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A Preliminary Evaluation of the Potential for a Shark Fishery in Virginia

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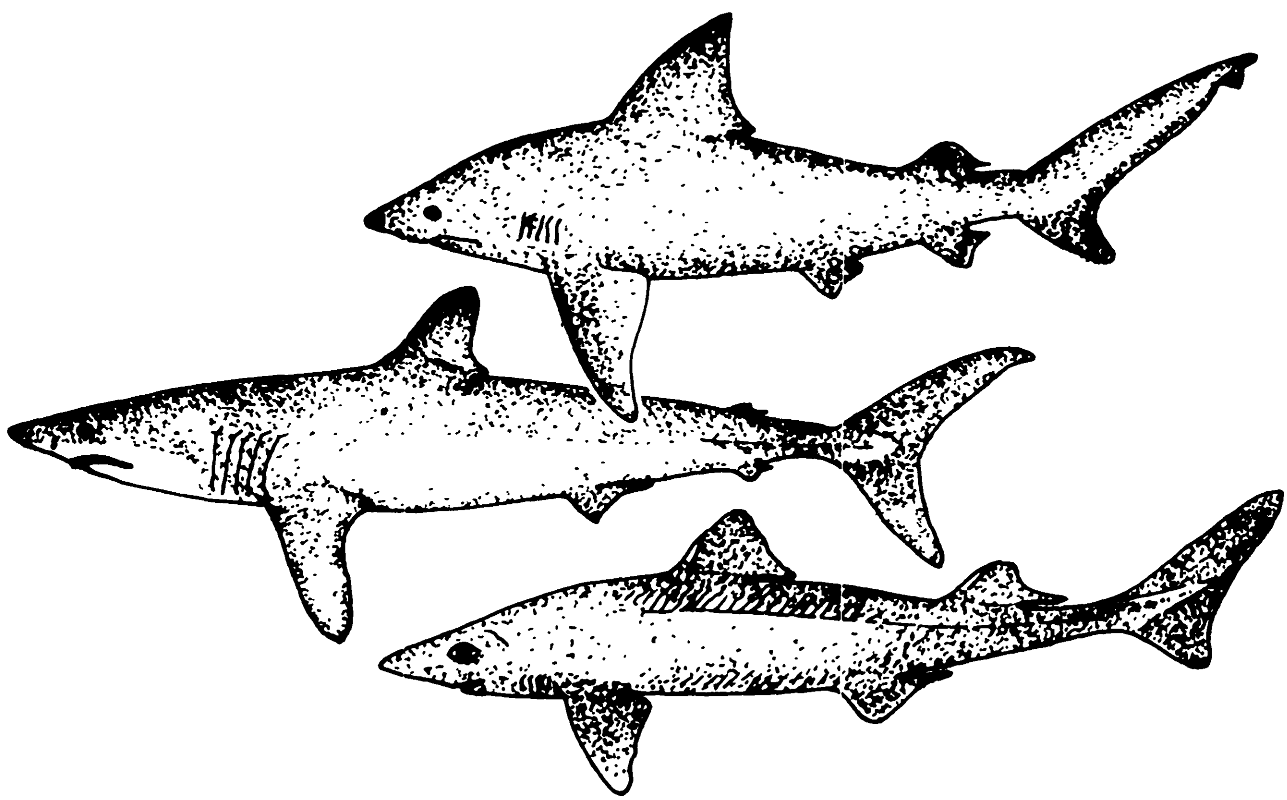

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Introduction

Sharks represent a potentially large and virtually unutilized resource in the mid-Atlantic Bight. While sharks are currently considered a nuisance by most local commercial fishermen, large and established fisheries for sharks are presently in operation in other parts of the world, particularly Europe. In view of this, the present investigation was undertaken in order to determine the practicality of a commercial shark fishery in Virginia, and if so, to identify those areas requiring future research for the optimal development and management of the fishery.

A successful fishery is contingent on four factors; 1) the availability of an adequate stock of the target species, 2) a means of harvesting the resource, 3) a suitable method(s) of processing the catch into a saleable product(s), and 4) the existence of a suitable market for that product(s). All of these aspects require careful attention when considering shark species as a potential resource.

Determination of what constitutes an adequate fishable shark stock requires consideration of life history parameters as well as overall abundance and stock size. Sharks exhibit slow growth rates, relatively long life spans and very low reproductive potentials. Annual recruitment into a given fishable size may be a small percentage of the standing stock. As a result the sustainable yield to be expected from a shark fishery is substantially lower than that for a bony fish stock, where fecundity is not generally considered to be limiting.

Sharks are relatively large and highly mobile. Few species are susceptible to harvest by conventional trawling methods. In most cases specialized capture methods such as longlining are required. Shark meat may be highly susceptible to spoilage, and provisions must be made for the preservation of the catch if it is not landed relatively quickly.

Unprocessed sharks are virtually unmarketable. While markets exist for the flesh, fins, hides and liver (Kruezer and Ahmed, 1978) these markets are separate and deal only with the pre-processed portion of the shark with which they are concerned. Products of marketable value vary from species to species and with location of the fishery, but in virtually all cases some presale processing is required prior to reaching the consumer. Usually this will entail at least heading, gutting and skinning.

Lack of sufficient markets has been the traditional limiting factor in the development of shark fisheries. Preparation of hides and fins are highly labor intensive and result in luxury products for which there is only limited demand. The use of shark liver oil for the production of vitamins resulted in boom fisheries for sharks in the 1940's, but the subsequent development of synthetic vitamins has severely reduced the demand for this product (it is currently only used for the extraction of special oils used in small quantities in the textile, tanning, cosmetic and pharmaceutical industries). Use of sharks for reduction purposes has met with only limited success. The largest potential market for sharks is as food. While the flesh of most species has been shown to be quite palatable (Gordievskaya 1971; Morris, 1975; Davies, 1976), consumers have displayed considerable reluctance in accepting sharks as food, and most successful markets have employed cryptic names for the product sold (greyfish, flake, huss, rock salmon, etc.).

It is with these limitations in mind that the present study was performed. Each of the four major prerequisites for establishment of a successful fishery will be examined for Virginia waters in the order given, inasmuch as they are sequentially dependent (only what is present may be harvested, only what may be harvested may be processed, etc.).

Potential Stocks

Analyses of available data have shown that the Chesapeake Bight shark fauna is divided seasonally into two major components; a summer fauna dominated by the sandbar shark, *Carcharhinus plumbeus* (= *milberti*), and a winter fauna composed almost exclusively of the spiny dogfish, *Squalus acanthias* (Lawler, 1976).

The summer fauna is known chiefly from VIMS longline survey data. While this survey has provided some valuable preliminary information on the occurrence, distribution and life histories of these species (Lawler, 1976), the data are insufficient for establishing any estimates of the actual populations. They do provide a rough estimate of the relative species composition (Table 1). Determination as to whether these species are present in harvestable concentrations will require a great deal more sampling.

