Spiny Dogfish in Canada

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ABSTRACT

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On both the East and West Coasts of Canada, there have been increasing claims that the dogfish infestation problem is so severe government must take action to resolve the problem.

This report provides detailed information about spiny dogfish (Squalus acanthias) in Canada to help resolve the debate about whether dogfish is a nuisance or a valuable resource.

Specifically, this report outlines the dogfish issue on the East and West Coasts of Canada, reviews existing biological information on the dogfish resource, documents factors known about harvesting the species, reviews traditional dogfish products and processing techniques, reports on existing and potential market outlets for dogfish products, and outlines options for addressing the dogfish problem facing Canada at this time.

It is recommended that fishery managers seek a workable solution to reduce the dogfish stocks rather than ignore the problem or try to eradicate the species entirely.

RÉSUMÉ

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Sur les côtes occidentale et orientale du Canada, de plus en plus de personnes affirment que le problème d'infestation par les aiguillats est si sérieux que les gouvernements doivent prendre des mesures pour le résoudres.

Le présent rapport fournit des informations détaillées sur l'aiguillat commun (Squalus acanthias) au Canada pour permettre de déterminer une fois pour toutes si l'aiguillat est une nuisance ou une ressource valable.

Plus précisément, dans ce rapport, on expose le problème de l'aiguillat sur les côtes est et ouest du Canada, on passe on revue les données biologiques existantes sur la population d'aiguillats, on présente les facteurs connus concernant l'exploitation de cette espèce, on examine les produits traditionnels tirés de l'aiguillat et les techniques de transformation, on signale les débouchés actuels et éventuels des produits de l'aiguillat et on expose les options qui se présentent pour aborder le problème de l'aiguillat auquel le Canada doit fairs face en ce moment.

On recommande que les gestionnaires des pêches essayant de trouver une solution réalisable pour réduire les stocks d'aiguillat plutôt qu'ignorer le problème ou essayer d'éliminer complètment l'espèce.

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Unfortunately, I cannot give appropriate credit to all who contributed to my research.

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While the project was funded by the Department of Fisheries and Oceans, the views expressed are mine and not necessarily similar to those of the Department. I alone am responsible for any errors or omissions that may exist.

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EXECUTIVE SUMMARY

On both the East and West Coasts of Canada there have been increasing claims that the dogfish infestation problem is so severe government must take action to resolve the problem.

This report provides detailed information about spiny dogfish (Squalus acanthias) in Canada to help resolve the debate about whether dogfish is a nuisance or a valuable resource.

Dogfish infestation along the Scotian Shelf, particularly in NAFO Division 4X, increased to crisis proportions in 1984 and 1985.

The main direct impact is on fixed gear fishermen carrying out a directed fishery for cod and haddock. Longline fishermen suffer economic loss and hardship as a result of lower catches of commercially valuable species, loss of bait to dogfish, and damaged gear.

The generally accepted dogfish problem in Atlantic Canada simply stated is: Dogfish are causing economic loss and hardship to some commercial fishermen and processors. Their numbers should be reduced.

On the West Coast, dogfish have generally been considered a nuisance species by both commercial and sport fishermen since the early 1900s. In addition, however, the industry on the West Coast has taken part in many intensive dogfish fisheries such as the one for oil in the late 1800s, for food during World War I, and for Vitamin A from livers during World War II.

Dogfish infestation on the West Coast is worst in the Hecate Strait off Queen Charlotte Islands, Queen Charlotte Sound, and on the West Coast of Vancouver Island.

Longliners fishing for halibut on the West Coast are hardest hit.

While dogfish have been widely blamed for the decline of commercially valuable species such as salmon and herring on the West Coast, there is virtually no scientific evidence to support the view that these commercial fisheries would be improved if dogfish were eradicated.

Simply stated the dogfish problem in Western Canada is this: Dogfish are causing economic loss and hardship to some commercial fishermen and are an inconvenience to sport fishermen. Their numbers should be reduced.

There have been many attempts since the 1950s, on both coasts, to subsidize development of dogfish fisheries. There is, at present, an ongoing dogfish fishery in British Columbia.

An historical examination of the Canadian fishing industry shows dogfish is not a new concern to fishermen. Fishery managers, however, have to date been unable to find satisfactory long-term solutions to the dogfish problem of the day.

Dogfish are slow growing, long living and late maturing. In addition, they have low fecundity and hence have low reproductive potential.

The commercial fishery generally seeks females because they meet the minimum market size requirements while males normally do not. If fillets are being produced, smaller fish are acceptable so males can be fished in addition to females.

The estimated total dogfish biomass in the Western Atlantic is 250,000 to 300,000 T. The estimated maximum sustainable yield is approximately 25,000 T per year. The estimated biomass of marketable size dogfish in the Northeast Pacific is 350,000 T of which 170,000 T is in British Columbia waters excluding Strait of Georgia. The estimated maximum sustainable yield is approximately 18,000 T per year.

Dogfish are opportunistic eaters consuming sandlance, mackerel, and herring as well as groundfish species if abundant. It is estimated that dogfish in the Western Atlantic eat about 390,000 T of fish per year and about 180,000 T of squid per year. Whereas research published in British Columbia in 1977 indicated that dogfish consume enormous quantities of herring, salmon, and crab, dogfish consumption of other species has been carefully reviewed since then. It is now felt that dogfish consume 20,000 to 30,000 T of herring per year and negligible quantities of salmon.

Some fishery managers in the United States feel that it might be necessary to implement a dogfish management plan to protect the Atlantic stock. The Canadian West Coast stock has been regulated by management plans for years.

Available scientific information does not provide an answer to why dogfish have been a larger problem in Atlantic Canadian waters in 1984 and 1985 than they have been historically. That is, we do not know if stock size has increased to the point that the traditional migration patterns of the stock have been disrupted; whether migration patterns have been altered in response to changes in water temperatures or changes in migration patterns of prey species such as mackerel; or whether the large numbers of dogfish in Canadian waters in 1984 and 1985 are a freak occurence.

Trawl gear can be used to harvest dogfish if the fish is sufficiently concentrated. Special modifications to the gear are needed and, even with modifications, significant damage can be anticipated.

Longline gear may be able to produce a higher quality product and it may allow a greater selectivity of fish caught.

There are two advantages to limited onboard processing (such as gutting and cutting off fins). The first is that overall quality can be improved. The second is that offal disposal costs can be significantly reduced. However, the final decision about onboard processing must be based on market requirements. Some products sold in some markets require dogfish to be landed round.

Temperature control is probably more important to overall quality than is gutting at sea. The primary goals of fishermen should be to keep dogfish as cold as possible and land it as quickly as possible.

The British Columbia fishery lands about 2,500 T per year. About half of this is landed in the United States. Trawlers land about 70 percent of the catch while longliners land about 30 percent of the catch. Sunken gillnets were used experimentally in Puget Sound.

Poland participated in a dogfish joint venture on the West Coast in 1977.

Further work is required before an accurate predicition can be made about the groundfish bycatch associated with trawlers over 79 m (200 ft.) long fishing for dogfish in Canadian waters.

Potential dogfish products include backs, belly flaps, fins and tails, frozen dressed, fillets, surimi, yu-sone, oil, fish meal, skins, and products such as silage from waste material.

A dogfish processing operation selling products into the traditional markets must be based on backs, flaps, and fins and tails. It would appear risky to develop a commercial operation based on products like surimi, yu-sone, oil, fish meal, skins or silage.

Dogfish processing is labour intensive. The machinery developed to date is unable to outperform people. Indeed, there are some processing operations, such as skinning belly flaps, in which there is a market preference for hand processing over machine.

In the plant, good manufacturing practices should be followed and the dogfish should be processed as soon as possible after it is harvested.

The consensus of opinion is that fresh dogfish, under ideal conditions, can be stored no longer than 10 days.

The consensus of opinion is that frozen dogfish backs, under ideal conditions and at temperatures of -30°C, can be stored no longer than six months. Frozen belly flaps under similar circumstances can be stored no longer than eight months.

The major British Columbia dogfish producer produces frozen backs and belly flaps for the European market, frozen fins and tails for the Oriental market, frozen dressed dogfish for sales to Japan, and dogfish oil for sale to the pharmaceutical and cosmetics industries in the United States.

At least two processors in Southwest Nova Scotia processed frozen dogfish fillets for the domestic market in 1985 and intend to do so again in 1986.

England consumes dogfish backs. Over 90 percent of the backs are sold in fish and chips shops within 150 kilometres (100 miles) of London.

The United Kingdom imports 3,500 to 4,000 T of dogfish per year. Fresh dogfish from Ireland fills over two thirds of the United Kingdom requirements.

The United Kingdom exports over 4,000 T of dogfish per year. France consumes 85 to 90 percent of total United Kingdom exports. About 90 percent of this quantity is fresh.

Belgium consumes dogfish backs only. Most backs are smoked. Some non-smoked backs are prepared by boiling the fish with onions and other vegetables to make a fish-in-gelatin product called escaveche.

Belgium imports about 650 T of dogfish per year.

France consumes dogfish backs only. Almost all backs are sold in the institutional market. France imported over 5,500 T of dogfish in 1983 and 1984.

Italy prefers fresh over frozen dogfish backs. Italy imports 3,000 to 3,500 T of dogfish per year.

In Germany, 70 to 80 percent of the imports are belly flaps while 20 to 30 percent are backs. German imports totaled 1,900 T of dogfish in 1984.

The Orient imports virtually all of the dogfish fins and tails produced in the world.

The current market price for frozen dogfish backs is as low as $.47 US per lb. CIF Europe. It is usually $.52 to $.55.

The current market price for frozen dogfish belly flaps is $.90 US per lb. FOB East Coast United States.

The current market price for frozen dogfish fins and tails is $.80 US per lb. FOB East Coast United States.

Canada supplies (from British Columbia) about 500 T or about four percent of total European dogfish imports. The United States supplies about 2,500 T or 20 percent of the European market.

Best available estimates are that the European market can import at most an additional 10 to 15 percent of its current imports. This converts to round weight of 4,000 to 6,000 T.

Attempts to develop the North American market have generated a lot of enthusiasm but met with limited success. Successful market development must focus on the "right" product. It appears costly techniques such as media coverage, in-store demonstrations, and even product samples will be required. At a minimum, marketers should select a name with more appeal than dogfish.

The fishery is, at best, a low margin one for processors. The price to fishermen therefore can be expected to be extremely low in comparison to the prices for species such as cod and haddock (on the East Coast) or halibut (on the West Coast).

Even if fishermen and processors worked to develop their dogfish processing skills, the market in Europe can absorb, as stated above, no more than an additional 4,000 T to 6,000 T round weight.

Harvesting 4,000 to 6,000 T is almost insignificant in a resource with a total Canadian biomass of about 500,000 T. Removals of this order are an inadequate solution if the problem is defined as "we have too much dogfish in our waters". Other options must be addressed.

Decision makers must be aware that a program implemented on one coast will likely result in requests for a similar program on the other coast.

At one end of the range of options is the status quo option. Ignoring the issue does not appear to be an appropriate solution.

At the other end of the range of options is a program to eradicate the species entirely. Eradication has never worked in the past and is not now likely to be successful. In addition, dogfish may play a useful balancing role vis-a-vis other forms of marine life and may one day become an extremely valuable source of protein. Eradication does not appear to be biologically appropriate or economically feasible.

If the dogfish problem is defined as a longliner problem, the location of dogfish could be closely monitored and this data could be made available to fishermen so infested grounds could be avoided. Fishermen probably do this informally now.

Further research could be conducted into repelling dogfish. It is possible that bait could be treated to make it unattractive to dogfish, sonar equipment could keep dogfish away from areas being fished, and plastic hooks could be less vulnerable to dogfish attacks.

The most practical way to decrease the dogfish nuisance factor is to harvest significant quantities of the fish on an ongoing basis. An almost endless number of suboptions exist. The harvesting itself can be by trawlers or longliners, small or large vessels, domestic or foreign, subsidized directly, indirectly or not at all. The processing of traditional products may or may not be subsidized. If there is to be a subsidy for processing dogfish, it should concentrate on developing new food and non-food products. If there is to be assistance at the marketing level, it should concentrate on new markets for new products. Examples are frozen dressed dogfish in the Orient and frozen fillets in North America.

New food and non-food products and/or new markets provide one of the best longterm solutions to the dogfish problem. These prospects warrant further investigation.

Additional biological research is needed to help place a "cost" on the dogfish problem. Specifically, the biomass and the maximum sustainable yield must be agreed upon. Also, target removal levels must be identified for specific goals (such as to contain growth or to cut the stock in half over five years). It would be nice to have a better understanding of the size and sex distribution of the dogfish that come to Canadian waters, and when and why they migrate. Finally, we should have a better understanding of the quantity of commercial species of fish that dogfish consume and how dogfish interact with other forms of marine life.

Further research should be conducted into the groundfish bycatch expected if large trawlers fish for dogfish. If small boats cannot participate in an extended experimental dogfish fishery or managers are not convinced that the data from draggers can be extrapolated to large trawlers, then consideration should be given to the experimental use of large domestic trawlers that are currently idle.

The Department of Fisheries and Oceans, if convinced action is required to reduce the dogfish population, should augment or replace the various committees and working groups investigating dogfish with a designated person on each coast to act as a full-time dogfish control program coordinator. This person would be responsible to arrange the meetings necessary to obtain the required biological input, put into place a program to get bycatch data, and consult with the various interest groups while expanding the options identified.

Dogfish presents fishery managers with a unique problem in an industry where the normal practice is to ensure the fish resource remains strong. However, the dogfish resource is a considerable nuisance to commercial fishermen and steps to control the stock should be closely examined and, if practical, implemented as soon as possible.

A comprehensive dogfish bibliography was published by the Department of Fisheries and Oceans Pacific Region in 1976 (Jones and Geen, 1976).

INTRODUCTION

"Dogfish". The name itself brings to mind something rather unpleasant. Is this fish the nuisance some people claim it is or is it a new resource waiting to be discovered?

This report provides detailed information about spiny dogfish (Squalus acanthias) in Canada to help resolve the debate about whether dogfish is a nuisance or a valuable resource. The report is national in scope. However, it deals separately with the East Coast and West Coast except when the subject matter is generally applicable.

Table 1 presents commonly used names for the species.

PURPOSE OF REPORT

The purpose of this report is to:

1. bring together and consolidate existing information on the species;
2. outline the issue facing fishery managers and industry participants;
3. review existing biological information on the dogfish resource in Canada;
4. document factors known about various methods of harvesting;
5. review traditional dogfish products and processing techniques;
6. report on existing market outlets for dogfish products; and,
7. outline options to address the dogfish issue in Canada.

REPORT FORMAT

The following section presents findings concerning dogfish biology. Then the report presents information about harvesting methods, actual harvesting on the West Coast, and the results of the 1985 experimental dogfish fishery on the East Coast. Detailed information about dogfish products and processing techniques is presented. Existing markets for the principal dogfish products are examined. The report then discusses this material and presents options for the East and West Coasts to deal with their respective dogfish issues. Finally, a summary of conclusions is presented.

First, however, the dogfish issue is defined and the issue is placed in historical context.

THE DOGFISH ISSUE

On the East Coast, dogfish infestation along the Scotian Shelf, particularly in NAFO Division 4X, is reported to have increased to crisis proportions during the summers of 1984 and 1985. Figure 1 shows the NAFO divisions in Atlantic Canada as well as the principal dogfish migration routes.

The cursed dogfish is one of the major items on the minds of fishermen from southwest Nova Scotia when they list factors that interfere with their livelihood. The local press has had an interest in the dogfish issue and this coverage has resulted in surprisingly broad public knowledge that dogfish is hurting the area's commercial groundfish fishery.

