fisheries agencies should regularly obtain data thus collected in order to monitor trade and determine its effects, if any, on national shark catches and landings.

***Recommendation*:** National fisheries agencies should 1) systematically collect national trade and market information for sharks and related species by monitoring domestic demand and international trade to determine their relationship to trends in landings; 2) conduct sample surveys of key fishery markets or auctions to note species availability and seasonality; 3) determine the value, volume, product forms, and routes of domestic or international trade; and 4) based on research from experimental fishing cruises or vessels and market surveys, compile or modify region-specific or ocean-specific conversion ratios for translating the volume of landed and traded products to live or round weight.

Conservation measures

6. Once species-specific catch and landing information has been compiled and analyzed by regional and national fisheries agencies, it will be pssible for them to work together to identify a list of shark species commonly caught but vulnerable to over-exploitation and therefore deserving of management measures.

***Recommendation*:** Regional and national fisheries agencies should develop economically feasible and sustainable management plans for shark fisheries vulnerable to over-exploitation.

7. The results of TRAFFIC research on chondrichthyan fisheries and trade repeatedly highlight the importance of chondrichthyan bycatch as a major contributing factor to rising world landings and trade of chondrichthyan species, and a critical issue in fisheries management, conservation, and trade monitoring.

Not only do incidental fisheries contribute a significant proportion of chondrichthyan landings and products in trade, but economically important species may be affected simultaneously by targeted fisheries, landings from incidentalcatches, and high rates of discard in other fisheries targeting more valuable species. Although distant water fleets are of particular concern owing to the sheer volume of bycatch, chondrichthyan bycatch is associated with most of the world's fisheries and gear types, including directed fisheries for specific chondrichthyan species or species groups.

***Recommendation*:** Governmental and inter-governmental fisheries agencies should provide technical and, when possible, financial assistance for global research and information dissemination on modifications to gear and fishing methods that will reduce shark bycatch and bycatch mortality.

***Recommendation*:** Whenever possible, fisheries agencies should attempt to ensure full utilization of shark catch, particularly for catches, bycatches, specific fisheries, and gears associated with high rates of catch mortality.

8. According to FAO (Anon., 1991), "sharks grow and reproduce slowly [so that] the resource is fragile and can easily be overfished." The FAO has therefore recognized that "in the interests of sustainability, shark fisheries should be closely monitored to ensure that they are not overexploited" (Anon., 1991).

In the absence of any international, inter-governmental body with management authority over worldwide shark fisheries, and recognizing the relevance of international trade to the management and conservation of sharks, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1994 adopted Resolution Conf. 9.17, calling on Parties to the Convention and international fisheries organizations to improve the collection of data on shark fisheries and trade. Parties were further requested to provide available information regarding shark fisheries, management, and trade to the CITES Secretariat.

> ***Recommendation*:** In the absence of any international, inter-governmental agency with management oversight over shark fisheries, CITES should continue to monitor the work of FAO and other agencies in the implementation of Resolution Conf. 9.17, through and beyond the Eleventh Conference of the Parties.
>
> ***Recommendation*:** A more formal method of monitoring can be instituted through the formation of a working group within CITES. CITES Parties should consider setting up a marine fisheries working group to review progress of the second phase of implementation of Resolution Conf. 9.17, and develop recommendations for measures needed to review and assess the status of sharks and other marine fisheries species that may be threatened by international trade.