C. plumbeus would obviously provide the nucleus for any Virginia fishery for the larger sharks available to longline. Additional VIMS data (unpublished) indicate that young of the year sandbar sharks are one of the most abundant large predators in the lower Chesapeake Bay in the summer and early fall. These young sharks appear to be present in harvestable quantities, but lack of knowledge concerning natural mortality and the relationships of this population to the overall sandbar shark population necessitate great care in the development of a fishery. Springer (1960) found the sandbar shark has a gestation period of about nine months and produces an average of nine young, but

Table 1. Shark species taken during the 1975-1979 VIMS longline survey, lower Chesapeake Bay and adjacent coastal waters.

Species	n	%
Carcharhinus plumbeus (sandbar)	273	62.2
Carcharhinus obscurus (dusky)	52	11.8
Rhizoprionodon terraenovae (Atlantic sharpnose)	43	9.8
Mustelus canis (smooth dogfish)	22	5.0
Odontaspis taurus (sand tiger)	11	2.5
Carcharhinus limbatus (black-tip)	11	2.5
Galeocerdo cuvieri (tiger)	9	2.1
Carcharhinus falciformes (silky)	8	1.8
Sphyrna lewini (scalloped hammerhead)	5	1.1
Nagaprion brevirostris (lemon)	3	.7
Carcharhinus leucas (bull)	2	.5
	439	100.0

that less than 20% of the mature females conceive in any given year. Lawler (1976) found that C. plumbeus females probably do not reach maturity until at least fifteen years of age. Thus the reproductive potential of this species must be considered to be very low, and it may be inadvisable to harvest this species at a small size.

Much more information is available for spiny dogfish, the nearly exclusive component of the winter shark fauna. Spiny dogfish are vulnerable to capture by trawl and have therefore been collected during regular groundfish surveys. Also, this species has been the target of numerous commercial fisheries throughout the northern hemisphere in the past half-century, with the result that the biology of Squalus acanthias has been studied as well as any other elasmobranch species (Jones & Geen, 1976). Unfortunately for the present study, very little of this work has been done in the Northwest Atlantic.

In the northwestern Atlantic the spiny dogfish occurs from Georgia, (Dahlberg & Heard, 1969) to Newfoundland (Bigelow & Schroeder, 1953). The population is generally distributed across the continental shelf and undergoes a seasonal migration, occupying the northern and inshore portions of the range during the summer and the southern and offshore portions during the winter months. The species' movements appear to be associated with a temperature preference for bottom water of between 7° and 13°C (Jensen, 1965).

Figures 1-4 illustrate the seasonal distribution of spiny dogfish in the Chesapeake Bight, as compiled from representative NMFS (Fig. 1 & 4) and VIMS (Fig. 2 & 3) trawl surveys. The height of the bars on the charts are proportional to the total fish biomass (kgs/hr) taken at each station located at the base of the bar, with the shaded area of each bar showing the portion of the total fish biomass contributed by spiny dogfish. The nets used during these surveys were standard commercial gear.

During October (Fig. 1) spiny dogfish are absent from the Chesapeake Bight, but appear in relatively high concentrations on the inner- and mid-shelf off New Jersey and northward. By November and December (Fig. 2) they have thoroughly invaded local waters and constitute well over half the fish biomass available to bottom trawls. During January and February (Fig. 3) they tend to concentrate in the offshore and southern portions of the study area, accounting for 72% of the biomass taken. By March and April (Fig. 4), they have begun to leave the area, moving northward along the outer- and mid-shelf.

Because of their extreme abundance, there can be no question that the Northwest Atlantic population of spiny dogfish constitute a fishable stock. A conservative estimate of the winter standing stock in the Chesapeake Bight (Cape May to Cape Hatteras, 9 to 274 m) alone is over 115,000 metric tons, based solely on the ratio of the area swept by the net to the total area and making no adjustment for catchability. The annual harvesting of even a small portion of this

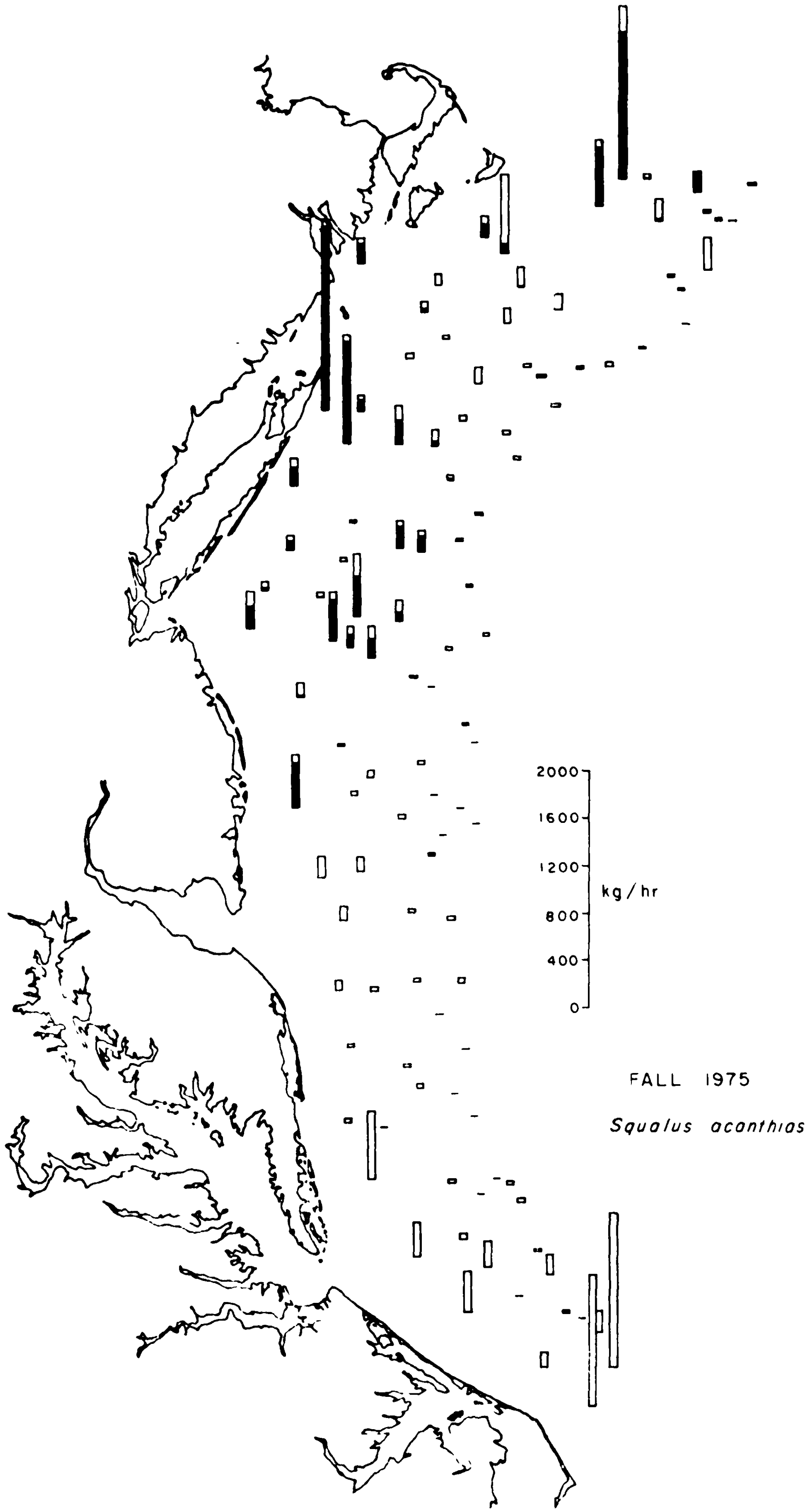

Figure 1. Catches of spiny dogfish (shaded portion) in terms of the proportion of total fish biomass taken during the fall 1975 NMFS Groundfish Survey, Oct. 15 - Nov. 3.