The main direct impact is on fixed gear fishermen directing their efforts for cod and haddock. Handline and longline fishermen are generally affected but the longline vessels less than 14 m (45 ft.) which rely on groundfish for the majority of their income are hardest hit. Longline gear is very effective at catching dogfish. This is a problem as long as shored-based processors are not interested in purchasing dogfish. The lack of a steady market means most fishermen throw dogfish back into the water. Thus, longline fishermen suffer economic loss and hardship as a result of lower catches of commercially valuable species, loss of bait to dogfish, and damaged gear. Finally, dogfish attack and consume groundfish already on longline gear and render the groundfish worthless.

The gillnet fishery is affected by damaged fish and torn nets.

Although the dogfish do interfere with draggers on the Scotia Shelf, to date the draggers have been able in large part to avoid catching excessive quantities. The crew can examine a tow of

fish to determine if the dogfish catch is excessive before the tow is brought aboard the vessel. Dogfish have also caused problems for the offshore pollock and silver hake fisheries (Annand 1985).

Fishermen generally believe that stocks of cod and haddock have declined in the areas infested by dogfish and it is possible that dogfish is in part responsible for this decline. The stocks may simply be dispersed by the dogfish or the dogfish may be eating a significant quantity of mature or pre-recruit groundfish. This secondary impact is more subtle but it is very significant to the local economy. The majority of the 208 registered fish plants in the southwest Nova Scotia area are partially dependent upon longline caught groundfish landings. With landings decreasing, fish plant employment has been adversely affected.

Although the true cost of dogfish infestation in Atlantic Canada has not been documented, there is no question that the problem is a very real one to the fishermen and plant workers involved.

Simply stated, the dogfish problem in Atlantic Canada is this: dogfish are causing economic loss and hardship to some commercial fishermen and processors. Their numbers should be reduced.

On the West Coast, dogfish have generally been considered a nuisance species by both commercial and sport fishermen since the early 1900s. What makes the West Coast different from the East is the West Coast's history of short term successful dogfish fisheries (such as in the 1890s, during World War I, and during World War II) followed by years of declining fortunes, and finally years during which the rebounding stock was regarded as a nuisance. The West Coast has a history of dogfish booms and busts.

Dogfish infestation is worst in the Hecate Strait off Queen Charlotte Islands, Queen Charlotte Sound, and on the West Coast of Vancouver Island. Figure 2 shows the Northeast Pacific and the principal areas of dogfish fishing.

Although the trawler and sport fisheries are affected, the main direct impact is on longline vessels. Longliners fishing for halibut are hardest hit. The International Pacific Halibut Commission conducts an annual survey of about 100 stations from May to July each year to determine halibut catch rates etcetera. Correspondence from the Commission indicates that for the years 1982 to 1985, dogfish made up 44, 76, 54 and 71 percent of the total catch by number (respectively). Thus, halibut fishermen suffer economic loss and hardship as a result of lower halibut catches, loss of bait to dogfish, and damaged gear.

Trawlers on the West Coast, similar to those on the East Coast, can generally avoid dogfish depending on the area fished.

Dogfish have been widely blamed for declining stocks of herring and salmon on the West Coast. The research published by Jones and Geen (1977), though subsequently discounted, convinced some industry representatives that dogfish consumed 230,000 T of herring, 84,000 T of salmon, and 28,000 T of dungenese crab annually. This research contributed, in a substantial way, to the severity of the dogfish "problem" even though the dogfish population has stayed the same or, if anything, decreased marginally in the last few years. The dogfish "problem" was, in part, caused by scientific information overstating the dogfish consumption of commercially valuable species of fish.

In fact, there is now an emerging realization that we know very little about dogfish and its interactions with other marine life. For instance, even though dogfish do consume herring (current consumption is estimated to be between 20,000 and 30,000 T per year [MacFarlane, 1986]), juvenile dogfish are known to prey heavily on jellyfish. And jellyfish are known to consume larval herring among other species. We could benefit greatly from a better understanding of the relationship among dogfish, jellyfish, and herring.

Similarly, there is very little evidence to support the allegation that dogfish eat large quantities of salmon. Evidence can be found, however, that older chinook and coho salmon are predators of young salmon smolts. This is still a very controversial matter, however, and those people whose livelihoods depend on salmon tend to

believe there is a severe dogfish problem. For instance, one fishermen's group claims, "a dogfish eradication program would be the cheapest and most effective salmon enhancement program that could be devised".

Although the true cost of dogfish infestation on the West Coast has not been documented, there is little doubt that the problem is a real one to the people involved.

Regardless of the facts concerning the extent and cost of the dogfish problem, the government has implemented about a dozen dogfish subsidy programs on the West Coast from 1956 to 1976. None, of course, have successfully lowered the stock level.

Poland participated in a dogfish joint venture arrangement in 1977. There have been no other forein fisheries for the species since then although many nations have expressed interest.

In the early 1980s, the Western Fishermen's Federation proposed another subsidy program to reduce dogfish stocks. Longliners were to catch dogfish for 20 cents per pound. The total program was proposed to cost $40 million over two years. The program was not implemented.

In 1985, the Department of Fisheries and Oceans, in reviewing a $12 million dogfish eradication proposal made by the Western Fishermen's Federation and considered by the Minister's Advisory Committee, concluded that the dogfish nuisance factor could be best dealt with by fishing the stock on a sustained yield basis by harvesting 18,000 T per year. The Department suggested a subsidy paid to fishermen for dogfish landings in Canada. At a subsidy equivalent to five cents per pound (round weight), the identified target of 4,000 T would have required a subsidy not to exceed $600,000 per year. This program was not implemented.

Simply stated, the dogfish problem in Western Canada is this: dogfish are causing economic loss and hardship to some commercial fishermen and are an inconvenience to sport fishermen. Their numbers should be reduced.

AN HISTORICAL PERSPECTIVE

In 1904, a fish packer in Petit de Grat, Nova Scotia packed a small sample of dogfish in cans. Some were sent to hotels where the product was served as "Japanese Halibut". At around the same time in Halifax, large quantities of dogfish were canned and marketed as "ocean whitefish". In Charlottetown, Prince Edward Island the product was canned and sold as "sea bass" (Mavor 1921).

In 1907, Mr. G.M. Cornish wrote about dogfish in Canso, Nova Scotia:

> "This is an extremely common species and often a great nuisance to the fishermen fishing with trawls and baited hooks. I have known gear with 700 hooks to have 690 of these dogfish upon it. No use is made of these fish; they are difficult to release from the hooks, and they snap off the snood; they are regarded with much disfavor" (Cornish 1907).

Mr. Cornish writes further about dogfish in the Tignish area of Prince Edward Island:

> "The picked dogfish is very common and extremely destructive. It appears about the end of July and remains until the end of the fishing season in the autumn. It is noticed in the east a few days before it reaches the west coast (of Prince Edward Island). As a result of its appearance, fishing for cod may often cease entirely early in August; the trawls of hooks are set for cod at night and when raised in the morning sometimes every fish had been devoured by this pest, only the heads and vertebral column remaining on the hook" (Cornish 1912).

Dogfish has been fished for years in the North Sea. European longliners and British trawlers caught 3,000 T of dogfish in 1930 for European markets. This peaked at 42,000 T in 1963 after which landings declined due to overfishing.

For an excellent detailed description of spiny dogfish utilization in the Northeast Pacific, see Ketchen (1986). The report reviews the taxonomy, distribution, migrations, definition of stocks and life history of the spiny dogfish as background to an historical account of its utilization in the Northeast Pacific. The report

concludes that development of a sustained dogfish fishery is the only plausible alternative for dealing with dogfish nuisance and predation problems.

On the Pacific coast, it is reported that the production of dogfish oil peaked in 1883 at a volume of 250,000 gallons. The oil was used in coastal sawmills and coal mines for lubrication and lighting. Shortly after this, the United States placed high tariffs on imported dogfish oils and calcium carbide lamps were introduced. Thus, this fishery virtually ceased in the early 1900s. The commercial fishery for dogfish started again around 1916 when dogfish was caught for the fresh fish market. The United States Congress appropriated $25,000 for a program to encourage the use of dogfish for human food on June 21, 1916. This product (both fresh and canned) appeared under the names of whitefish, rock salmon and greyfish.

The British Columbia industry boomed during the First World War, then collapsed. In the late thirties, a fishery for livers for Vitamin A commenced. Landings exceeded 5,000 T for over a decade. This Vitamin A fishery boomed during World War II when European supplies were cut. Landings peaked at about 30,000 T in 1944. At the time, it was the fifth most important fishery in the nation. Despite market demand, the fishery declined due to overfishing until 1948. By 1950, a synthetic Vitamin A had been introduced. Landings that year were 2,020 T.

An indication of the views towards dogfish in the United States Pacific northwest in the late 1950s can be found in the title of a document submitted by Washington State fishery representatives to the United States Senate Committee investigating dogfish. Their submission is titled, "The Menace of the Dogfish Shark on the Pacific Coast". The first sentence reads:

> "One of the most pressing problems of the Pacific coast fishery today is the growing menace of the dogfish shark upon our valuable fisheries" (Wedin and Moore 1959).

The hearings of the United States Senate Committee in 1959 resulted in agreement to implement a broad-based program aimed at reducing dogfish abundance on the west coast. It was estimated that the dogfish control program would cost $345,000 per year and no more than $1,380,000 for the full four year program.

That same year, the British Columbia Fisheries Department chartered five trawlers as "killer boats".

In 1968, New England fishermen asked the University of Rhode Island to investigate ways to help the industry find methods of reducing the dogfish menace. Andreas Holmsen's report is the University's response. The first sentence in this report is:

> "The spiny dogfish is considered an unmitigated curse by New England fishermen because of its destruction of nets and its malicious depredation of other fish and young crustaceans" (Holmsen 1968).

The Federal Government implemented a dozen dogfish subsidy programs on the west coast of Canada from 1956 to 1976.

In 1973/74, the government was willing to pay a subsidy of $50.00 a ton for dogfish caught and processed in British Columbia. Terms of the program meant that a company received an additional two tonnes of roe herring quota for every tonne of dogfish bought. Companies participated at least in part to secure additional quotas of roe herring.

The Newfoundland government provided a subsidy to establish a dogfish fishery on the south coast in 1979. Due to economic factors, the fishery did not develop as hoped.

There is an ongoing dogfish fishery in British Columbia. Slightly over one-half of the total annual catch of 2,500 T to 3,000 T is landed in the United States. The remainder is processed in British Columbia.

Dogfish is <u>not</u> a new concern to commercial fishermen. Fishery managers, however, have to date been unable to find satisfactory longterm solutions to the dogfish problem of the day.

THE DOGFISH RESOURCE IN CANADA

This section presents information of a biological nature on the dogfish resource in Canada. First, a description of the species is presented. Second, unique biological properties of the species are discussed in detail. Third, the Western Atlantic stock is examined. This examination concentrates on the range and behaviour of the stock, size estimates, and fishery management measures. Fourth, the Northeast Pacific stock is examined in a similar fashion. Finally, points of significance for this report are listed.

DESCRIPTION OF SPECIES

Squalus acanthias, the scientific name for spiny dogfish, comes from the Latin Squalus meaning shark and the Greek Akanthias referring to spines.

This report uses "dogfish" and "spiny dogfish" to refer to Squalus acanthias. In addition to spiny dogfish, Canadian waters contain smooth and black dogfish though these species are not nearly as common as spiny dogfish. For further information, see Leim and Scott (1966) concerning dogfish in Atlantic Canada or Clemens and Wilby (1967) concerning dogfish in the Pacific.

This slender streamlined fish is a small but true shark. Virtually all articles written about spiny dogfish contain the following general description:

Spiny dogfish is a small brown or gray shark with a large spine lying along the front margin of the dorsal fin. The spine preceeding each of its two dorsal fins and its lack of an anal fin distinguish it from other sharks. It is slender with a flattened head and a snout tapering to a blunt lip. It has a cartilaginous rather than a bony skeleton. Its mouth is situated on the underside of the head well behind the snout and jaws are covered with many sharp teeth in several rows.

Mature Atlantic fish generally range from 70 cm to 105 cm long (two to three and a half ft.) and weigh from three to five kg (six and one half to 12 lb.). Mature male dogfish in the Pacific reach one m (three ft.) and weigh four kg (nine lb.). Mature female dogfish in the Pacific reach 1.5 m (4.5 ft) and weigh up to nine kg (20 lb.).

Figure 3 displays a drawing of dogfish.

UNIQUE BIOLOGICAL PROPERTIES OF DOGFISH

Dogfish is characterized by slow growth and long life. In the Western Atlantic, females reach a maximum age of 40 years and a theoretical maximum length of 100.5 cm (40 in.). Males reach an age of 35 years and a length of 92.49 cm (36 in.) (Nammack et al 1985). On the Pacific Coast, a different aging technique is used by biologists and, while the Atlantic and Pacific dogfish may be similar, the Pacific fish are considered longer living and slower growing. The age can reach 95 years and the length 124.3 cm (49 in.) according to Ketchen (1975), but the generally accepted maximum age is 60 years. For more information on the current West Coast aging techniques, see Beamish and McFarlane (1985).

Tag return data support the theory that dogfish is slow growing. A spiny dogfish in the Western Atlantic was tagged at 74 cm and when caught eleven years later had grown only 13 cm (Nammack et al 1985).

There has been a great deal of work concerning maturation of dogfish. The standard measure used is the age and size at which 50 percent of the dogfish are mature. Slauson et al (1983) report that 50 percent of the males are mature at a size of 75.7 cm or an age of 14 years. The same authors conclude that 50 percent of females reach maturity at 92.8 cm or 18 to 19 years of age. Ketchen (1972) reports that 50 percent of Pacific Coast male dogfish reach maturity at 72 cm while the corresponding measure for females is 93.5 cm.

Dogfish have low natural mortality rates for a variety of reasons. The most significant is that the only known predators of dogfish are larger sharks and there is no evidence to suggest that larger sharks prey heavily upon the dogfish in Canadian waters.

Dogfish are also characterized by low fecundity. The number of pups per litter ranges from one to 11 in the northwest Atlantic (Jensen 1966) or from two to 15 according to Nammack et al (1985). On the West Coast, the number of pups per litter ranges from two to thirteen (Ketchen 1972). In both areas, the average number of pups is six per litter. Pups are born live after a gestation period of approximately two years. Hence, each mature female has an average of three pups every year. This is a very low reproductive rate.

The literature contains many warnings about the potential for rapid over-exploitation of sharks because of slow growth rates and low fecundity rates, the schooling of large mature individuals by sex and direct stock recruitment relationships.

Dogfish are opportunistic eaters. Their diet consists primarily of fishes, crustaceans, and mollusks. The fact that sandlance, mackerel, and herring are major prey for dogfish in the northwest Atlantic may reflect the availability of prey more than a preference for those species per se. In addition, it is not possible to rule out groundfish as a prey species in times of high abundance. Annand (1985) points out that dogfish may be a significant source of mortality on commercially valuable groundfish species.

On the west coast, fish constitutes two thirds of the diet of dogfish. The most prominent species reported by Bonham (1954) are ratfish, herring, and krill. The author concludes that large and small dogfish eat essentially the same kinds of foods. He also reports the results of another study conducted in 1921 in England. Of the sample of 143 dogfish, 137 contained fish in their stomachs, six had crustaceans, and three had eaten mollusks. Of the 137 with fish in their stomachs, 67 percent had consumed herring, 19 percent mackerel, and four percent had eaten cod.