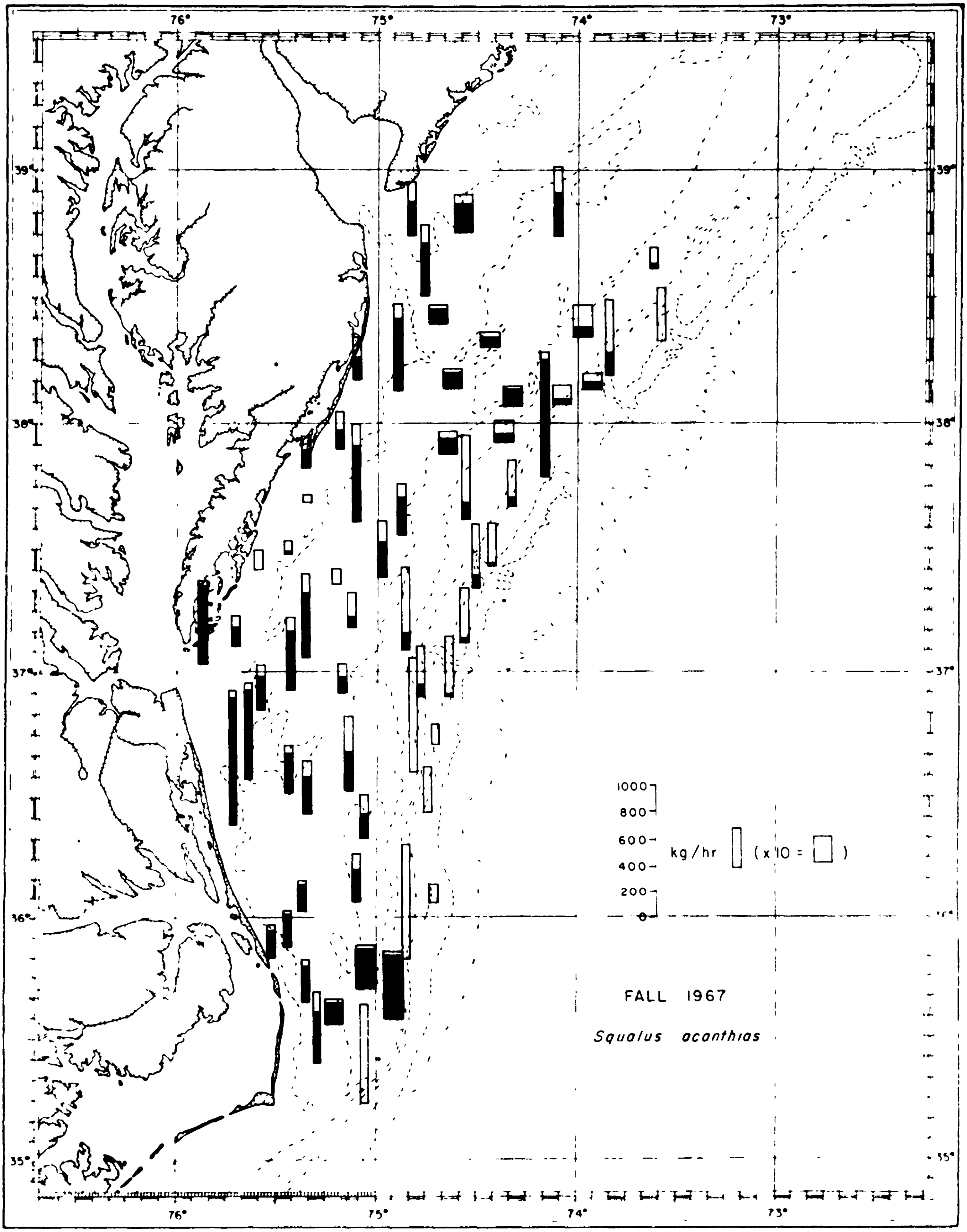

Figure 2. Catches of spiny dogfish (shaded portion) in terms of the proportion of total fish biomass taken during the fall 1967 VIMS Industrial Fish Survey, Nov. 15 - Dec. 18.

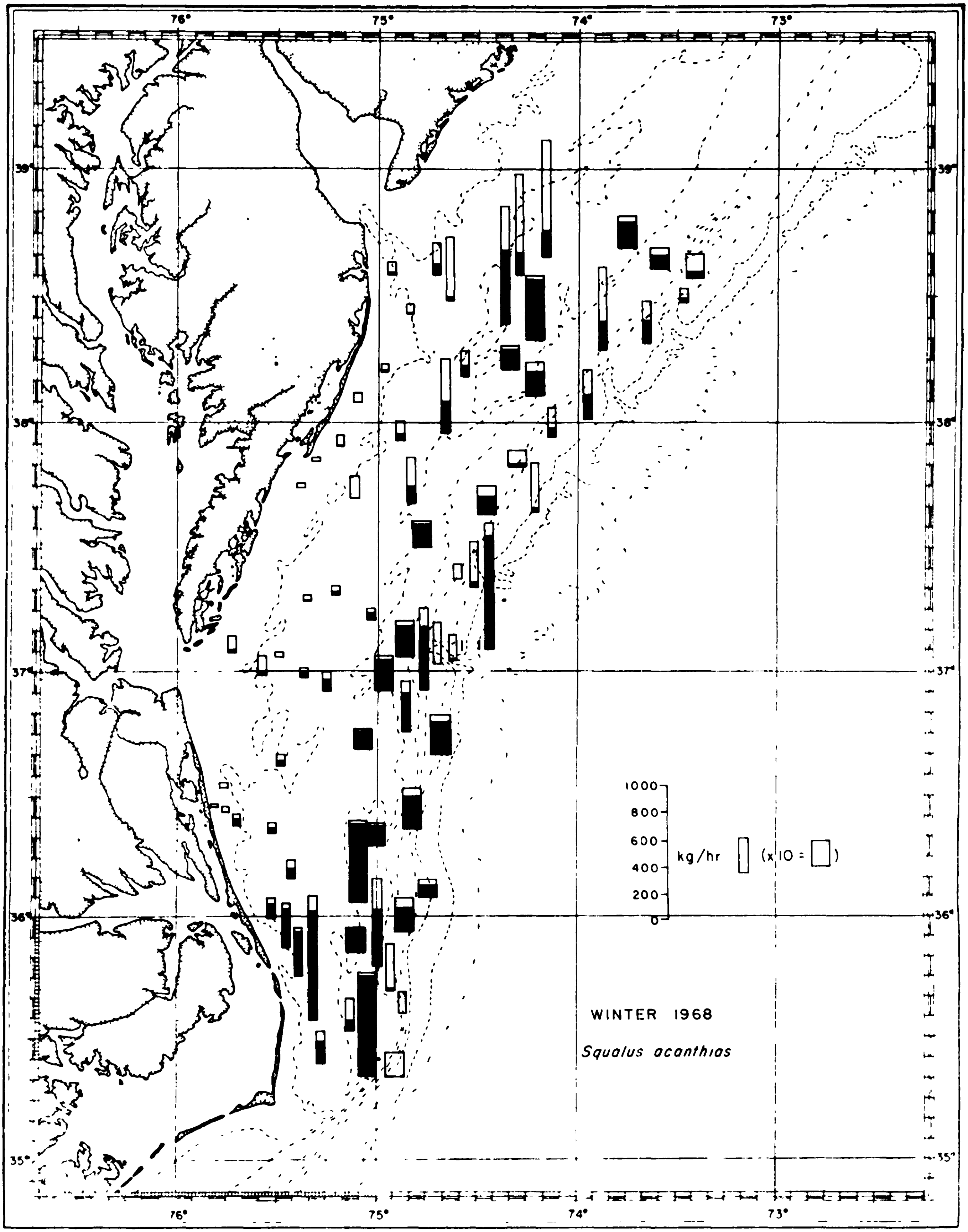

Figure 3. **Catches of spiny dogfish (shaded portion) in terms of the proportion of total fish biomass taken during the winter 1968 VIMS Industrial Fish Survey, Jan. 18 - Feb. 28.**

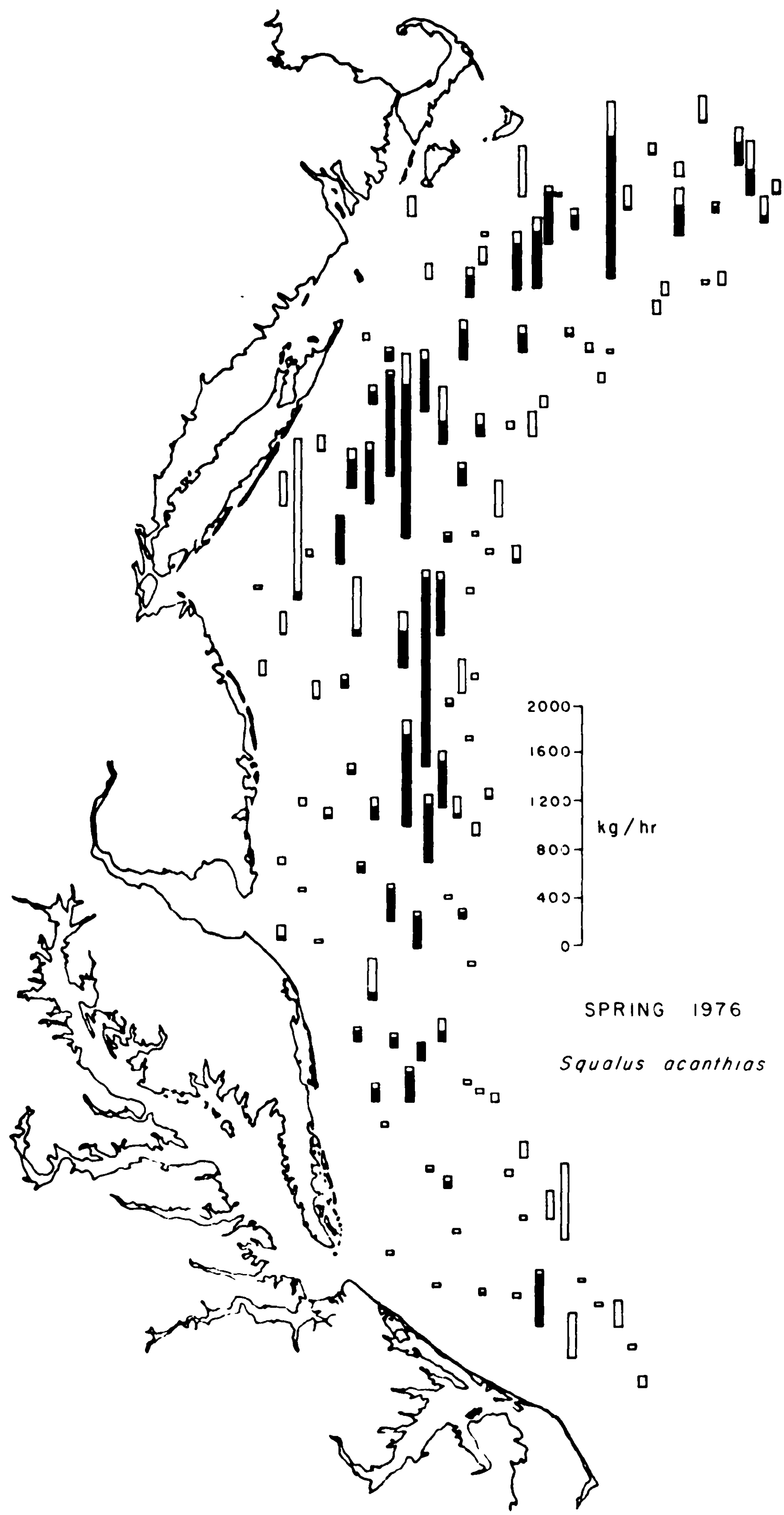

Figure 4. Catches of spiny dogfish (shaded portion) in terms of the proportion of total fish biomass taken during the spring 1976 NMFS Groundfish Survey, Mar. 4 - Apr. 9.

stock would support a major fishery. Such a fishery must, however, be developed with caution. The life history characteristics of this species indicate that the sustainable yield may indeed be a small fraction of the stock size.

Numerous investigations have been conducted on the life history of the spiny dogfish, and some of the results of the more important studies are summarized in Table 2. It is immediately evident that the life history parameters of the species vary from area to area and that the Pacific populations are considerably longer lived, slower growing and later maturing than the Atlantic populations. Work in the Atlantic suggests that males mature between 4 and 8 years of age at a length of about 62 cm and that females mature between 7 and 11 years of age at about 80 cm. Maximum longevity in the Atlantic probably does not approach the 40 - 60 year figures reported from the Pacific, but it seems likely that members of the Atlantic population attain ages of 20 or more. The 21 year old individual aged by Holden and Meadows (1962) had attained a length of 97.5 cm, while numerous larger specimens have been reported. Female spiny dogfish in the Northwest Atlantic apparently produce an average of only 5 young every <u>two</u> years (the gestation period is twenty-two months, the longest for any vertebrate).

In view of the low fecundity and late maturation of this species, the age structure of the population is an important determinant of its reproductive potential. Figure 5 illustrates the composite length

Table 2. Life history information reported for spiny dogfish, *Squalus acanthias*.