McFarlane et al (1984) extensively surveyed the diet of dogfish in Hecate Strait. Table 2 presents selected data from stomach content analysis conducted in August 1977 and June 1978.

Waring (1984) has tried to estimate the food intake of dogfish. Based on a biomass of 210,000 T of dogfish greater than 60 cm, estimated consumption of fish is 387,000 T annually. In addition, the biomass of 21,900 T of dogfish smaller than 60 cm is estimated to consume 179,000 T of squid each year.

As reported earlier, Jones and Geen (1977) estimated the food intake of dogfish in the Pacific Ocean. Their estimates have subsequently been refuted by biologists at the Pacific Biological Station. The Biological Station scientists consider the extrapolation made by Jones and Geen to be inaccurate because their sampling was biased towards one area (Strait of Georgia) where herring, as well as dogfish, is known to exist disproportionately to its coastwide distribution. McFarlane (1986) currently estimates dogfish consume 20,000 to 30,000 T of herring per year and negligible amounts of salmon. He states there is no evidence to suggest a reduction in dogfish biomass would lead to an increase in other commercially valuable species.

THE DOGFISH STOCK IN ATLANTIC CANADA

Dogfish Range and Behaviour

Dogfish has been reported from Greenland to Southern Florida and Cuba but more typically it ranges from Newfoundland to Georgia. The fish is highly migratory and travels in schools which are generally segregated by size (for immature individuals) and by sex (for mature individuals).

Dogfish are chiefly summer visitors to the Gulf of Maine and the more northern waters of the Scotian Shelf and the Gulf of St. Lawrence. During winter, they migrate south and are concentrated in the mid-Atlantic region where mating and pupping presumably occur.

Tag returns indicate that some dogfish migrate from Newfoundland to Virginia and Florida or even east to Iceland. Tagging suggests that dogfish in the northwest Atlantic may constitute one stock but that migration patterns differ during different stages of maturity.

Very little information is available about the part of the stock that moves north from United States waters into Canadian waters, but generally only dogfish greater than 65 cm (25 in.) are found in Newfoundland waters. This suggests that juveniles do not make lengthy migrations. Both mature and immature dogfish have been known to overwinter off Newfoundland and in other parts of Atlantic Canada.

Migration seems to be associated with a preference for bottom water temperatures of from 7°C to 13°C (44°F to 55°F). This may be related to the migration patterns of prey species, though, and the actual causes of differing migration patterns have not been adequately investigated.

Detailed information on dogfish migration patterns and related subjects can be found in Nammack et al (1985) and Waring (1984).

Stock Size Estimates

Minimum biomass estimates of dogfish from 1968 to 1983 spring and 1968 to 1982 autumn surveys have fluctuated widely in recent years. The spring estimates range from 96,000 T to 898,800 T and average 285,700 T. The autumn estimates range from 85,400 T to 347,500 T and average 148,000 T (Waring 1984). The 1984 spring estimate of 275,000 T is slightly above the 1968 to 1983 geometric mean of 240,000 T.

Most fishery representatives estimate the dogfish biomass in the western Atlantic to be between 250,000 and 300,000 T.

Current estimates of the maximum sustainable yield from this stock are 20,000 to 25,000 T per year (Grulich and DuPaul 1985c).

Waring also reports that the size composition and fecundity of dogfish in the northwest Atlantic have increased in recent years. These increases are believed to result from a combination of limited exploitation, reduced competition, and increased abundance of suitable prey.

Although there is a small ongoing directed fishery for dogfish in the New England area, the last major removals from the stock occurred in the early and mid 1970s when foreign (primarily Russian) trawlers removed approximately 20,000 T per year.

The removal of foreign effort combined with the lag time dictated by the species' slow growth and low reproductive rates could be factors responsible for an increasing dogfish stock, which in turn could be causing the current dogfish problem in NAFO Division 4X.

Fishery Management Measures

There has been no formal fishery management plan developed in either the United States or Canada to protect the dogfish resource. However, as the current interest in prosecuting an ongoing dogfish fishery increases in the New England and mid-Atlantic areas of the United States, there is more interest in creating a management plan.

Nammack et al (1985) conclude:

> "The spiny dogfish fishery is expanding off the northeastern United States, and a management plan may soon be needed to protect the stock. Underexploitation of the male stock will result from imposing a minimum size limit (irrespective of sex) sufficient to protect the female stock . . . . Expansion of the fishery and changes in market demands in the future may necessitate more complex management based on catch quotas by sex."

THE DOGFISH STOCK IN THE NORTHEAST PACIFIC

Dogfish Range and Behaviour

The Pacific dogfish is found from southern California to northwestern Alaska, but is most abundant from southern Oregon to Dixon Entrance.

There are generally considered to be three distinct stocks in this area. One is off the coast of the United States, the west coast of Vancouver Island, and in Hecate Strait-Dixon Entracnce; one is in the Strait of Georgia and the third in Puget Sound. These latter two stocks are sometimes considered to be one.

Immature dogfish usually form schools in about equal proportions of males and females. When maturity is reached, they school by sex.

Until they reach about 15 or 20 years of age, juvenile dogfish remain near the surface or in mid-water depths. After this age, they gradually become demersal.

Although some schools of dogfish exhibit distinctive migration patterns, northward in summer and southward in the winter, their overall migration patterns are confusing. In Dixon Entrance and Hecate Strait, older dogfish move into deeper water during the winter but inhabit shallower water during the summer. Immature dogfish are available year round in British Columbia and at least part of the adult population remains over winter. Some industry representatives report that large dogfish enter Puget Sound and the Strait of Georgia in the fall. Dogfish were reported in southeast Alaska for the first time when the El Nino current brought warm water to this area. Although the water temperature has returned to normal, the dogfish have remained in Alaskan waters (Brynjolfson, 1986).

A Californian tagging experiment indicated general stock mobility, a resident population, and extensive seasonal migrations. Tagging information suggests the Strait of Georgia and Puget Sound stocks may be indigenous. They migrate within the region. Distant migrations have also been recorded. A dogfish tagged in Hecate Strait was caught seven months later in Santa Cruz, 1,900 km (1,200 miles) away. Another tagged at the entrance to Juan de Fuca Strait was recaptured seven years later off the coast of Japan, a direct distance of 7,800 km (4,900 miles).

Detailed information on dogfish tagging in the Pacific can be found in Saunders et al (1985).

Stock Size Estimates

The following information is from McFarlane (1986).

Based on the catch/effort statistics from the dogfish fishery for the liver oil in the 1940s, the dogfish stock size of marketable fish prior to the liver fishery was estimated to be 300,000 to 500,000 T for all three stocks. It was estimated that half of the biomass inhabited British Columbia waters. The stock was considered to be in equilibrium.

By the mid 1970s, the dogfish stock had rebuilt to its pre-liver fishery level.

Recent British Columbia stock size estimates indicate a total marketable biomass of 180,000 to 220,000 T of which 45,000 T inhabits the Strait of Georgia and 70,000 T inhabits Hecate Strait.

The current estimate of the maximum sustainable yield from this stock is 18,000 T per year.

Fishery Management Measures

The British Columbia dogfish fishery has been controlled by fishery management plans for years. Generally, the quota since 1980 has allowed a total catch of 3,000 T in the Strait of Georgia and 6,000 T coastwide (west of Vancouver Island and in the Hecate Strait).

The Strait of Georgia fishery opens on October 1st of the year prior to the year for which the quota is actually intended.

In 1981 the Strait of Georgia quota was increased from 3,000 T to 5,000 T for one year only. This was based on market requirements, not changes in the stock itself.

In 1985 the coastwide quota was increased to 15,000 T while the Strait of Georgia quota remained at 3,000 T. This increase in quota reflects the Department's belief that initiating a sustained fishery removing 18,000 T per year will decrease dogfish population abundance over a period of time.

Information on dogfish catches is presented in a later section of this report.

SIGNIFICANT POINTS

Significant points for the purpose of this report are:

1. Dogfish are slow growing, long living and late maturing. In addition, they have low fecundity and hence have low reproductive potential.
2. The commercial fishery generally seeks females because they meet the minimum market size requirements while males normally do not. If fillets are being produced, smaller fish are acceptable so males can be fished as well.
3. The estimated dogfish biomass in the western Atlantic is 250,000 to 300,000 T. The estimated maximum sustainable yield is approximately 25,000 T per year. The estimated biomass of marketable size dogfish in the Northeast Pacific is 350,000 T of which 170,000 T is in British Columbia waters excluding the Strait of Georgia. The estimated sustainable yield is approximately 18,000 T per year.
4. Dogfish are opportunistic eaters consuming sandlance, mackerel, and herring as well as groundfish species if abundant. It is estimated that dogfish in the western Atlantic eat about 390,000 T of fish per year and about 180,000 T of squid per year.
5. Whereas research published in British Columbia in 1977 indicated that dogfish consume enormous quantities of herring, salmon and crab, dogfish consumption of other species has been carefully reviewed since then. It is now felt that dogfish consume 20,000 to 30,000 T of herring per year and negligible quantities of salmon.
6. There are emerging indications in the United States that a fishery management plan should be implemented to protect the Atlantic dogfish stock. The Canadian West Coast has had a dogfish management plan in place for years.
7. Scientific information is unable to tell us why dogfish have been a larger problem in Atlantic Canadian waters in 1984 and 1985 than they have been historically. That is, we do not know if stock size has increased to the point that the traditional migration patterns of the stock have been disrupted; whether migration patterns have been altered in response to changes in water temperatures or changes in migration patterns of prey species such as mackerel; or whether the large numbers of dogfish in Canadian waters in 1984 and 1985 are a freak occurrence.

DOGFISH HARVESTING

This section presents information about dogfish harvesting. First, major fishing methods and gear used in fishing dogfish are discussed. Second, information is presented on handling dogfish at sea. Third, details about the ongoing British Columbia fishery are presented. Fourth, the report examines results of the experimental dogfish fishery conducted in southwest Nova Scotia in 1985. Finally, points of significance for this report are listed.

FISHING METHODS AND GEAR

Otter Trawl

Where concentrations of dogfish warrant, otter trawl gear seems to be the most efficient method of catching dogfish. Trawls are so effective that tows must often be shortened to prevent overloading and damaging the gear. Figure 4 shows dogfish in an otter trawl.

Dogfish do not fall out of the net bag like groundfish species do. They often have to be taken out of the net one at a time. They are very hard to handle. Gloves must be replaced daily. The skins are so abrasive that the fish can get caught against one another in conveyor systems. They demand unique offloading systems.

While successful dogfish fishermen are reluctant to discuss details, substantial modifications are made to their gear. The twine of the net must be heavy to minimize chafing from contact with the abrasive skin of the fish and in addition the extension and cod-end must be strongly roped in view of the dead weight. A gradual tapering of the bosom and belly into the extension helps to prevent the time consuming labour of removing meshed dogfish ahead of the cod-end and small meshes are sometimes recommended for the same reason.

Lifting gear must also be very robust to ensure that a large bag of dogfish can be safely split into manageable lifts. Various configurations of extension and cod-end are used in an effort to alleviate the very difficult work of handling dogfish; however despite such efforts and short tows, large quantities of small male fish are

sometimes encountered, necessitating many hours of arduous work to handle the net and remove fish from the meshes for no monetary return since small dogfish have little or no commercial value and are generally discarded.

On the Pacific Coast, otter trawls land about 70 percent of the annual dogfish catch.

The existing fishery in New England is based exclusively on otter trawlers. The February 1986 issue of "The Captain's Log", published by the Mid-Atlantic Fisheries Development Foundation, reports the results of at-sea sampling to determine discard rates for small fish. The one day trip to Stellwagen Bank recorded a 71 percent discard rate for small dogfish.

In 1985, one company in Cape May, New Jersey sold dogfish over the side to an Italian vessel. The 86 ft. American steel stern trawler White Dove sold dogfish to the 220 ft. Italian factory freezer trawler Amoruso Settimo. The cod end was passed from the American to the Italian vessel at sea.

Only 50 T of dogfish was caught in this joint venture. The biggest technical problem encountered was damage to the net bag caused by the dogfish while unloading (Dudley 1985).

Longlines

Longline gear can be more selective than otter trawl gear and may produce a consistently larger size dogfish. This is advantageous given market requirements that require a minimum round fish length of approximately 75 cm (30 in.).

In addition, longlines can produce a product superior in quality. A dogfish caught by a longline can remain alive. It is not crushed and it is not ripped or torn while being removed from the gear as it may be when using trawls.

Longlines are preferred in Norway. The town of Maloy in the past hosted 40 longline vessels in the 70 to 90 ft. range fishing exclusively for dogfish.

The Scotia-Fundy Region Fisheries Development Branch conducted a longline fishing demonstration during the summer of 1982 in Southwest Nova Scotia. The 14 fishing days produced about 25,000 kg (55,000 lb.) of dogfish and 8,500 kg (18,700 lb.) of other groundfish. For further information, see Peeling (1985).

On the Pacific Coast, longline vessels land about 30 percent of the annual dogfish catch.

Gillnets

It is reported that gillnets can be more effective than longlines in catching dogfish when the fish is abundant. However, dogfish tend to foul gillnets and damaged gear is generally considered to be very costly.

Because of the high maintenance costs for gillnets, they do not appear to be a preferred method of fishing dogfish in the Western Atlantic. Indeed, gillnets are not permitted in British Columbia.

Sunken gillnets were used on an experimental basis in the Washington State Puget Sound fishery.

HANDLING AT SEA

It has been reported that quality is the major impediment to expanding the dogfish fishery in the United States by penetrating the domestic market.

A typical feature of sharks is the high amount of non-protein nitrogen including trimethylamine oxide and urea in their bodies. These substances help regulate their osmotic pressure. Once the dogfish dies, the urea breaks down into ammonia and carbon dioxide giving the dogfish an unpleasant odour.

It has been demonstrated that the conversion of urea to ammonia is due to urease (urea splitting enzymes) produced by bacteria. The production of ammonia can be minimized by observing maximum sanitation practices in the handling of shark flesh and by keeping holding temperatures as low as possible (Seymour 1982).

As a result of the findings of Seymour and other authors, bleeding, gutting and icing at sea are generally recommended for dogfish harvesters. Seymour carried out tests on gutting and skinning machinery onboard a fishing vessel to determine the feasibility of mechanized methods of handling dogfish at sea. He concluded that gutting dogfish at sea was not feasible with the machinery then available but that skinning the fish was (Seymour 1982).

Many people strongly believe that bleeding, gutting and icing at sea are necessary to prevent urea conversion to ammonia. The more appropriate concern may be the development of rancidity in dogfish flesh.

In the dogfish fishery in the North Sea, onboard handling is determined by market considerations. For instance, in Britain dogfish is marketed as rock salmon. Since the consumer wants pink flesh, dogfish is absolutely not bled or gutted at sea. It is, however, extremely well iced.

For those markets requiring white flesh, there is a preference for dogfish that has been bled and/or gutted at sea.

The Norwegian longline fishermen do not bleed or gut at sea. The fish is brought to shore round. Trips are six to seven days in the summer and nine to 10 days in the winter without affecting quality (Holmsen 1968).

The Irish trawlers fish near the Shetland Islands. Trips are two days long. Fish is iced but not gutted at sea and quality is rated superb in the British market (Benniwith 1985).

A number of conclusions can be drawn from this information, but, in summary, proper temperature control (icing) is by far the most important element of good handling practices onboard the vessel.

Recent literature from the United States concerning handling at sea assumes icing will take place and discusses bleeding and gutting in the context of "value added processing at sea" (Grulich and DuPaul 1985c). They conclude:

> "Strong consideration should be given to some form of limited onboard processing. It should not be necessary to provide finished products at the dock. Onboard processing should focus on such activities as gutting and heading the sharks and removing the belly flaps and fins from the carcass. All trimming, skinning, packaging and freezing should be handled on shore to insure that yields remain high and export specifications are met" (Grulich and DuPaul 1985c).

THE PACIFIC COAST FISHERY

Currently, the British Columbia fishery lands about 2,500 T of dogfish per year. Prior to 1981, longline vessels dominated the fishery. Since then, about 30 percent of the catch is landed by longliners and 70 percent is landed by trawlers. A significant amount of the catch (ranging from one third to two thirds of the total) is landed directly in the United States. The decision to land dogfish in the United States results from close proximity, occasionally higher prices, and cheaper fuel there than in Canada. Table 3 presents information on British Columbia dogfish landings.

320 vessels reported fishing for dogfish in 1979 but about half of this fleet fished one or two trips only. In 1985, the dogfish fleet consisted of 65 vessels of which 37 were trawlers, 25 longliners and three trollers. Some of the longliners can freeze at sea and most of the trawlers have refrigerated sea water or champagne systems. None of the vessels prosecute dogfish exclusively. The vast majority fish dogfish when they cannot fish more valuable species.

In addition to the Canadian effort, Canada has granted both national and cooperative allocations of dogfish to foreign nations. Poland received an allocation of 20,000 T in 1977 and 7,500 T in 1978. A Canadian/Japanese venture was allocated 5,000 T in 1978. The only fishery that took place was the 1977 Polish joint venture.

Two Polish factory trawlers started fishing west of Vancouver Island on October 7, 1977 using midwater trawl gear. This fishery resulted in high incidental catches including salmon, hake, and rockfish. When the vessels changed to bottom trawls, the catches averaged 90 to 95 percent

dogfish. The best dogfish catches were made during the day. In a total of 13 fishing days, 92.2 T of dogfish and 48.1 T of incidental catch were taken.

Besides the observation about midwater trawl gear resulting in high incidental catches, it was noted that October is an inopportune time to fish dogfish west of Vancouver Island.

The vessels then moved to Hecate Strait and fished from October 18 to November 14, 1977. Midwater trawls proved to be unsuccessful and the gear was again changed to bottom trawls. A total of 349 T of dogfish and 191 T of incidentals were taken.

Since 1981, Greece, Mexico, Korea and Japan have expressed interest in allocations of Pacific dogfish.

Table 4 presents data on Puget Sound dogfish landings.

1985 EXPERIMENTAL DOGFISH FISHERY

In the fall of 1985, the Department of Fisheries and Oceans, Scotia-Fundy Region, Development Branch in conjunction with the Nova Scotia Department of Fisheries contracted two 13.7 m (45 ft.) vessels to engage in an experimental fishery for dogfish. Captain David Tait acted as project coordinator.

The fishing vessels Ocean Otter and Charlie's Angels II attempted to fish a large geographical area off southwestern Nova Scotia in NAFO Division 4X in late November and December. A total of 4,331 kg (9,550 lb.) of dogfish and 12,032 kg (26,530 lb.) of groundfish were landed in 17 fishing days.

Bad weather was responsible for few fishing days and low landings.

One purpose of the experimental fishery was to determine the ability of small draggers to land good catches of quality dogfish. Unfortunately, the small landings prohibit any generalization about the effectiveness of vessels this size to catch and land quality dogfish.

The second purpose of the experimental fishery was to try to determine the anticipated bycatch problem associated with larger trawlers fishing dogfish in Canadian waters. This approach may be criticized because the bycatch results obtained from a 14 m (45 ft.) vessel cannot be extrapolated accurately for vessels exceeding 79 m (200 ft.).

Even though groundfish catches exceeded the catch of dogfish by a ratio of approximately three to one, it should not be assumed that this is the bycatch anticipated in a directed dogfish fishery.

Clearly, further work is required before we can accurately predict the levels of groundfish bycatch that would be associated with introducing large fishing vessels to fish for dogfish.

Additional resources should be directed toward a continuation of the experimental fishery for dogfish in NAFO Division 4X in the spring and summer.

SIGNIFICANT POINTS

1. Trawl gear can be used to harvest dogfish if the fish is sufficiently concentrated. Special modifications to the gear are needed and, even with modficiations, significant damage can be anticipated.
2. Longline gear may be able to produce a higher quality product and it may allow a greater selectivity of fish caught.
3. Adequate icing is essential to landing good quality dogfish. Bleeding and/or gutting may be desirable depending on the requirements of the market the processor is trying to satisfy.
4. There are two advantages to limited onboard processing (such as gutting and cutting off fins). The first is that overall quality can be improved. The second is that offal disposal costs can be significantly reduced.
5. In the British Columbia fishery, trawlers land about 70 percent of the catch and longliners land about 30 percent. Sunken gillnets were used experimentally in the dogfish fishery in Puget Sound.

6. The British Columbia fishery lands about 2,500 T per year. About half of this is landed in the United States. Poland participated in a dogfish joint venture in 1977.
7. Further work is required before we can accurately predict the groundfish bycatch associated with trawlers over 79 m (200 ft.) long fishing for dogfish in Canadian waters.

DOGFISH PRODUCTS AND PROCESSING

This section presents information on dogfish products and processing techniques. First, basic information is presented on dogfish products. Second, the most marketable of these products are examined in greater detail. Third, common processing techniques are described. Fourth, the quality issue is addressed. Fifth, current dogfish processing activity in Canada is examined. Finally, points of significance for this report are listed.

DOGFISH PRODUCTS

This section provides basic information on dogfish products. These include backs, belly flaps, fins and tails, frozen dressed, fillets, surimi, yu-sone, oil, fish meal, skins, and waste material used for bait or silage.

Backs

The back is the product left after cutting off fins and tail, and removing guts, belly flaps, head and skin from the fish. "Backs" are known in the trade as carcasses, loins, or bodies in addition to their normal name.

Backs can be marketed either fresh or frozen. In some markets they are smoked. North American producers generally freeze backs for export to Europe.

Belly Flaps

Belly flaps are produced after the guts have been removed by cutting around the stomach cavity on each side of the fish. The skin is removed from the flaps before they are packaged.

This product is sold exclusively in Germany where it is subsequently smoked and known as schillerlocken. Its appearance is very important to the final consumer.

Fresh or previously frozen belly flaps can be smoked. North American producers generally freeze flaps for export to Germany where value added processing and consumption occur.

Fins and Tails

While the fins of bony fish are used for propulsion, the fins of sharks are used only for balance and stabilization. For this reason, collagen and elastin fibres in thick skin give sharks adequate support. These fibres are called fin needles and are used in Oriental cuisine to make shark fin soup.

Shark fins are generally sold to end users such as restaurants in sets including two pectoral, one dorsal and one tail fin. The fins from small sharks (such as dogfish) are not sold as a set but as fin net or mixed fins after full processing.

North American dogfish producers generally freeze fins and tails for shipment to shark fin processors in the Orient. Some shark fin processors in the United States and Canada are conducting preliminary value added processing before shipping to the Orient for final processing.

Frozen Dressed

There is a market in the Orient for head off, gutted, and frozen dogfish. Some customers want the tail on; others want it off. Some customers need five pounds net weight (minimum). The belly flaps are left attached to the fish and they are rolled into the belly cavity. The skin is left on. The product is glazed following freezing.

There is some potential for increased sales of this product in the Orient.

Fillets

There is a view that only dogfish fillets can crack the North American market. There is virtually no production of this product at present.

Since the fillets need to be white, this product requires bleeding and/or gutting at sea. Rather than removing the back, two fillets are cut; one from each side of the cartilage. While yield drops about five percent, labour is more efficient at producing fillets than backs.

Surimi and Yu-sone

Wu and Stevens completed a report in 1982 in response to enquiries concerning the suitability of dogfish for Oriental products such as surimi and kamaboko that have well recognized market volume in Japan or the yu-sone product that has great market potential in China.

Production of surimi involves deboning the fish, mincing, soaking, washing and dewatering. Dewatering removes blood, fat, pigments, and undesirable soluble proteins. Wu and Stevens report that other investigators have rated dogfish as a substandard to poor material for surimi production depending on its freshness and flesh treatment.

Surimi serves as an intermediary product in the production of various final products such as the recently introduced artificial crab legs. Surimi has been used for centuries to produce kamaboko which may loosely be described as a traditional Japanese fish pudding.

Kamaboko produced from surimi made from dogfish fillets stored in ice for nine days produced fish gel with very good textural properties (Wu and Stevens, 1982). Improvements may be achieved by searching for optimal additives, and better means of chopping, presetting and cooking.

It seems that minced dogfish is sometimes added to surimi produced from other species to give it special properties. The surimi industry generally frowns on dogfish use because a surimi plant requires consistent year after year supply of large volume low priced raw material. Research to date on the West Coast reveals that intermediate sized dogfish would be needed to satisfy raw material requirements. This would necessitate mid-water trawling for dogfish.

In addition, there are some recent developments in the surimi industry that would indicate a need for caution in establishing a surimi plant in North America. The vertically integrated Japanese companies that produce kamaboko from surimi are letting the world surimi price drop because they can realize profits in the kamaboko industry. Given the nature of the Japanese-American joint ventures to produce surimi on the West Coast of North America, close ties to Japanese purveyors of equipment, additives and technology are recommended.

The following information is extracted from Grulich and DuPaul (1985b):

> "Lanier conducted several studies relative to producing . . . . . surimi from dogfish. Gels prepared from dogfish surimi compared well with other species (trout, croaker, spot, catfish, bluefish, mullet). The studies indicated little "setting" ability when cooked at 40°C but formed better than most species at 60°C. Dogfish gels prepared at 80°C were firmer than most species tested but lacked the cohesiveness of species such as croaker or trout. The dogfish surimi prepared in the study exhibited excellent organoleptic qualities and achieved colour scores for lightness similar to croaker and trout. Flavour scores reveal that surimi made from dogfish is very bland, even more so than croaker. Wu reported yields of dogfish surimi at 15 percent of headed and gutted fish and 10 percent of whole fish. Both reports suggested that, with additional technical improvements, dogfish can be used successfully to produce surimi products that compare favourably with those currently being produced by commercial operations" (Grulich and DuPaul 1985b).

Some dogfish caught in the 1985 experimental fishery were sent to the Technical University of Nova Scotia for surimi production and evaluation. Although the project administrators have a concern that yields were somewhat low, it should be noted that the product was produced in

a pilot plant batch process which may not be indicative of actual production scale yields. The process produced acceptable quality surimi.

Industry representatives appear to be cautiously optimistic that surimi can be successfully produced from dogfish in a commercial operation.

Yu-sone is a seasoned-dried fish flake product. Processing yu-sone involves separation of pure fish flesh, boiling the flesh, dewatering, addition of ingredients such as oil, starch, sugar, salt and spices and stir frying until dry. The authors conclude that dogfish produces yu-sone product with good colour, flavour and stability. The fibre texture was finer than from other types of shark but was still comparable with many commercially available products.

Oil

The dogfish liver is approximately one sixth of total round weight of the fish. The West Coast dogfish fishery in the late 1940s and early 1950s produced Vitamin A from dogfish liver oil. This fishery virtually ceased when Vitamin A was successfully synthesized in the early 1950s.

There is, however, still a market for dogfish oil. Arrowac Fisheries in Washington State sells dogfish livers to a nearby rendering plant which extracts oil for soaps and cosmetics (Laitin 1981). The major producer in British Columbia is placing a great deal of emphasis on oil production. This product (called shark oil) is sold to perfume manufacturers in the United States.

Skins

Although there is a market for shark skins, dogfish are generally too small for their skins to be commercially valuable (Grulich and DuPaul 1985c).

Fish Meal

While in 1981 it was reported that Arrowac Fisheries sold dogfish offal to a fish meal plant for production of fertilizer (Laitin 1981), this is no longer the case. Arrowac has to pay to have their offal removed.

Most other reports conclude that dogfish offal makes poor raw material for fish meal primarily because of its high urea content. Fish meal processors in New England found their final product degraded when dogfish was added to their raw material. Dogfish contained too much oil and the skins bound the machinery. However, some fish meal producers undertook to accept dogfish offal if the livers were removed.

March et al (1971) responded to a renewed West Coast interest in the feasibility of manufacturing dogfish meal for poultry feed by manufacturing several types of dogfish meal and testing each for nutritional value.

The authors concluded that supplementary protein values of the meals were consistently lower than values reported for meals made from traditional fish. Chemically-estimated lysine availability was low in the meals, as was the pepsin digestibility of the protein. These attributes were considered to be at least partly due to the processing conditions necessitated by the nature of the dogfish itself.

Waste Material

Strasdine and Jones (1983) report that silage for an animal feed supplement can be produced from dogfish waste. This process requires that the dogfish frames be minced, acid added to the waste, and stored for the duration of the liquefaction process. Liquefaction occurs in a few hours or days depending on the temperature. The silage produced has been found to be deficient in a few key amino acids but this can be overcome by artifically supplementing the silage with the amino acids necessary to produce a balanced livestock diet.

Two major obstacles must be overcome. Farmers must be convinced to use liquid feed in lieu of traditional meal based feeds. Second, the economics must be proven. The transportation costs could prove prohibitive to further silage development because silage is approximately 75 percent water (Grulich and DuPaul 1985c).

In Norway, dogfish heads are often included in wet feed for farmed fish. Wet feed can contain as much as 25 to 30 percent dogfish heads. the

heads are a lean feed but well suited with more fatty species. Because the keeping ability is not particularly good, the heads must be used very fresh or frozen.

A large part of the aquaculture industry in Atlantic Canada is located in the same area (Bay of Fundy) as the dogfish resource. Use of dogfish waste as feed probably warrants further investigation.

The October 1985 issue of "Captain's Log", published by the Mid-Atlantic Fisheries Development Foundation, presents an update on the work of Dr. Chai of the University of Maryland. He is researching possible uses for dogfish wastes. He has used dogfish skins and fins as crab bait and compared them to the efficiency of menhaden. While the project is still underway, he concludes that the dogfish bait catches less crab per day than menhaden, but the total number of crabs caught per unit of bait consumed was higher for the dogfish than the menhaden. The dogfish also appears to attract more male crabs than does the menhaden bait.

MARKETABLE DOGFISH PRODUCTS

Under current circumstances, the marketable products upon which a dogfish processing operation must be based are backs, belly flaps, and fins and tails.

While some of the other products listed in the previous section are currently being sold, and while others may have great potential, these products are either not in demand or in a very preliminary state of development. It would appear to be risky to develop a commercial operation based on those products.

Backs

Following removal from the fish, skinned backs are examined to ensure the skin is completely removed and the bloodline is removed. The unwashed backs are placed in individual plastic sleeves or polybags. The ends are generally twisted but not sealed shut. The backs are laid straight in corrugated cardboard containers.

Backs ranging in size from one half to two kg (one to four lb.) are accepted by the European market. They should be graded one half to one kg (one to two lb.) and one to two kg (two to four lb.). Backs larger than two kg (four lb.) are discouraged and those less than one half kg (one lb.) are rejected.

The British market prefers dogfish backs packed in 28 lb. (two stone) packages while other European countries prefer 10 kg packages. These preferences are carryovers from the days before the European Economic Community and are less important than they were a few years ago.

The British market requires that backs have a pinkish colour. Therefore, the back should not be placed in ice water after production as the colour tends to leach out and it should be frozen as soon as possible after production.