Investigator	Area	Size* at birth	Maximum Size ♂	Maximum Size ♀	Maximum age obs.	Size at Maturity ♂	Size at Maturity ♀	Age at Maturity ♂	Age at Maturity ♀	Fecundity Range	Fecundity Mean
Ford (1921)	N.E. Atl.	25-31	83	110		60	75			1-11	4
Hickling (1930)	"	26				60	80				
Holden & Meadows (1962, 1964)	"		88	110	21		82		11	2-15	6
Aasen (1961, 1964)	"	26								2-13	6.2
Templeman (1944)	N.W. Atl.	24-31	86	108		64	79	4-5**	7-8**	1-9	3.9
Jensen (1965)	"									1-11	5.8
Kaganovskaia (1933, 1937)	N.W. Pac.	24		126	25		100		19	5-19	11
Bonham et al. (1949)	N.E. Pac.	27	100	124	29	72	92	12	18	2-17	7.3
Ketchen (1972, 1975)	"	26.2	107	130	64		93.5	14	23	2-13	6.2
Jones & Geen (1977 a, b)	"	25.4	103	130	48	78.5	93.5	19	29		7.3

* all sizes given are total lengths in centimeters.

** inferred ages based on the application of European data.

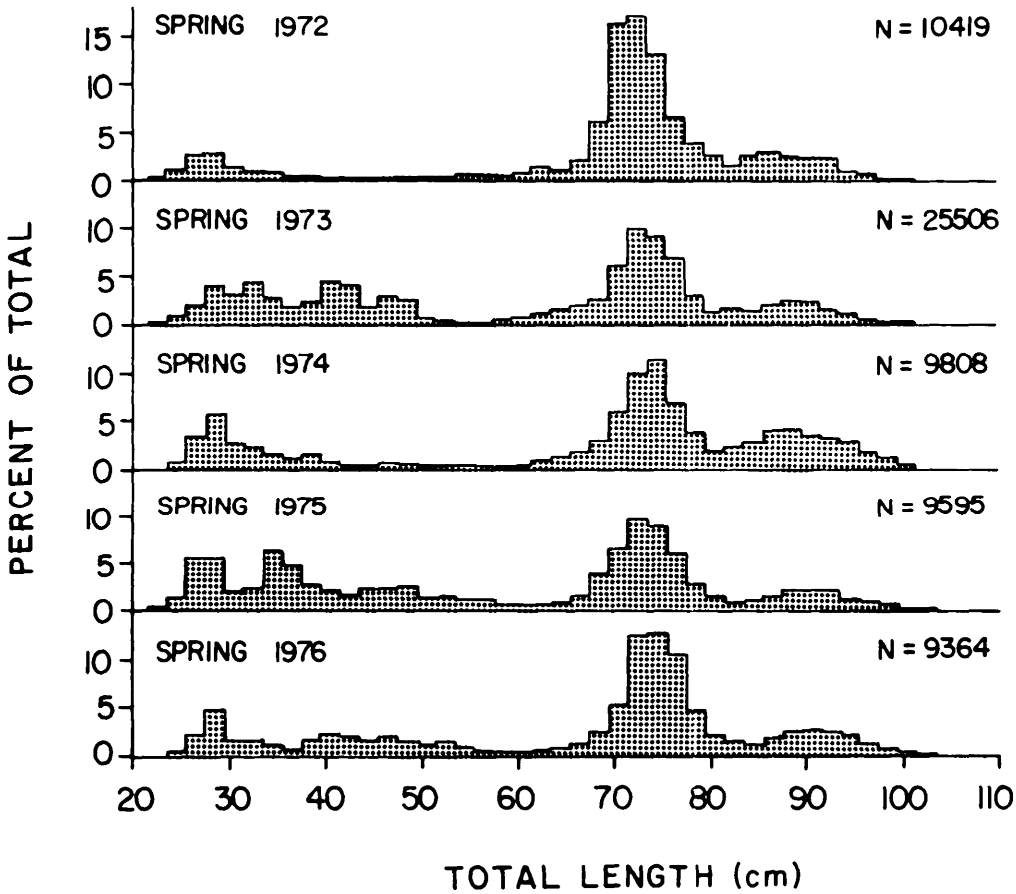

Figure 5. Composite length frequencies of all spiny dogfish taken during the 1972-1976 NMFS spring Groundfish Surveys.

frequencies for all spiny dogfish taken during the 1972-76 spring NMFS Groundfish Surveys. These surveys were performed during a time of year (March-April) when virtually all of the Northwest Atlantic populations of this species occurs within the survey area (Nova Scotia to Cape Hatteras, 27-365 m). During all five cruises the size distribution is characterized by an initial peak at about 27 cm, one or more small peaks between 30-70 cm, a large and pronounced peak at about 75 cm, and a smaller, less distinct peak at about 90 cm. Interpretation of these peaks in terms of age composition is somewhat tenuous inasmuch as no direct ageing of the northwestern Atlantic population has been performed, but Templeman's (1944) study, which included some inferential estimates of age, indicated that the life history parameters of the Northwest Atlantic population are at least similar to the Northeast Atlantic populations.

If the age-length relationships determined for Northeast Atlantic spiny dogfish (Holden & Meadows, 1962, Fig. 6) are assumed to apply here, the two prominent and consistent peaks at the upper end of the size range appear to be caused by the packing of age groups between the average size at maturity and the average maximum or asymptotic length for each sex. Thus, the peak between 65 and 85 cm is composed primarily of mature males while the peak between 85 and 100 cm is composed almost exclusively of mature females. The apparent preponderance of males may be a sampling artifact, since the larger, faster mature females should be better at avoiding capture by the trawl.