While back yields of 41.5 percent for males and 37.5 percent for females have been recorded by Shiau and Chai (1985), industry representatives commonly refer to yields of 25 to 30 percent of round weight depending on fish size and sex.

Belly Flaps

After the belly flaps have been cut from the fish, they are skinned. Germans prefer hand skinned flaps because machine skinned product may have small pieces of membrane attached to the belly flap. Membrane left on the flap causes smoke to improperly penetrate the product. This causes the flap to curl improperly. In addition, the membrane is difficult to chew.

Some processors use machines to skin belly flaps but product wastage and customer complaints offset to some degree savings in wages.

Following skinning, the flaps are examined to ensure the product is of top quality. Ideally the belly flap contains no knuckles from the anus area, no dark body meat, and no white or clear membrane.

The belly flaps are laid loose in a corrugated cardboard container containing a plastic liner.

The minimum size for belly flaps is 25 cm (9.8 in.) (Simonsen 1985). Flaps smaller than the minimum desired receive about 50 percent of the normal market price.

The minimum belly flap size is responsible for the minimum size of fish the processor can accept. This minimum is generally considered to be about 75 cm (30 in.) long but some West Coast processors prefer fish over 85 cm (34 in.) long.

Belly flaps yield about five or six percent of the round weight of the fish.

Figure 5 shows the finished product, schillerlocken, on display in Germany.

Fins and Tails

Fins and tails are sold in the Orient where they are made into shark fin soup.

The tail is removed from the dogfish using a straight dorsal cut. Care is taken to avoid cutting deep into the shark trunk because large chunks of meat from the carcass reduce the value of the tail.

Back fins are less desirable than the pectoral fins. While there is generally good demand for pectoral fins and tails, the back fins are attractive to buyers only if supply of other fins is low and/or if the price is lower to compensate for the smaller fins. Fins must be carefully cut and trimmed to obtain premium wholesale prices. Three common methods of cutting recommended by fin traders are the crude cut, the straight cut and the half moon cut (concave cut). These are illustrated in Figure 6.

The quality of the fin needles can deteriorate if the fins remain attached to the animal after death. Therefore, fins should be cut from the dogfish as soon as possible after capture to maintain quality.

Tails generally yield two percent of round weight and fins three percent.

Further information on shark fin processing and the Hong Kong market can be found in the excellent article by Ka-Keong (1983).

PROCESSING TECHNIQUES

This section describes actual dogfish processing operations and provides information on attempts to mechanize production.

First, the dogfish cutter removes the fish from the container in which it arrived. The head may be jammed onto a spike to restrict excessive movement of the fish. The fish can be processed either vertically or horizontally.

The cutter next cuts off tail and fins with a knife. These are placed in a separate container for periodic removal and quick freezing.

The cutter then rips open the gut cavity by inserting the knife at one end of the belly and ripping along the center line. The guts are pulled out.

The cutter carefully cuts the belly flaps off the remaining meat of the fish. Care is taken to try to get the largest possible belly flaps. The flaps are taken to packers.

The skin is cut on both sides of the back of the neck at the base of the head. Using hands, pliers or vicegrips, the skin is pulled from the body of the dogfish until there is only head and exposed flesh remaining.

The cutter then separates the back meat from the head. The head is discarded and the back meat is collected by packers.

An experienced cutter can process 2,200 to 2,700 kg (5,000 to 6,000 lb.) of round dogfish per day in this way.

Processing on a West German factory freezer trawler is essentially the same. The dogfish is placed upside down in a chute set up so the fish slides below the deck to a worker who rips open the gut. After about five minutes in a bleeding tank, the next worker cuts off fins and tail. The third worker cuts off the belly flaps. The following worker puts the head in a clamp and skins the fish, keeping the back and discarding the rest.

There have been a number of attempts to mechanize dogfish processing. The Massachusetts Institute of Technology produced a prototype dogfish processing machine before 1980. Hoff and Wilson (1980) report that the objective of the MIT project was to produce a machine which could take a spiny dogfish shark in the round and remove its tail, dorsal fins, back, and belly flaps. They wanted a feed rate sufficient to make the machine competitive in the fishing industry. They claim the prototype machine successfully emulated hand processing and achieved their goals.

Industry does not, however, seem to agree. The owner of Arrowac Fisheries states that the machine is unsatisfactory and the President of North Atlantic Products say there is no machine available that will produce the products they are currently selling (Laitin 1981).

The National Marine Fisheries Service has given Saltonstall-Kennedy funding to the High Seas Corporation of Fall River, Massachusetts to install the MIT developed machine for at sea cutting and skinning of dogfish. The project also includes funding for the installation of a small freezer onboard the vessel for dogfish products, demonstration of the equipment at sea, and marketing of the dogfish products.

No project reports had been received by NMFS by November 1985 primarily because the principal investigator experienced health problems. The project has been extended.

Grulich and DuPaul conclude:

> "To date, all attempts to develop fully automated eviscerating and cutting machiney have provided unsatisfactory results" (Grulich and DuPaul 1985c).

DOGFISH QUALITY

This section presents information of a general nature about dogfish quality in addition to information about product quality in fresh and frozen storage.

General Quality Factors

Proper onboard handling and good manufacturing practices in plants can ensure uniform top quality product. Bleeding and gutting at sea are desirable and icing to keep the fish cold is essential.

In the plant, the processing should be conducted as soon as possible in a sanitary environment. Reduction of the time prior to freezing goes a long way to promoting top quality product.

Several recent studies have attempted to outline acceptable processing guidelines for dogfish. Morris (1975) suggested the following steps for increasing the quality of dogfish products:

1. bleed the dogfish by cutting off the tail;
2. fillet promptly after harvest and avoid rupturing the digestive tract;
3. remove any adhering kidney tissue from the dorsal area of the peritoneal cavity;
4. ice quickly; and
5. prevent exposure to air or elevated temperatures.

Quality of Fresh Product in Storage

The Canadian Institute of Fisheries Technology under contract to the Fisheries Development Branch conducted a study on the shelf life of refrigerated dogfish fillets using dogfish caught in the 1985 experimental fishery.

Gutting produced the best product and round dogfish produced the product that deteriorated fastest. Shelflife is significantly shortened by raising the temperature above 2°C (35°F). The breakdown of urea to ammonia allows little margin of error in handling or storage. The tests reveal that even slightly spoiled fillets are violently rejected by the least discriminating consumer.

The CIFT study concluded that fillets were of borderline quality after six days of storage at +2°C (35°F). For more information, see Woyewoda and Bligh (1986).

A study concerning fresh dogfish and subsequent storage stability was funded by the Mid-Atlantic Fisheries Development Foundation in 1983. The study found that dogfish iced immediately after capture and held in ice is of acceptable quality for 10 to 12 days. According to the sensory evaluation tests, gutting provided a more preferable product than bleeding or leaving whole. At 10 to 12 days of age, although flavour and aroma were rated acceptable, the texture and appearance of the cooked product were rated borderline (Hicks 1983).

Bilinski et al (1983) examined the factors controlling the deterioration of dogfish during iced storage. These authors concluded that in gutted and iced fish, there was no sigificant increase of ammonia during the 20 days of storage. In fish stored at five and 10°C, the ammonia content of the muscle increased significantly after six and four days respectively. This was followed by a stage of very rapid formation of ammonia which reached very high levels in a few days. Besides ammonia formation, loss of quality in dogfish during iced storage was caused by other factors such as development of off odours and off flavours, softening of the flesh and autolysis of the abdominal walls. These changes tend to limit the useful iced storage life of dogfish to eight to 10 days. A rapid chilling of dogfish to 0°C is of major importance in retarding the post-mortem formation of ammonia. Dogfish iced without delay prevents the buildup of ammonia for at least 12 days.

Jhaveri studied the fatty acid distribution, cholesterol level, and mineral composition of the edible portions of dogfish. He found that the shelf life of iced dogfish ranged between six and eight days (Grulich and DuPaul 1985c).

Quality of Frozen Product in Storage

Various studies have been undertaken on the keeping quality of frozen dogfish.

Boyd et al (1967) suggested that the factors contributing to deterioration of dogfish in frozen storage are rancidity development, colour changes, protein denaturation, and lipid hydrolysis. The authors conclude that the discolouration of red outer muscle of skinned frozen dogfish is the initial noticeable deterioration in quality. The discoloration of red muscle in the dogfish back is thought to be due to the oxidation of hemoglobin to form methemoglobin. The next changes that were evident were the development of an acidic type flavour and rancidity. Lipids of frozen dogfish undergo oxidation at a similar or greater rate than do the lipids of certain other species of fish.

They conclude, "it might be assumed that under commercial conditions of handling and storage, the quality of frozen dogfish carcasses and belly flaps could possibly be maintained during storage at -20 to -25°C for three to five months".

Bilinski et al (1980) found that after four months the red muscle of the dogfish back became yellowish to light brown in backs stored at -18°C but remained red in backs stored at -30°C. The authors concluded that -18°C is not recommended for storage of dogfish. Even during shipment, dogfish should not be exposed to this temperature for more than one month. At -30°C, the backs can be stored for six months without an appreciable loss of quality and the flaps can be kept for eight months.

Hicks concluded that dogfish has a shelflife of less than three months at 0°F (Hicks 1983).

CURRENT DOGFISH PROCESSING ACTIVITY IN CANADA

There is an ongoing fishery for dogfish in British Columbia. The largest processor produces frozen backs and belly flaps for the European market, frozen fins and tails for the Oriental market, frozen dressed dogfish for sales to Japan, and dogfish oil for sale to the pharmaceutical and cosmetics industries in the United States.

Table 5 presents information on dogfish exports from British Columbia.

At least two processors in southwestern Nova Scotia processed small quantities of frozen dogfish fillets and sold these in the Toronto area in 1985. Both intend to pack dogfish again in 1986.

SIGNIFICANT POINTS

1. Dogfish products include backs, belly flaps, fins and tails, frozen dressed, fillets, surimi, yu-sone, oil, fish meal, skins and products such as silage from waste material.
2. A dogfish processing operation selling products into the traditional markets must be based on backs, flaps, and fins and tails. It would appear risky to develop a commercial operation based on products like surimi, yu-sone, oil, fish meal, skins or silage.
3. Dogfish processing is labour intensive. The machinery developed to date is unable to outperform people. Indeed, there are some processing operations, such as skinning belly flaps, in which there is a market preference for hand processing over machine.
4. To ensure uniform top quality production, bleeding and gutting at sea are desirable and icing to keep the fish cold is essential. In the plant, good manufacturing practices should be followed and the dogfish should be processed as soon as possible after it is harvested.
5. The consensus of opinion is that fresh dogfish, under ideal conditions, can be stored no longer than 10 days.
6. The consensus of opinion is that frozen dogfish backs, under ideal conditions and at temperatures of -30°C, can be stored no longer than six months. Frozen belly flaps under similar circumstances can be stored no longer than eight months.
7. The major British Columbia dogfish producer produces frozen backs and belly flaps for the European market, frozen fins and tails for the Oriental market, frozen dressed dogfish for sales to Japan, and dogfish oil for sale to the pharmaceutical and cosmetics industries in the United States.
8. At least two processors in Southwest Nova Scotia processed frozen dogfish fillets for the domestic markets in 1985 and intend to do so again in 1986.

THE DOGFISH MARKET

This section presents information about dogfish markets. First, detailed information is presented about major markets for dogfish. Second, recent attempts to develop the North American market are examined. Finally, points of significance for this report are listed.

TRADITIONAL MARKETS FOR MAJOR PRODUCTS

This section examines the markets for dogfish products in England, Belgium, France, Italy, Germany and the Orient.

England

England consumes dogfish backs exclusively. The country does not consume belly flaps or fins and tails. In England, dogfish is known primarily as rock salmon. It may also be called huss, flake, or rigg. Industry representatives feel that over 90 percent and perhaps as high as 99 percent of the dogfish consumed in England is consumed in fish and chips shops. Almost all the rest goes to Chinese restaurants.

The price charged to consumers in these fish and chips shops is normally the same for rock salmon and cod. These two items are the best sellers on the menu.

It is interesting to note that only those fish and chips shops in the southern part of England (about a 150 kilometre or 100 mile radius from London) sell dogfish. There are essentially no sales for dogfish in any form outside this geographical area.

There seems to be a fairly uniform year round demand for dogfish in England. However, sales of fish in the fish and chips shops increase during the summer. The majority of small fish and chips shops prefer fresh dogfish if it is available and buy frozen product only if fresh is either too expensive or unavailable. There are, however, some chains of fish and chips shops which prefer to buy frozen dogfish because of ease of distribution and storage and dependability of supply.

Dogfish consumers in England expect the flesh to have a pink colour. The fish should not be bled or gutted at sea and the product should be frozen very quickly after the skin is removed. Importers stress the need to ensure backs are frozen straight. The English market has a preference for white boxes rather than brown. Most importers prefer to have the boxes banded and palletized with shrinkwrap if possible. The number of pieces per box should be marked on the outside of each. Some importers state a preference for the backs to be packaged in sealed polybags; others believe twisting the sleeve is adequate. Large backs are preferred. Those backs exceeding $1\frac{3}{4}$ kg (four lb.) are too large and those less than .7 kg (one and a half lb.) are too small (Benniwith 1985).

Tables 6 to 8 present detailed information about United Kingdom imports of dogfish.

Tables 6 to 8 indicate that imports in 1985 are almost 20 percent greater than in 1983. Ireland is an increasingly important supplier. While Ireland supplied the United Kingdom with 62 percent of its dogfish imports in 1983, it supplied 75 percent in 1985. In 1983, fresh dogfish formed 62 percent while frozen comprised 38 percent. In 1985, fresh dogfish increased to 77 percent of the total while frozen dropped to 23 percent.

Tables 9 to 11 present detailed information about United Kingdom exports of dogfish.

British exports have increased by 65 percent from 1983 to 1985. France is the largest market for dogfish from the United Kingdom. France consumed 85 to 90 percent of total British exports from 1983 to 1985.

United Kingdom dogfish landings have been approximately 12,000 T (round weight) in the years 1983 to 1985.

It is possible to calculate the approximate consumption of dogfish in the United Kingdom by converting landings to product weight equivalent, adding imports, and subtracting exports. This calculation shows that consumption in 1983 was approximately 5,600 T. It decreased to 3,600 T in 1984 and increased in the first part of 1985 to 4,300 T.

Belgium

In Belgium dogfish is known principally as doornhai or zeepaling. In the french part of Belgium (southeast of Brussels) it is known as rousette.

The market in Belgium is for dogfish backs only. The preferred size is over one kg (two lb.). The colour of packaging is insignificant. The product should be bled and gutted at sea and frozen products should be individually quick frozen. The blood vein should be removed.

The majority of dogfish backs sold in Belgium are smoked. Smoked backs are sold in shops and supermarkets for home consumption. Smokers generally prefer frozen backs because they are assured of product availability and can schedule production more efficiently. Smokers also prefer large backs because the unit cost of labour decreases if large backs are being used instead of small. Some smokers prefer one large polybag in a cardboard container rather than individually wrapped backs.

Thirty or forty percent of the backs are processed by plants and fish shops into a product call escaveche. This product looks similar to herring rollmops. It is dogfish backs cut into small pieces and boiled with onions and a variety of other vegetables. Escaveche is also known as zeepaling in gelei. Figure 7 shows escaveche on display in Oostende, Belgium.

Table 12 presents the most current data available on Belgian imports and exports of dogfish.