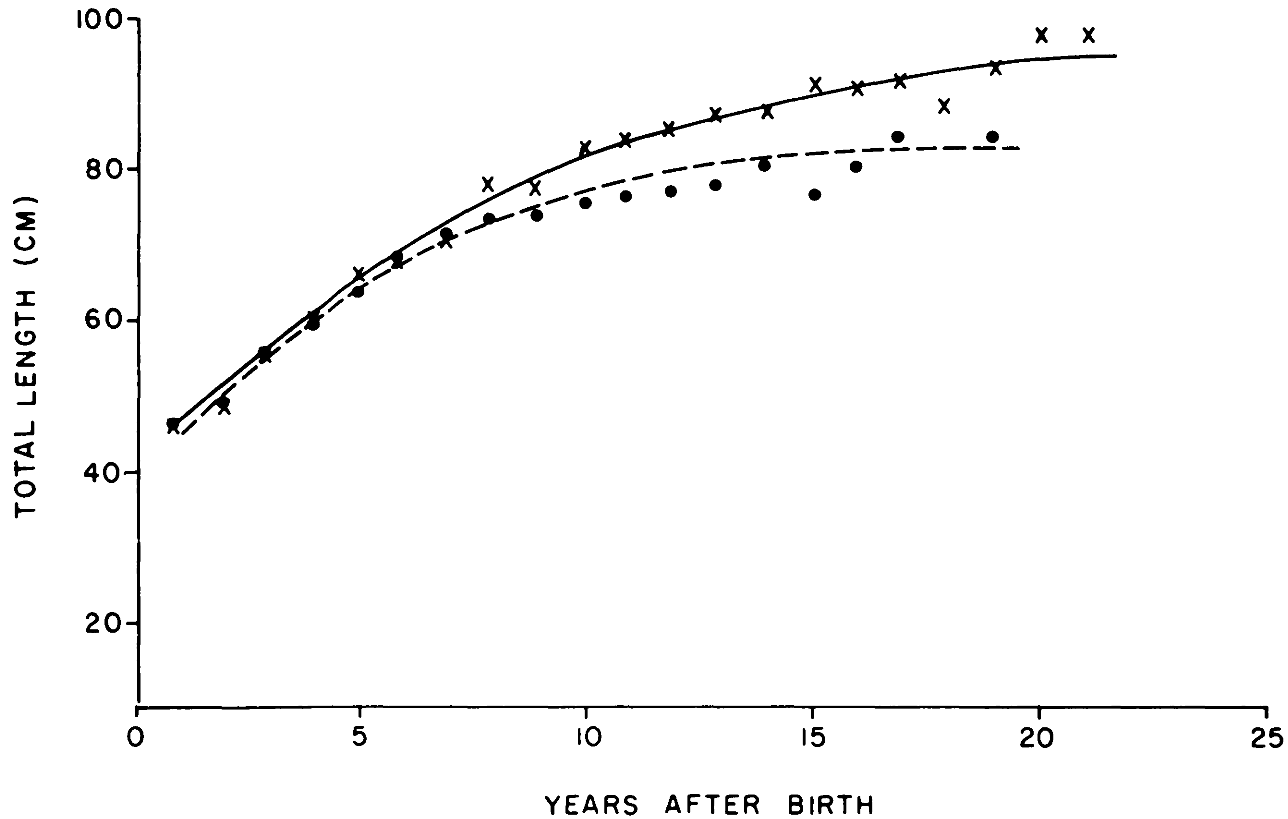

Figure 6. Age-length relationships for male (•) and female (x) spiny dogfish in the Northeast Atlantic, as determined by Holden and Meadows. (1962)

The above interpretation of Fig. 5 strongly suggests that either the population is strongly dominated by older, mature fish or that the smaller, immature spiny dogfish are less susceptible to capture by bottom trawls. While there is some evidence that spiny dogfish less than 45 cm may preferentially occupy the middle portions of the water column in some areas (Ketchen, 1975), most studies have shown the smaller size classes to be well represented in trawl catches (Ford 1921, Hicklin 1931, Bonham et al. 1949, Holden 1968). It is therefore likely that the annual recruitment into the mature size classes is a very small percentage of the total standing stock in the Northwest Atlantic. While previous studies have indicated that recruitment in this species may be inversely density-dependent (Holden 1968, 1973), it is evident that a major portion of the adult stock must be protected if the stock is to be maintained at a sizeable level. Work on the heavily exploited Northeast Atlantic spiny dogfish stock has indicated that the maximum sustainable annual yield may be only about 20% of stock size (Holden, 1968).

In addition to the summer fauna and spiny dogfish, several other species may have a limited fishery potential in this area. Smooth dogfish, Mustelus canis, appear briefly but abundantly in inshore waters during the migrations of this species, northward in late spring and southward in fall. A portion of this population may overwinter along the shelf break off Virginia (Musick, et al., 1979; Colvocoresses and Musick, 1979; unpublished VIMS records). Two species of oceanic sharks, the short-fin mako, Isurus oxyrhinchus, and the blue shark, *Prionace glauca*, have been taken regularly in offshore longline sets along the continental shelf break, but the data are too sparse to draw any conclusions concerning the fishery potential for these species.

Harvest Methods

Sharks are usually harvested by one of three methods; longlines, gill nets or trawls. The optimal method varies with the species sought, local bottom conditions and the economic capabilities of the participants in the fishery.

Longlining involves the attachment of baited hooks at regular intervals along a rope or wire mainline which is deployed behind a moving vessel. One or more marker buoys are attached to the mainline, and after the entire piece of gear has been paid out, it is allowed to set, or fish, for a suitable period and then retrieved with the catch. This procedure may be performed over a wide variety of vessel capabilities ranging from a small boat, two-man, hundred-hook, completely manual process to a fully automated, multi-thousand hook, large vessel operation. Longlining is particularly effective for the capturing of large species of sharks.

Large mesh (7-12 inch stretched mesh) gill nets are effective for the capture of sharks, particularly if the vicinity in which they are fished is 'chummed' or baited. Gill nets set for sharks in inshore waters are usually fixed in position with anchors, while those fished offshore are usually suspended from floatation buoys and allowed to drift. Gill nets are more effective than longlines at moderate to high shark population densities, but are considerably more cumbersome and expensive. Gill nets may be used to capture virtually any size shark depending on mesh size used.

Trawling is the most efficient method for capturing small sharks, provided the bottom is not too rough. Since even small sharks are relatively good swimmers, moderate to large size trawls are required at all but the highest population densities. Most of the larger species are generally capable of avoiding trawls.

While there is insufficient information available to assess the possible success of harvesting the summer shark fauna by either longline or gillnet, it is obvious that spiny dogfish are present in Virginia waters in insufficient concentrations during the winter months to be successfully harvested by any of the three methods. Because Squalus acanthias is a relatively small species of shark and the ocean bottom off Virginia is almost uniformly smooth, trawling should be the most cost-effective method of large-scale harvest, but the abundance of this animal should also allow for the effective harvest of this resource by small scale longline and gill net operations. Trawling operations directed at this intensely schooling species (which lacks a swim bladder) must be conducted with caution, however; if the net is fished for an excessive period of time it may become so filled with dogfish that it cannot be brought aboard without damage or loss of gear.

Processing Methods

As previously noted, the processing of a shark catch will depend upon the product or products which may be most profitably derived from the species in question. Ideally the whole shark should be utilized, resulting in the production of meat, fins, hides and liver oil, but this has generally been found to be impractical (Kruezer and Ahmed, 1978). Proper preservation of the meat generally results in spoilage of the hides, and vice versa. Fins from large sharks are considerably more valuable than those from small sharks on a per weight basis, as well as being more easily processed. Only a few species of deepwater sharks have livers of sufficient biochemical quality to be profitably rendered into a marketable oil.

In general, small sharks have been found to have the greatest value when processed for food, while large species tend to produce greater return when the hides and fins are taken and the remainder of the carcass is used for reduction purposes. Exceptions to this are the mako and porbeagle sharks, two relatively large sharks that are highly sought after as food.

If the sharks are to be primarily processed for hides and fins, skinning operations must commence within 24 hours after the shark is dead. Scarred or damaged hides have little value. Details of the skinning process may be found in Beaumariage (1968). After being removed from the shark prior to skinning, the fins must be dried, a process requiring about two weeks. The fins may then be packed and exported to the Far East (Hong Kong or Singapore), where virtually all of the final processing occurs. The remaining portions may be reduced to fish meal or processed into crab bait by salting. Shark meal is high in non-protein nitrogen and has generally been found to be inferior to other fish meals or unsuitable for use as animal feed in straight form, but produces an acceptable food supplement for cattle (Marshall et al., 1946), swine (Marshall & Davis, 1946), poultry (March et al., 1971) and pen-reared fish (Spinelli & Mahnker, 1976).

If the catch is to be primarily processed for food (as is the case for spiny dogfish), the catch must be carefully handled to avoid spoilage. Sharks have an unusually high content of urea in their bodies, which may become bacterially reduced to ammonia if the meat is not properly preserved. Urea content has been found to be somewhat proportional to the size of the shark (Morris, 1975), and for large species immediate bleeding of the shark and subsequent soaking of the meat in either water or weak acid (fruit juice) has been recommended to reduce the urea content (Ronsivalli, 1978). For spiny dogfish, however, immediate icing of the whole fish has been found to be adequate if the catch can be processed within 48 hours (Kruezer and Ahmed, 1978).

Subsequent processing of spiny dogfish involves removal of the head, tail, fins, entrails and skin from the trunk musculature, which is then individually wrapped and quick frozen. During this process the belly musculature is separated from the upper trunk and skinned and wrapped separately. The head, fins, skins and entrails may then be reduced.

Currently most of this processing is done by hand. A knife is inserted through the animal slightly below the lateral midline, and a cut is made posteriorly to the vent, passing over the pelvic fins but then exiting on ventral surface of the trunk. The belly flap may then be removed from the animal by making a cut from the origin of the first incision ventrally to immediately behind the pectoral fins. The dorsal fins and tail are then removed, the skin is cut along the back of the head and then pulled posteriorly down the length of the trunk. The trunk may be severed from the head and washed and packed, the belly flaps being likewise treated after the skin is removed.

The cleaning and packing of dogfish by hand is highly labor intensive but is currently the most common method. Some automated equipment is in use or is being developed. The Steen III skinning machine has been reported to be suitable for use on sharks, but requires operator labor for a significant portion of the process. The Massachusetts Institute of Technology Sea Grant Program has been developing a fully automated complete processing machine, but this machine has yet (December 1979) to be successfully demonstrated.

Other automated devices have been reported to be in use by processors who prefer to keep the nature and design of their machinery confidential.

Markets

The market for shark liver oil is currently restricted to those species which have over 80% unsaponifiable substance (mostly squalene) in their livers (Kruezer and Ahmed, 1978). Because none of the species taken locally even approach this content, it is unlikely that the production of shark liver oil would be profitable in the area at this time. A great deal of research is being conducted into the pharmaceutical uses of shark liver oils with some promising results (Ronsivalli, 1978).

Dried shark fins are used in the preparation of the oriental specialty shark fin soup, and demand has traditionally been very strong, especially for the larger fins. Dried shark fins in the U.S. can usually be sold for at least $4 a pound. The absorptive capability of this market, however, is obviously limited and the large scale production of shark fins, would probably lead to a depression of prices.

The shark leather tanning industry is based largely in the U.S. and the demand for shark hides is reported to be very high. While tanners have reported that the absorptive capacity of the market is "unlimited" and the industry is now severely supply-limited, it has been pointed out that the major factor in this situation has been the inability to obtain shark hides from domestic sources at competitive prices (Kruezer and Ahmed, 1978). The success of a local shark skinning operation is at this point questionable.

The domestic demand for shark meat is presently small but growing, as the prices of other fish escalate. Fresh shark steaks and fillets are sold in fish markets in many areas of the U.S., particularly along the Gulf and southern California coasts. Mako steaks, which are considered to be comparable to swordfish, are at a premium and bring over a dollar a pound ex-vessel. Ex-vessel prices for other species are much lower, usually 10-20 cents per pound. Some shark meat is frozen and shipped to inland areas and a small amount has been processed into breaded fish products for institutional use in the Gulf States (Davies, 1976). Consumer reluctance has been the traditional limiting factor of shark food fisheries. This appears to be changing as the consumption of shark meat is increasing despite the recent legislated abandonment of market-place pseudonyms (greyfish, flake, etc.). The long-term development of shark meat as seafood seems bright, but no dramatic increase in the domestic demand for shark meat appears eminent unless a major producer of prepared fish products should decide to use shark. This is unlikely at present since market conditions for competing products allow imported bulk frozen fish to sell for less than 10 cents a pound. Prepared fish products made from shark have been shown to be completely acceptable to consumers (Ronsivalli 1978; Morris, 1975), and a changed in the import situation could dramatically increase the domestic demand for shark meat.

There is little export demand for most shark with the exception of dogfish. Spiny dogfish, as noted above, have supported major fisheries in other countries for a number of years. The largest fishery has taken place in the Northeast Atlantic, where a large European market has been chiefly supplied by Norway and the United Kingdom. Squalus acanthias is virtually the only species used in the traditional 'fish and chips' trade in southern England. West Germans produce two very popular smoked delicacies from spiny dogfish: one of these, 'Schillerlocken', is made only from the belly portion. This produce has created a very strong import demand in West Germany for frozen belly flaps.

The European dogfish stocks have been very heavily exploited in the past few decades and there is strong evidence that they have been overfished (Holden, 1968). Landings in the Northeast Atlantic have steadily declined during the last ten years even with increased fishing effort (Fig. 7). Norwegian landings declined by 40% between 1970 and 1977. Greatly increased effort in the British fishery has compensated for this loss, but their fishery also appears to be declining. As a result, the price of spiny dogfish in Europe has steadily risen and an import market has developed. Canada attempted to enter this market on a large scale in 1973 with a resurrection of the Pacific coast dogfish fishery which had thrived during the 1940's, when dogfish livers were highly sought after for their vitamin A content. This new fishery ran into two immediate problems: mercury content was often found to be unacceptable and Canadian labor rates, which are among the highest in the free world, were found to be prohibitive for the extensive processing required. As a result the