In late 1985, Belgian importers were paying $.52 US per lb. CIF for dogfish backs. At the same time, quotes from Turkey were 9 French Francs per kg for medium dogfish backs and 9.5 French Francs per kg for large dogfish backs. At the average mid rate conversion rates for November 1985, the Turkish quotes were $.53 US per lb. for medium backs and $.56 US per lb. for large backs.

France

In France, dogfish is known as chien de mer, chat de mer, saumonette or rousette. It is most commonly known as saumonette. The literal translation for saumonette is cute little salmon.

The market in France is for backs only. No belly flaps and no fins and tails are sold in France.

While there is a small market for smoked dogfish backs along the German/Belgian border, the primary market in France is for unsmoked backs in the institutional market. Dogfish is served in prisons, hospitals and schools to "captive consumers".

Large backs are preferred in the market place. Backs from one to two lb. are discounted about 10 percent from the normal market price. It is important to grade production because some small backs mixed in with large backs can result in a price reduction.

Tables 13 to 15 present data on French imports and exports of dogfish.

It is interesting to note that Turkey has become the third largest dogfish supplier to France and that Chile and New Zealand sold about 50 T to France in 1984.

In the fall of 1985, the French dogfish market was reported slow. This is at least in part because Turkish production is of relatively poor quality and consumers are reacting negatively to dogfish after encountering poor Turkish product in the last few years. Buyers indicated they were paying in the low 50 cent US range CIF for American dogfish backs. However, at least one buyer stated that he was paying a Montreal broker $.47 US per lb. CIF for east coast United States production. At the same time, it was reported that quotes from Turkey were 8 French Francs per kg for medium dogfish backs and 9 French Francs per kilogram for large dogfish backs. At the average mid rate conversion rates for November 1985, the Turkish quotes were $.47 US and $.53 US per lb. respectively.

Italy

Dogfish is known in Italy as spinarolo. There is a marked preference for fresh product. This restricts Italian imports of dogfish to other European nations. It is normally purchased in 20 kg packs. Ice should not touch the flesh and leach out the blood during shipment to the market as the pinkish coloured flesh is a requirement.

Germany

In Germany, dogfish is known as dornhai or see aal. Dornhai or see aal backs are either smoked or consumed fresh. Dogfish belly flaps are smoked. It is estimated that 70 to 80 percent of German imports are belly flaps and 20 to 30 percent of the market is backs. The smoked belly flaps are known as Schillerlocken. They are considered a delicacy and consumed in beer gardens as a snack.

Table 16 presents information on German imports and exports of dogfish.

The European Supplies Bulletin reports that German imports of dogfish increased from 1,837 T in 1983 to 1,926 T in 1984. This represents an increase of 4.8 percent.

Grulich and DuPaul (1985b) estimate that the average annual demand for belly flaps in West Germany is 1,200 to 1,500 T. This can increase to a high of 1,800 T. In the fall of 1985, German importers reported that the normal price for North American dogfish production was $.52 to $.54 US CIF per lb. for the backs. However, there was a large supply of backs in frozen storage at the time and the price paid was $.47 or $.48 US per lb. CIF.

The price quoted for belly flaps exceeding nine inches in the fall of 1985 was $.90 US per lb. FOB east coast United States.

The Orient

The Orient is the largest market for dogfish fins and tails. Prices as high as $1.50 or $2.00 Canadian per lb. are reported for dogfish fins and tails.

The Department of Fisheries and Oceans reported that preliminary surveys undertaken by External Affairs have found that several Asian markets exist for frozen dogfish products. The prospects of this new market potential warrant further research (Roger 1985).

Summary

Table 17 is compiled from various tables in this section. It summarizes import/export data from the North American point of view.

Table 17 warrants close examination. Assuming there is no double counting, it shows the European market imported a total of about 12,000 T of dogfish in the most recent year statistics were available. Overall, North America holds 24 percent of the market. Of this, the United States represents 20 percent and Canada four percent.

The real surprise is France. Canada supplies less than one percent of total French imports while the United States supplies 17 percent of the market demand. Another surprising fact about France is the sheer volume of demand relative to other European nations. France alone accounts for over 50 percent of total European imports of dogfish.

Assuming a combined back and belly flap yield of 31 percent, the actual North American exports of 2,933 T represent a landed (round) weight of approximately 9,500 T. This is close to Canadian government estimates of 1983 dogfish landings (Roger 1985).

The question that must be addressed is: What additional tonnage of dogfish products can Canada sell in the European market?

There is not a simple answer to the question. It depends on demand in Europe, the success of fisheries from competing sources of supply, and the price at which Canadian companies could offer dogfish products to the European market.

European demand is generally believed to be static.

The most important competing source of supply is the North Sea. The biggest dogfish fishing nations are Britain and Norway. The Norwegian fishery is now small in comparison to the past. Landings recently are less than 5,000 T per year while over 40,000 T per year has been recorded. This decrease in landings is due to Norwegian overfishing over the past 15 years. While there is no evidence to suggest the North Sea dogfish resource is continuing to be overfished, the recent large removals by Ireland might indicate trouble for the stock some time in the future.

Information about the success of the dogfish fisheries in Turkey and Chile is unavailable. There is no evidence to suggest Turkey will slow down its marketing of dogfish in Europe. In fact, the Turkish pricing strategy seems to be to undersell United States prices by about 10 percent.

The major factor influencing the price Canadian processors could expect for dogfish is changes in currency valuations. These changes in currencies are, of course, beyond the control of people in the fishing industry.

All indications are that the European market is extremely price sensitive. An example of this is that the prices Unites States processors were able to charge in late 1985 decreased from the low to mid 50 US cents per lb. CIF to about 47 cents when 250 to 300 T of frozen backs piled up in frozen storage.

Best estimates are that the European market can absorb each year at most an additional 10 to 15 percent of its current imports. This converts to round weight of between 4,000 T and 6,000 T.

Further examination of this potential market demand is presented later in this report. It should be carefully considered before drawing conclusions about the prospects for marketing large quantities of dogfish.

THE NORTH AMERICAN MARKET

This section presents information on recent attempts to develop a market for dogfish products in North America.

The United States

Studies have indicated that while seafood may be rated comparably to meat on such attributes as price, nutritional value and image, United States consumers have negative perceptions about seafood relative to its preparation, perishability, appearance and availability (Gillespie and Houston 1975).

If American consumers are to purchase unfamiliar species such as dogfish, they will have to be educated and encouraged by point of sale demonstrations, recipes and other educationalmaterials. Grulich and DuPaul (1985c) report that Gillespie and Brandon (1976) presented a series of questions to consumers about their perceptions of shark meat including taste, nutrition and ease of preparation. The responses were segmented using various demographic variables.

The results indicate that:

1. most consumers found shark less desirable than other fish;
2. nearly 50 percent of the respondents would try shark meat if it were available on a consistent basis;
3. women were slightly less likely to eat shark than men;
4. the group most likely to try shark is between 26 and 35 years of age;
5. families with three or fewer members were unwilling to try shark; and
6. the higher the education level the more favourable response to trying shark.

This indicates that certain market niches are available to prospective dogfish marketers if the product is presented properly. Grulich and DuPaul conclude that it should be possible to develop a dogfish market in the United States. Even if consumers cannot be convinced to buy dogfish directly, they may represent a large target market for institutional users.

An extensive report to determine the feasibility of marketing spiny dogfish in Virginia was completed in 1982 by Dean et al. The project was intended to educate consumers about shark and seafood in general, to introduce dogfish into the market, and to evaluate the effect of consumer education on the sales of this product.

Over 10,000 lb. of dogfish were sold in Hampton Roads over a three week period. The product was sold fresh and unwrapped. Factors influencing consumer demand were identified as price, desire for variety, availability of suitable recipes and the ability to sample the product at the store. Consumer demand was so great for dogfish that some new stores and at least two other local chains began carrying the species.

The project results indicate that with the aid of the media and use of such merchandising techniques as in-store demonstrations and sampling a new product - even one such as shark that has widespread psychological barriers against its use as food - can be successfully sold in certain areas.

On the Pacific Coast the owner of Arrowac Fisheries is convinced that the dogfish industry can expand only if a domestic market in the United States is found (Laitin 1982).

Canada

The Nova Scotia Department of Fisheries has played a lead role in attempting to introduce dogfish into the Canadian market. A significant portion of the promotional program during the summer of 1985 was directed towards dogfish. As part of an effort to establish a market for dogfish, radio commercials were aired and samples were given at a variety of events. Recipes were distributed in the newspaper and a pamphlet was made available free of charge to be distributed at fish markets and grocery stores.

The product was called Northern Shark and all references to dogfish were eliminated. Unfortunately, those who made the connection between dogfish and Northern Shark would usually not try the sample. Also, because of its special cooking properties, people who substituted it in haddock recipes often experienced failure. It should be deep fried or barbecued. In general though, when properly prepared and sampled, people enjoyed Northern Shark.

It is possible to conclude that significant resources will have to be expended before dogfish can be successfully marketed in North America. At a minimum, marketers of dogfish should select a name for the species which has more appeal than dogfish. The Nova Scotia Department of Fisheries favours the name Northern Shark.

SIGNIFICANT POINTS

1. England consumes dogfish backs. Over 90 percent of the backs are sold in fish and chips shops within 150 kilometres (100 miles) of London.

2. The United Kingdom imports 3,500 to 4,000 T of dogfish per year. Fresh dogfish from Ireland fills over two thirds of the United Kingdom imports.

3. The United Kingdom exports over 4,000 T of dogfish per year. France consumes 85 to 90 percent of total United Kingdom exports. About 90 percent of this quantity is fresh.

4. Belgium consumes dogfish backs only. Most backs are smoked. Some non-smoked backs are prepared by boiling the fish with onions and other vegetables to make a fish in gelatin product called escaveche.

5. Belgium imports about 650 T of dogfish per year.

6. France consumes dogfish backs only. Almost all backs are sold in the institutional market.

7. France imported over 5,500 T of dogfish in 1983 and 1984.

8. Italy prefers fresh over frozen dogfish backs. Italy imports 3,000 to 3,500 T of dogfish per year.

9. In Germany, 70 to 80 percent of the imports are belly flaps while 20 to 30 percent are backs. German imports totalled 1,900 T of dogfish in 1984.

10. The Orient imports virtually all of the dogfish fins and tails produced in the world.

11. The current market price for frozen dogfish backs is as low as $.47 US per lb. CIF Europe. It is usually $.52 to $.55.

12. The current market price for frozen dogfish belly flaps is $.90 US per lb. FOB East Coast United States.

13. The current market price for frozen dogfish fins and tails is $.80 US per lb. FOB East Coast United States.

14. Canada supplies about 500 T or about four percent of total European dogfish imports. The United States supplies about 2,500 T or 20 percent of the European market.

15. Best available estimates are that the European market can import at most an additional 10 to 15 percent of its current imports. This converts to round weight of 4,000 to 6,000 T.

16. Attempts to develop the North American market have generated a lot of enthusiasm but met with limited success. Successful market development must focus on the "right" product. It appears costly techniques such as media coverage, in-store demonstrations, and even product samples will be required. At a minimum, marketers should select a name with more appeal than dogfish.

DISCUSSION AND OPTIONS

This section discusses the implications of the processing and marketing material contained in the preceeding sections. It then presents options for addressing the dogfish issue in Canada. Finally, points of significance for this report are listed.

Two recent reports have investigated the feasibility of expanding or establishing a dogfish industry based on producing backs, flaps, and fins and tails and selling these products into the traditional markets.

Their conclusions are:

> "It appears that a commercially viable non-food application is almost essential in the case of dogfish if there is to be any large scale sustained and viable development of the fishery" (Roger 1985).
>
> "The current market does not appear to be capable of supporting additional production without a substantial decrease in market price" (Grulich and DuPaul 1985a).

The inevitable conclusion is that the traditional fishery is, at best, a low margin one for processors and the price to fishermen can be expected to be extremely low in comparison to the prices for groundfish species such as cod and haddock (on the East Coast) and halibut (on the West Coast).

One conclusion of this report is that the European market can import no more than an additional 10 to 15 percent of its current imports - a round weight equivalent of 4,000 T to 6,000 T.

Harvesting 4,000 T to 6,000 T per year from a resource with a total Canadian biomass of 500,000 T is an inadequate solution to the Canadian dogfish problem. And if the estimated market demand is supplied by dogfish from both Eastern and Western Canada, the level of removals will actually allow the stock to grow.

Even if Canada were the only source of dogfish for the apparently unsatisfied portion of the European market, removals of this level do virtually nothing to address the dogfish issue.

Traditional market development, surimi usage, or non-food uses of dogfish should not be ruled out as potential long term solutions to the dogfish problem, but in the short and medium terms other options must be pursued.

OPTIONS FOR ADDRESSING THE DOGFISH ISSUE IN CANADA

This section discusses options that are available to address the Canadian dogfish issue. Further examination of these options is necessary and additional options may well exist. More than one option may, of course, be implemented at the same time to form a program to reduce dogfish stocks.

There are a number of factors that should be considered when evaluating the options. First, as a general rule, we have inadequate information regarding dogfish to make informed guesses about some of the impacts of choosing a particular option. For example, we do not know what bycatch is associated with a foreign factory trawler fishing dogfish in our waters.

Second, implementation of some options may impact American interests, in New England and the mid-Atlantic states as well as Washington State, who are harvesting and processing dogfish or gearing up to do so. We should carefully evaluate the anticipated U.S. reaction to any large scale dogfish stock reduction program we propose.

Third, costing these options is beyond the scope of this report. Detailed cost/benefit analysis should be conducted on each coast before a final decision regarding these options can be made. Some questions (such as bycatch levels associated with large foreign trawlers) can probably not be fully answered until that kind of program is actually implemented. This uncertainty should not slow down the decision making process. It would be wise, however, for the decision makers to ensure that any program put into place is flexible so it can be altered as more data is obtained.

Finally, the decision makers must be aware that a program implemented on one coast will likely result in requests for a similar program on the other coast.

Ignore the Issue

At one end of the range of options available on each coast is the status quo option. On the East Coast, it is possible that dogfish infestation may disappear as mysteriously as it appeared. However, it would appear to be risky to ignore the problem on the basis that is might go away. On the West Coast, the issue will not go away on its own.

Ignoring the issue does not appear to be an appropriate solution.

Eradicate the Species

At the other end of the available range of options is a program to eradicate the species entirely. There are a number of problems with this option.

First, eradication may be theoretically possible but practically impossible to implement. Over a dozen subsidy programs on the West Coast have failed to eradicate the species and even the intensive liver fishery in the 1940s, while it did decrease the stock, did not do irrepairable harm. The reasons eradication may be impossible in a practical sense are that: 1) the larger fish are sought first to fulfill market requirements so that juvenile fish survive to take the place of the adults a few years after the program stops, and 2) attempts to fish out the juvenile dogfish stocks would likely result in unacceptably high bycatch rates.

There is some evidence pointing to the conclusion dogfish play a useful balancing role vis-a-vis other types of marine life. For instance, there is a possibility that the fishing industry may be better off by leaving dogfish alone so dogfish will continue to eat jellyfish because otherwise the larger jellyfish population might eat more larval herring.

In addition, eradication is usually talked about in general terms because few people know how to go about it. There is no doubt substantial sums of money (from the government) would be required and it is doubtful the purse strings can be coaxed open at this time of deficit reduction.

The opponents of eradication point out that the United States trend to eat more and more seafood means dogfish is a protein source that may become extremely valuable in the next few years. They argue it would be shortsighted to kill dogfish at this time and point to previously underutilized species which have achieved a high level of demand in the market. Catfish is an example.

Some people speak about a bounty to eradicate dogfish. These people may be more interested in additional income than in reducing the stock of dogfish.