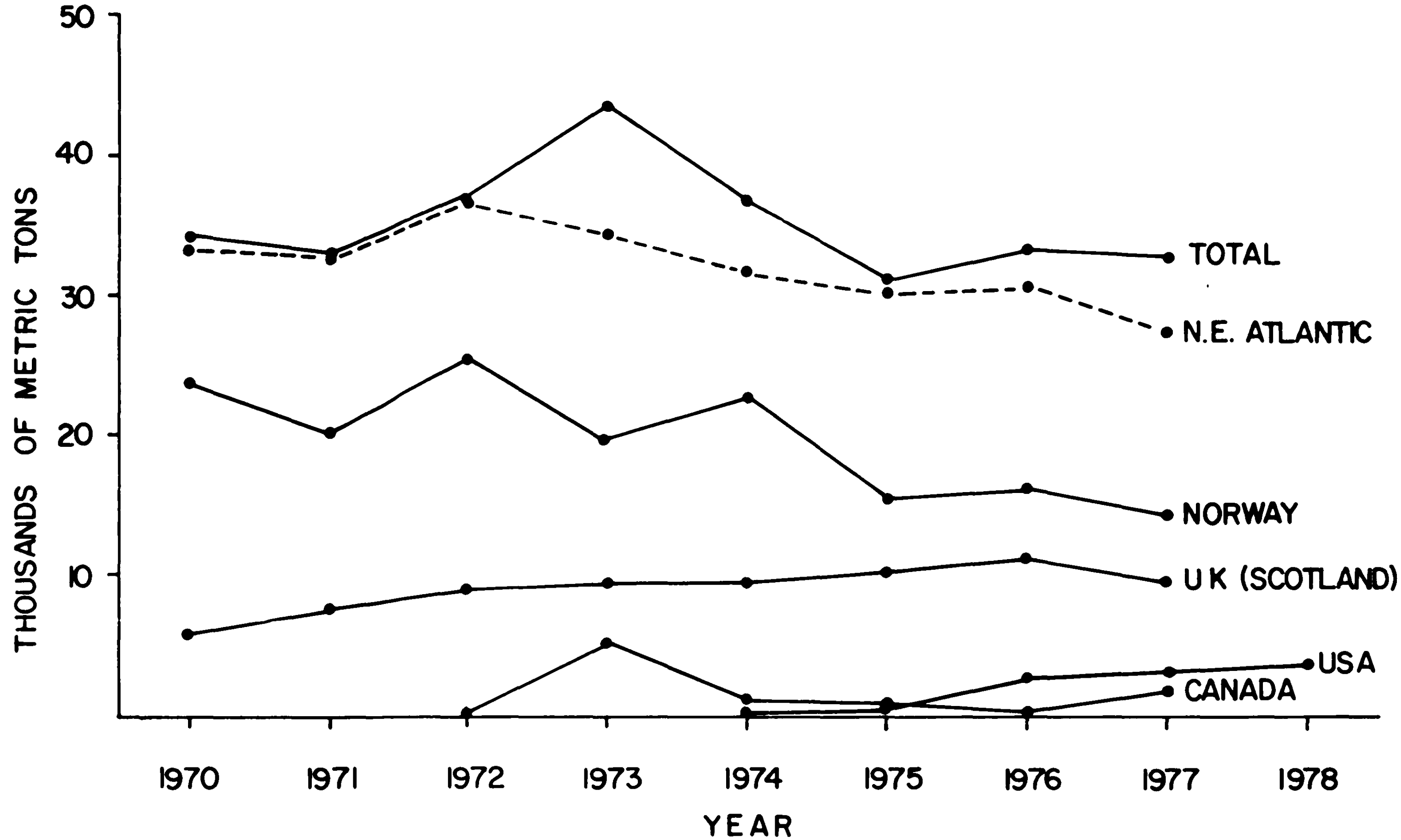

Figure 7. Reported world landings of spiny dogfish for the period 1970-1978 (sources: FAO Yearbook of Fishery Statistics, Fishery Statistics of the United States, State of Washington Department of Fisheries).

fishery sharply declined over the next three years and shifted southward to the Puget Sound area, where labor costs were lower and mercury concentrations more acceptable. By 1976 the U.S. was the world's third leading supplier of spiny dogfish to the world market. Other countries, notably Japan, France, and some Communist Bloc countries undoubtedly land significant quantities of this species but do not process or report their catches separately from other dogfish species. The Puget Sound fishery has continued to grow and virtually all of the catch is being processed for export to West Germany and Great Britain.

In view of the success of the Pacific coast fishery and the abundance of spiny dogfish along this coast, there can be little doubt of the success of an export fishery here. In fact, such a fishery is rapidly developing. Dogfish landings have sharply increased along the East coast during the past six months in response to solicitations from European (particularly West German) buyers. One Virginia processor, Fass Bros. of Hampton, has already begun processing of dogfish for export to West Germany. The prospects for expansion of this market appear good as northeastern Atlantic stocks of dogfish continue to decline. The potential of this fishery is reflected by the Fisheries Management Plan (FMP) for this species that is already being formulated despite the low levels of present harvest. In addition, there is an extant market for the meat of other species of dogfish including Mustelus canis, along the European Mediterranean coast, particularly Italy. Prices paid for these species, however, are considerably lower than for spiny dogfish (Kruezer and Ahmed, 1978).

A 1967 study (Holmsen, 1968) into the economic feasibility of an export fishery for spiny dogfish in New England concluded that such a fishery would operate at about a 20% net loss. Since that time, however, prices for dogfish in Europe have risen about fourfold, while the domestic cost of living index has only slightly more than doubled (2.17 in 1979). Dogfish bodies, cleaned, skinned and individually quick frozen which brought 17¢/lb. on the West German market in 1967 have recently been quoted as high as 65¢/lb. The price for belly flaps has risen even more sharply, from 30¢/lb. in 1967 to over $1.50/lb. in early 1980. The National Marine Fisheries Service provides a weekly review of European prices and market conditions for dogfish and other underutilized species which may be obtained by requesting the European Weekly Frozen Report from the National Marine Fisheries Service, News Market Branch, P.O. Box 1109, Gloucester, MA 01903, or by telephoning (617) 281-3600 ext. 212.

Conclusions and Recommendations

The local fishery potential for shark species other than dogfish is questionable. The size of the stocks are largely unknown and the current market demands for products deriveable from these species are low or unstable. Appropriate harvesting gear is not currently in local use. Mercury content of the flesh of these larger species is often above acceptable standards for human consumption (Hall et al., 1978).

We recommend that fisheries for such species be pursued in a very small scale and exploratory manner, if at all, until such time as the market and yield potential can be demonstrated to warrant further expansion. Eventual commercial exploitation seems inevitable. In the meantime, collection of biological and distributional data on these species is urged. A substantial and growing sport fishery is already acting upon these species (Stearns, 1976; Ronsivalli, 1978).

The fishery potential for spiny dogfish is unquestionably very large and there can be little doubt that the incipient East Coast fishery for this species will continue to expand rapidly in the coming years. Further research is needed immediately in the areas of processing technology and population biology of the Northwest Atlantic stock.

Perhaps the strongest indicator of the substantial commercial value of this stock is that the fishery is developing despite extremely labor intensive processing methods. Development of new automated processing techniques and the tests of the applicability or adaptability of extant machinery are sorely needed.

Although a considerable body of information exists on the general biology of spiny dogfish and their distribution in the Northwest Atlantic, these data will have to be carefully analyzed and expanded before firm management decisions can be reached. Of paramount concern are the assessment of the current population size and its ability to replenish itself. A first estimate of population size can probably be derived from extant data sources, but evaluation of the reproductive potential of this stock will require the collection of additional data on the age and sex structure of the population and refinement of average fecundity estimates. Breakdown of distributional information by size and sex may also provide optimal harvesting strategies.

Further examination of the ecological impact of this very abundant large predator would also seem advisable. Spiny dogfish have been shown to be a major predator on other commercial stocks (Bonham, 1954; Holden, 1966; Jones and Geen 1977c). Control of dogfish abundance strictly to reduce its impact on other species has been repeatedly urged in the literature (Templeman, 1944; Alverson and Stansby, 1963; Jensen, 1966). The eventual optimal management of this species may entail maintenance of depressed population size subsequent to initial overfishing. Such a strategy will require a very thorough understanding of the population dynamics of the stock in order to avoid depletion of the stock below harvestable levels.

Therefore, for the present, fishery development for sharks in Virginia (and the other Middle Atlantic and New England states) should be centered on the export market for spiny dogfish. The knowledge gained in this effort should be largely applicable to the future development of fisheries for other elasmobranch fishes. Preliminary work should be continued on the other species inasmuch as the knowledge available for these stocks is presently inadequate for even the roughest estimate of potential yield. Successful automation of the spiny dogfish industry will probably pave the way for the harvesting of other small sharks, particularly the smooth dogfish, *Mustelus canis*.

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