Finally, eradication is totally opposed by the people who view dogfish as a resource and are fishing or processing the species at this time.

Eradicating dogfish does not appear to be a biologically appropriate or economically viable solution.

Monitor and Avoid

If the dogfish issue is defined as "longliners are suffering a loss of income", then the solution has to address only that aspect of the problem. Fishermen could report areas of intensive dogfish infestation and a central organization, presumably government, could compile dogfish location data and make it available to interested parties on a timely basis. Longliners should then be able to avoid the grounds known to be infested with dogfish.

Upon close examination, it may be found that fishermen are already doing this informally on marine radios at no expense to taxpayers. In any event, it does not reduce the stock size.

Repel the Species

Assuming once again the dogfish issue is narrowly defined as a longliner problem, repellants could theoretically be used to allow longline gear to catch valuable species and avoid dogfish.

Bait could be treated so that it would be unattractive to dogfish but attractive to the desired species. Research could be conducted to see if such a repellant can be produced inexpensively. This does not reduce the stock size nor does it resolve the problem caused by dogfish consuming fish captured by the longline.

Sonar equipment could be used to frighten away dogfish while longline gear settles to the bottom. The theory is that a device, maybe similar to a battery operated radio, could emit sonar frequencies known to be irritating to sharks. This assumes juvenile dogfish, which inhabit the upper water levels, are attacking the baited longline gear before it even reaches the

ocean bottom. Research into the effectiveness of sonar equipment should be conducted. This does not reduce the stock size.

Plastic hooks may not attract dogfish as readily as metal hooks because the metal hooks are surrounded by an electrical field which the shark is very sensitive to. Because plastic hooks would not give off any electrical signals, they may be less vulnerable to attacks by dogfish. In addition, plastic hooks might reduce gear damage and cut down repair time.

Fish Dogfish

There are an almost endless number of options which address the dogfish issue by fishing dogfish. All these options have one aspect in common - fishing vessels harvesting dogfish. They differ in the way harvesting, processing, and marketing are undertaken.

In terms of harvesting, the domestic effort could be longliners or trawlers. The vessels could be small or large. They may be subsidized directly, indirectly, or not at all. No foreign effort is required. Indeed, foreign partners may jeopardize the marketing efforts of the existing Canadian industry by competing in the same markets. Notwithstanding this, there may be foreign effort directly fishing dogfish or participating as the joint venture partner in an over-side-sale arrangement. The foreign partner's commitment might be subsidized by access to Canadian fish, or it might be bought through a commercial charter, or there may be no subsidy at all.

In terms of processing, there may or may not be a subsidy for production of traditional products like backs, belly flaps or fins and tails. If there is to be a subsidy, it should probably encourage development of new food and non-food products.

In terms of marketing, there may or may not be assistance for marketing dogfish products to existing markets. If there is to be assistance, it should probably concentrate on developing new markets (such as North America and the Orient) for new products such as fillets and frozen dressed dogfish.

SIGNIFICANT POINTS

1. The fishery is, at best, a low margin one for processors. The actual price to fishermen therefore can be expected to be extremely low in comparison to the prices for species such as cod and haddock (on the East Coast) and halibut (on the West Coast).

2. Even if fishermen and processors worked to develop their dogfish processing skills, the market in Europe can absorb no more than an additional 10 to 15 percent of its current imports - a round weight equivalent of 4,000 T to 6,000 T.

3. Harvesting 4,000 to 6,000 T is almost insignificant when the biomass of the resource is about 500,000 T. Removals of this order are an inadequate solution to the problem. Other options must be addressed.

4. Decision makers must be aware that a program implemented on one coast will likely result in requests for a similar program on the other coast.

5. At one end of the range of options is the status quo option. Ignoring the issue does not appear to be an appropriate solution.

6. At the other end of the range of options is a program to eradicate the species entirely. Eradication has never worked in the past and is not now likely to be successful. In addition, dogfish may play a useful balancing role vis a vis other forms of marine life and may one day become an extremely valuable source of protein. Eradication does not appear to be biologically appropriate or economically feasible.

7. If the dogfish issue is defined as a longliner problem, the location of dogfish could be closely monitored and this data could be made available to fishermen so infested grounds could be avoided. Fishermen probably do this informally now.

8. Further research could be conducted into repelling dogfish. It is possible that bait

could be treated to make it unattractive to dogfish, sonar equipment could keep dogfish away from areas being fished, and plastic hooks could be less vulnerable to dogfish attacks.

9. The most practical way to decrease the dogfish nuisance factor is to harvest significant quantities of the fish on an ongoing basis. An almost endless number of suboptions exist. The harvesting itself can be by trawlers or longliners, small or large vessels, domestic or foreign, subsidized directly, indirectly or not at all. The processing of traditional products may or may not be subsidized. If there is to be a subsidy for processing dogfish, it should concentrate on developing new food and nonfood products. If there is to be assistance at the marketing level, it should concentrate on new markets for new products. Examples are frozen dressed dogfish in the Orient, frozen fillets and surimi-based imitation products in North America.

CONCLUSIONS

Previous sections of this report presented detailed information on dogfish biology, harvesting, processing, marketing and options available to deal with the dogfish infestation problem. This section presents conclusions and recommendations that emerge from this research into the dogfish issue.

The generally accepted dogfish problem is that dogfish cause economic loss and hardship to commercial fishermen.

The main direct impact is on fixed gear fishermen, particularly longliners. Their catches of ish are reduced, bait is lost to dogfish, and their gear is damaged. The indirect impact is felt by fish plant workers and plant owners.

The principal conclusion of this report is that harvesting dogfish by domestic boats and processing the fish into traditional products for sale in the traditional markets of Europe cannot solve the dogfish problem on either coast of Canada. This is because the additional quantity of dogfish the European market can absorb each year converts to a round weight of between 4,000 and 6,000 T. To place this in context, the estimated size of the dogfish biomass in the northwest Atlantic is 250,000 to 300,000 T while the Northeast Pacific biomass of marketable size dogfish is 350,000 T. The estimated maximum sustainable yield is 20,000 to 25,000 T on the East Coast of North America and about 18,000 T in the Northeast Pacific. Clearly, this level of removals from the biomass enables the resource to grow rather than bringing it under control.

It should be noted that the estimated 4,000 to 6,000 T round weight assumes ideal conditions. First, the fish must be at least 30 in. long to meet market specifications for the backs and belly flaps. Second, it must be available in sufficient quantities that it can be economically harvested. Third, an agreement on price must be reached. Fourth, processors have to produce top quality in a low margin product line. Fifth, the timing of catching and selling must be timed to avoid spoilage in cold stores. The assumption that another 4,000 to 6,000 T round weight can be sold in Europe is an estimate of aggregate market demand. It is signficant to note that Arrowac Fisheries intends to stop dogfish production in the summer (which is the only time dogfish is available in Atlantic Canada) because fresh product from the North Sea is on the market and the market is sluggish. Reaching that figure may be impossible in the short term for these reasons.

Other options must be considered.

Decision makers might be irresponsible to maintain the status quo and hope that the problem disappears on its own.

At the other end of the spectrum, it is hard to support an eradication program. Given recent developments in the North American market (such as the California shark craze), we should not eradicate a potentially valuable protein source. More practically, it is virtually impossible to eradicate or eliminate dogfish. Past programs on the West Coast have succeeded in removing some

large dogfish for a temporary period but the young fish take their place a few years later.

A workable solution to reduce the dogfish stock must be sought. It almost certainly requires boats harvesting significant quantities of dogfish.

It is possible that new food products (such as surimi based imitation products) and/or new markets (North America) may provide a partial solution to the dogfish problem in the longer term. These possibilities warrant further investigation.

Similarly, non-food uses of dogfish (such as feed for the Atlantic Canadian aquaculture industry) may provide a partial solution to the problem. These too should be researched.

The Nova Scotia Department of Fisheries is convinced the dogfish problem is a serious one that requires immediate action. The Department supports additional biological research into the dogfish stock. In particular, they feel the research should examine the dogfish in its ecosystem. We should try to improve our understanding of how dogfish interacts with the more commercially valuable fish species in the water.

The fishing industry organizations are not as vocal about the dogfish problem as the fishermen directly affected would like them to be. The Eastern Fishermen's Federation, for instance, states that public money would be more wisely spent on a seal reduction program than on dogfish control. The Maritime Fishermen's Union thinks the government should do something to solve the problem, but they view the solution to the problem in terms of benefits to MFU members.

On the West coast, fishermen's groups have called for dogfish stock reduction subsidies year after year.

The Seafood Producers Association of Nova Scotia wants to have meaningful input into the decision making process concerning options for dogfish control and program implementation. While the Association is generally opposed to an increased foreign presence in Canadian waters, it has not ruled out this possibility in the case of dogfish. The processors want evidence a serious problem exists and they want adequate input into the decision-making process.

Additional biological research is needed to help place a "cost" on the dogfish problem. Specifically, the biomass and the maximum sustainable yield must be agreed upon. Also, target removal levels should be identified for specific goals (such as to contain growth or to cut the stock in half over five years). We need a better understanding of the size and sex distribution of the dogfish that come to Canadian waters, and when they migrate and why. Finally, we should have a better understanding of the quantity of commercial species of fish that dogfish consume and how dogfish interact with groundfish.

Once an accurate "cost" is obtained, we will have a more accurate definition of "the problem" than we currently have. We will know if dogfish is an industry wide problem costing millions of dollars each year or if it is a nuisance to some longline fishermen. Once the problem is costed, the various potential solutions under consideration can be evaluated in a cost/benefit framework.

The potential bycatch problem associated with fishing for dogfish is an unknown factor in many of the options that call for direct fishing of dogfish. Further research must be conducted into the groundfish bycatch expected if large trawlers direct for dogfish. If small boats cannot participate in an extended experimental dogfish fishery or if managers are not convinced that the data from draggers can be extrapolated to large trawlers, then consideration should be given to the experimental use of large domestic trawlers that are currently idle.

The options discussed above should be further researched and presented to industry-government consultation meetings. If possible, the options should be costed, and pros and cons of each should be identified.

Further analysis should not fail to take into consideration the fact that there is an existing dogfish fishery in British Columbia. Neither

coast should implement a "solution" causing serious disruptions to the other coast.

The Department of Fisheries and Oceans should augment the various committees and working groups investigating dogfish with a designated person on each coast to act as a full-time dogfish program coordinator and investigator. This person would be responsible to arrange the meetings necessary to obtain the required biological input, put into place a program to get bycatch data, and consult with the various interest groups while expanding the options identified.

Dogfish presents fishery managers with a unique problem in an industry where the normal practice is to ensure the fish resource remains strong. However, the dogfish resource is a nuisance to commercial fishermen on both coasts and to sport fishermen on the West Coast. A workable solution to control the stock should be implemented as soon as possible.

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Table 1

DOGFISH NAMES

Common Usage:

dogfish	spiny dogfish	dogs	dog shark
spurdog	greyfish	bone dog	mud shark
skittle dog	picked dogfish	piked dogfish	cod shark
horned dogfish	rockfish	flake	thornback shark
huss	rigg	collie	

National Names:

Britain - rock salmon
France - aguillat commun
- chein de mer
- chat de mer
- saumonette
Belgium - doornhai
- zeepaling
Germany - dornhai
- see aal
Italy - spinarolo
Canada - northern shark (Proposed by the Nova Scotia Department of Fisheries, 1985)
- kahada (West Coast native name)

Table 2

DOGFISH DIET IN HECATE STRAIT

Food Item	AUGUST 1977		JUNE 1978	
	Number of Occurrences	Percent of Total Volume	Number of Occurrences	Percent of Total Volume
Jellyfish (all kinds)	91	4.5	577	28.7
Crab (all kinds)	461	9.8	567	14.5
Sandlance	217	16.1	277	10.6
Unidentified Organic	96	1.9	644	10.5
Molluscs (all kinds)	506	20.4	276	7.8
Unidentified Fish Remains	237	17.1	153	5.8
Unidentified Flatfish	18	1.0	21	5.4
Herring	15	1.3	23	2.7
Sablefish	-	-	17	2.6
Shrimp	408	2.8	355	2.4
Dogfish	17	2.9	8	0.5
Salmon	3	1.0	4	0.2

Source: McFarlane et al (1984)

Table 3

BRITISH COLUMBIA DOGFISH LANDINGS
1980 to 1985

	YEAR					
	1980	1981	1982	1983	1984	1985
Strait of Georgia:						
Quota (T)	3,000	5,000	3,000	3,000	3,000	3,000
Total Catch* (T)	2,108	764	1,259	231	317	666
Coastwide:						
Quota (T)	6,000	6,000	6,000	6,000	6,000	15,000
Total Catch* (T)	2,439	1,151	1,319	479	668	1,583
TOTAL:						
Quota (T)	9,000	11,000	9,000	9,000	9,000	18,000
Total Catch* (T)	4,550	1,900	2,578	710	985	2,249

* Excluding U.S. Landings

Source: Annual Summary of B.C. Catch Statistics; Commercial Fishing Guide - Department of Fisheries and Oceans

Table 4

PUGET SOUND DOGFISH LANDINGS
1980 to 1983
(Converted to T)

AREA	YEAR			
	1980	1981	1982	1983
Gulf - Bellingham	794	891	1,217	823
San Juan	877	461	222	296
Juan de Fuca	662	197	112	204
Hood Canal	232	56	33	93
Central Sound	357	158	352	278
South Sound	90	50	14	8
TOTAL	3,012	1,813	1,950	1,702

Source: United States Government Documents

Table 5

BRITISH COLUMBIA DOGFISH EXPORTS

PRODUCT	YEAR							
	1981		1982		1983		1984	
	Weight KG	Value $	Weight KG	Value $	Weight KG	Value $	Weight KG	Value $
Fresh Round	598,513	53,037	2,091,000	516,351	2,520,336	604,881	1,690,557	390,238
Fresh Dressed	51,585	13,031	13,608	3,788	-	-	-	-
Frozen Round	-	-	-	-	111,276	26,011	-	-
Frozen Dressed	213,141	37,552	357,317	130,278	23,749	41,498	-	-
Fins and Tails	16,230	7,745	30,659	60,263	4,961	46,309	14,286	256,957
Belly Flaps	45,900	59,582	80,186	191,929	55,948	101,811	37,137	96,032
Backs	455,484	207,975	433,415	468,907	122,144	225,857	201,548	235,658
Smoked	-	-	-	-	452	4,170	-	-
DOGFISH TOTAL	1,380,853	378,922	3,006,185	1,371,516	2,892,866	1,050,537	1,943,528	978,885

Source: DFO; Fish Products Exports of British Columbia, various years.

Table 6

UNITED KINGDOM DOGFISH IMPORTS - 1983
(T)

Imported From	Fresh	Frozen	Total
Belgium and Luxembourg	11.7	-	11.7
Denmark	6.8	3.9	10.7
France	13.9	26.5	40.4
Ireland	1891.4	160.2	2051.6
Netherlands	4.1	61.0	65.1
West Germany	2.8	10.2	13.0
Ireland	3.0	-	3.0
Norway	99.4	28.3	127.7
Canada	19.0	133.9	152.9
USA	-	823.6	823.6
TOTAL	2052.1	1247.6	3299.7

Source: M.A.F.F., London, England

Table 7

UNITED KINGDOM DOGFISH IMPORTS - 1984
(T)

Imported From	Fresh	Frozen	Total
Belgium and Luxembourg	6.9	15.2	22.1
Denmark	11.6	-	11.6
France	1.4	34.3	35.7
Ireland	2317.7	59.0	2376.7
West Germany	-	20.1	20.1
Ireland	1.0	3.5	4.5
Norway	124.2	26.5	150.7
Canada	-	135.6	135.6
USA	-	599.3	599.3
Singapore	-	0.5	0.5
Turkey	-	20.1	20.1
TOTAL	2462.8	914.1	3276.9

Source: M.A.F.F., London, England

Table 8

UNITED KINGDOM DOGFISH IMPORTS - 1985
January to September
(T)

Imported From	Fresh	Frozen	Total
Belgium and Luxembourg	0.7	-	0.7
Denmark	10.0	24.6	34.6
France	32.0	15.8	47.8
Ireland	2958.9	4.9	2963.8
Netherlands	16.5	-	16.5
Norway	0.3	1.1	1.4
Canada	-	249.0	249.0
USA	-	611.2	611.2
TOTAL	3018.4	906.6	3925.0

Source: M.A.F.F., London, England

Table 9

UNITED KINGDOM DOGFISH EXPORTS - 1983
(T)

Exported To	Fresh	Frozen	Total
France	2020.0	253.0	2273.0
Belgium and Luxembourg	1.0	-	1.0
West Germany	2.5	185.0	187.5
Netherlands	0.5	17.0	17.5
Italy	3.0	-	3.0
Irish Republic	10.0	-	10.0
Thailand	17.0	80.0	97.0
Oman	-	0.5	0.5
Singapore	-	20.0	20.0
TOTAL	2054.0	555.5	2609.5

Source: M.A.F.F., London, England

Table 10

UNITED KINGDOM DOGFISH EXPORTS - 1984
(T)

Exported To	Fresh	Frozen	Total
France	3644	478	4122
Belgium and Luxembourg	15	2	17
West Germany	1	310	311
Netherlands	7	57	64
Irish Republic	4	-	4
Denmark	1	-	1
Thailand	-	118	118
Singapore	-	13	13
Spain	-	9	9
Taiwan	-	11	11
TOTAL	3672	998	4670

Source: M.A.F.F., London, England

Table 11

UNITED KINGDOM DOGFISH EXPORTS - 1985
January to September
(T)

Exported To	Fresh	Frozen	Total
France	3062.0	629.0	3691.0
Belgium and Luxembourg	27.5	15.0	42.5
West Germany	19.0	335.0	354.0
Netherlands	2.0	53.0	55.0
Thailand	-	172.0	172.0
Switzerland	7.0	-	7.0
TOTAL	3117.5	1204.0	4321.5

Source: M.A.F.F., London, England

Table 12

DOGFISH IMPORTS AND EXPORTS - BELGIUM - 1983
(T)

Imported From	Fresh	Frozen	Total
EEC (Other)	13.0	61.2	142.5
Netherlands	32.1	-	32.1
Denmark	36.3	-	36.3
Norway	43.3	-	43.3
Canada	-	103.4	103.4
USA	-	299.2	299.2
TOTAL	124.7	463.8	656.8

Exported To	Fresh	Frozen	Total
EEC	10.9	1.8	10.9
TOTAL	10.9	1.8	12.7

Source: Belgian government documents

Table 13

DOGFISH IMPORTS AND EXPORTS - FRANCE - 1982
(T)

Imported From	Fresh	Frozen	Total
Britain	835	53	888
Denmark	104	-	104
Norway	400	-	400
USA	35	473	508
Canada	-	36	36
Turkey	-	41	41
Other	22	50	72
TOTAL	1396	653	2049

Exported To	Fresh	Frozen	Total
Italy	58	-	58
Other	1	24	25
TOTAL	59	24	83

Source: French government documents

Table 14

DOGFISH IMPORTS AND EXPORTS - FRANCE - 1983
(T)

Imported From	Fresh	Frozen	Total
Britain	2422	164	2586
Ireland	-	51	51
Denmark	67	-	67
Norway	682	-	682
USA	-	1326	1326
Canada	-	153	153
Turkey	90	477	567
Other	83	77	160
TOTAL	3344	2248	5592

Exported To	Fresh	Frozen	Total
Italy	582	-	582
Norway	-	62	62
Other	7	40	47
TOTAL	589	102	691

Source: French government documents

Table 15

DOGFISH IMPORTS AND EXPORTS - FRANCE - 1984
(T)

Imported From	Fresh	Frozen	Total
Britain	3583	491	4074
Ireland	260	123	383
Denmark	39	-	39
Norway	408	-	408
USA	-	1053	1053
Canada	-	47	47
Turkey	-	738	738
Chile	-	44	44
New Zealand	-	46	46
Other	62	2	64
TOTAL	4352	2544	6396

Exported To	Fresh	Frozen	Total
Italy	582	-	582
Norway	-	62	62
Other	7	40	47
TOTAL	589	102	691

Source: French government documents

Table 16

DOGFISH IMPORTS AND EXPORTS - GERMANY - 1984
(T)

Imported From	Fresh	Frozen	Total
EEC	220.8	580.8	801.6
France	-	46.2	46.2
Great Britain	31.8	464.4	496.2
Ireland	-	45.0	45.0
Denmark	183.1	-	183.1
Norway	120.2	243.0	363.2
Turkey	-	63.6	63.6
USA	-	496.5	496.5
Canada	-	198.5	198.5
TOTAL	343.2	1582.4	1925.6

Exported To	Fresh	Frozen	Total
EEC	0.8	42.6	43.4
Other	1.0	1.2	2.2
TOTAL	1.8	43.8	45.6

Source: German government documents

Table 17

NORTH AMERICAN DOGFISH EXPORTS TO EUROPE

EXPORTED FROM	EXPORTED TO									
	UNITED KINGDOM		BELGIUM		FRANCE		GERMANY		TOTAL	
	T	%	T	%	T	%	T	%	T	%
Canada	136	4	103	16	47	-	199	10	485	4
United States	600	18	299	45	1053	17	496	26	2448	20
North America	736	22	402	61	1100	17	695	36	2933	24
TOTAL IMPORTS	3277	100	657	100	6396	100	1926	100	12256	100

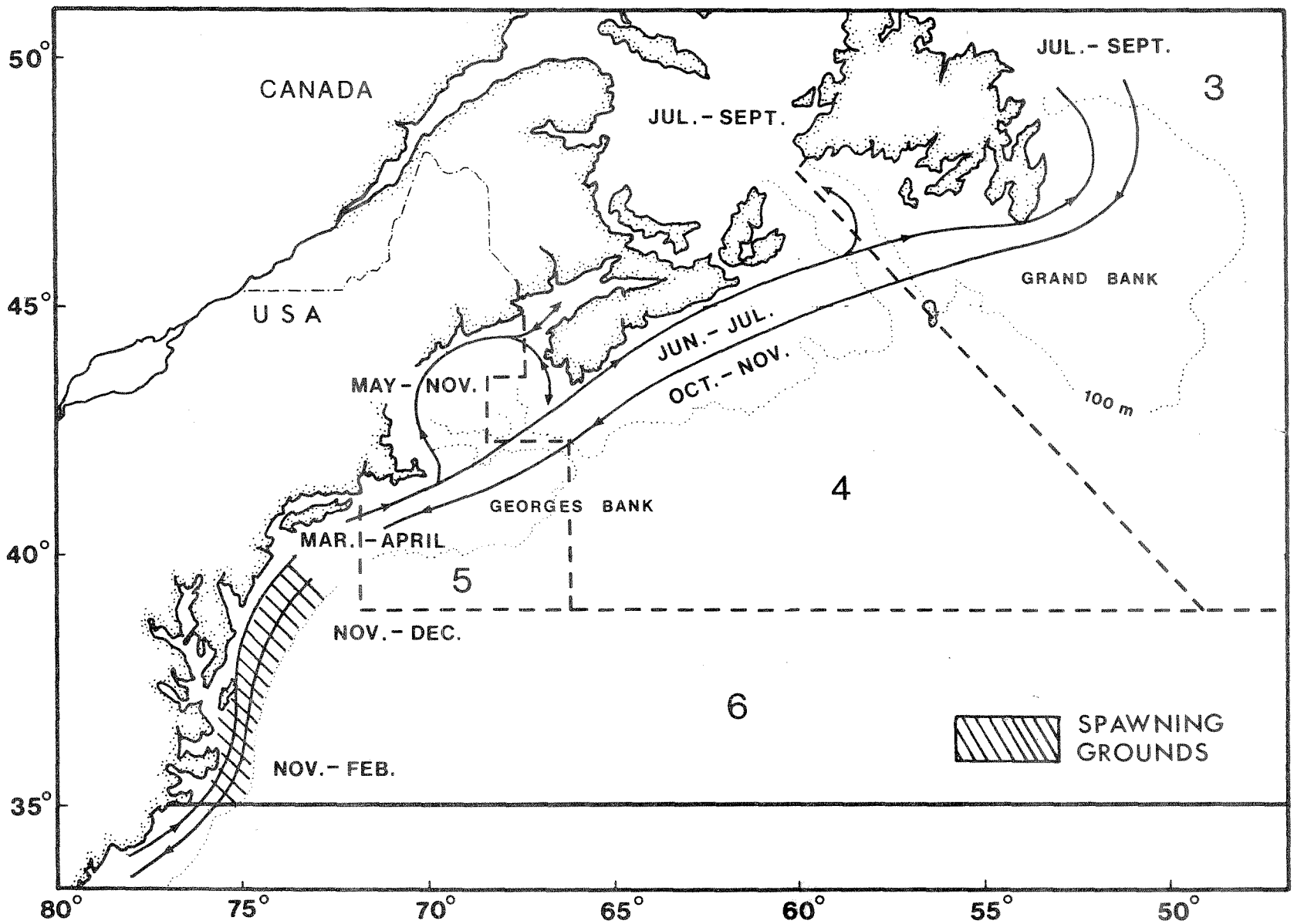


FIGURE 1. ATLANTIC CANADA:
NAFO DIVISIONS AND DOGFISH MIGRATION

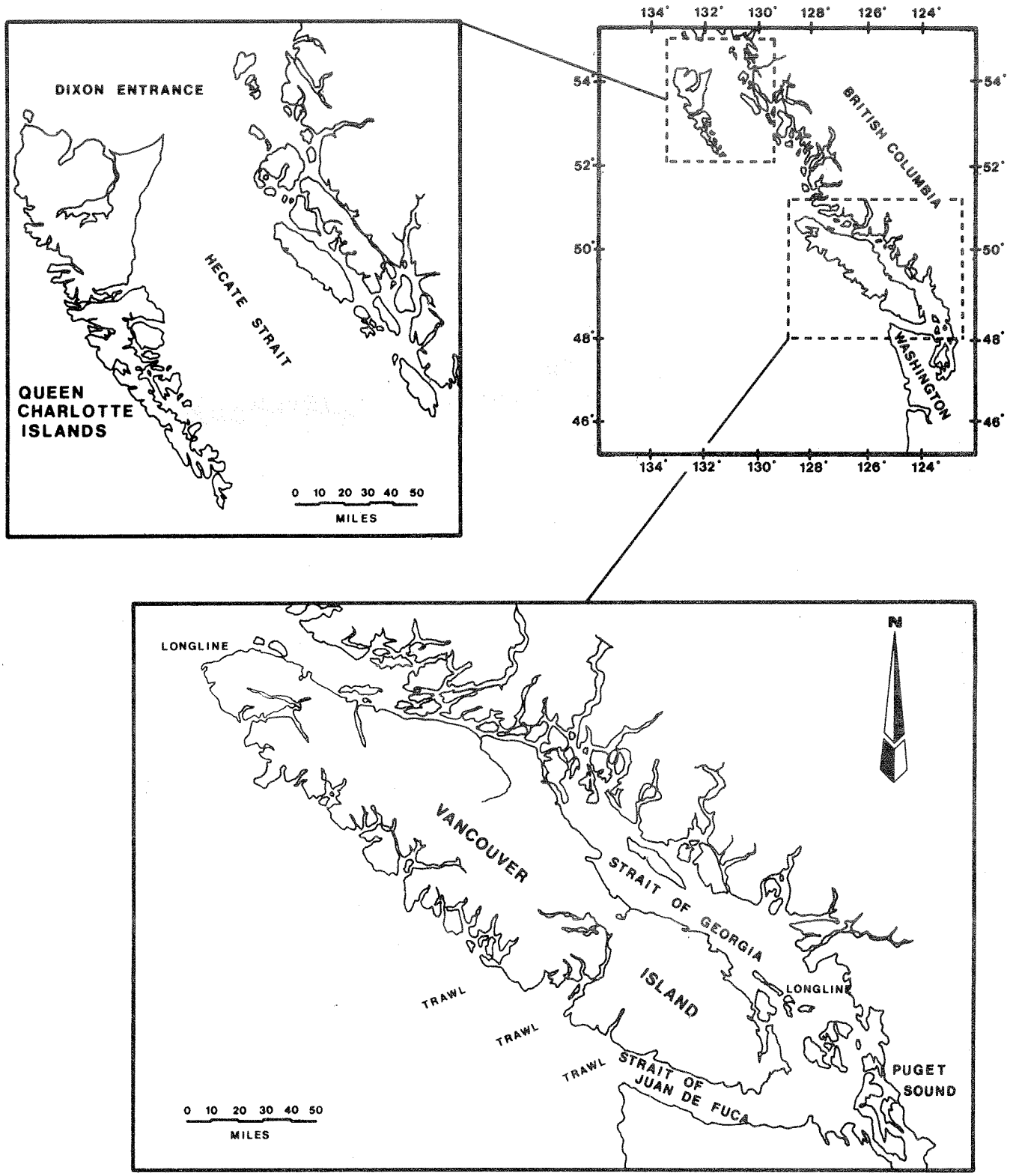


FIGURE 2. NORTHEAST PACIFIC:
PRINCIPAL DOGFISH FISHERIES

Figure 3

DOGFISH

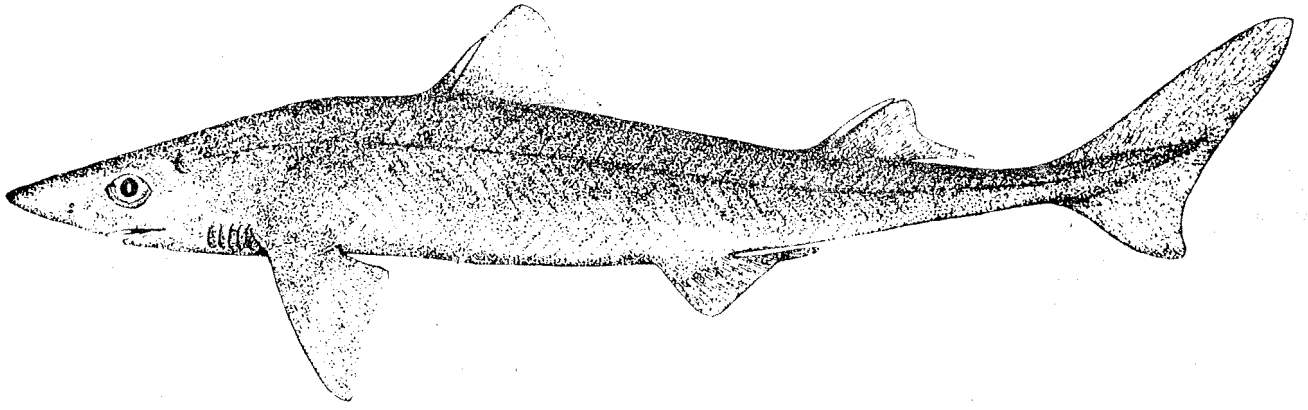


Figure 4

DOGFISH IN AN OTTER TRAWL

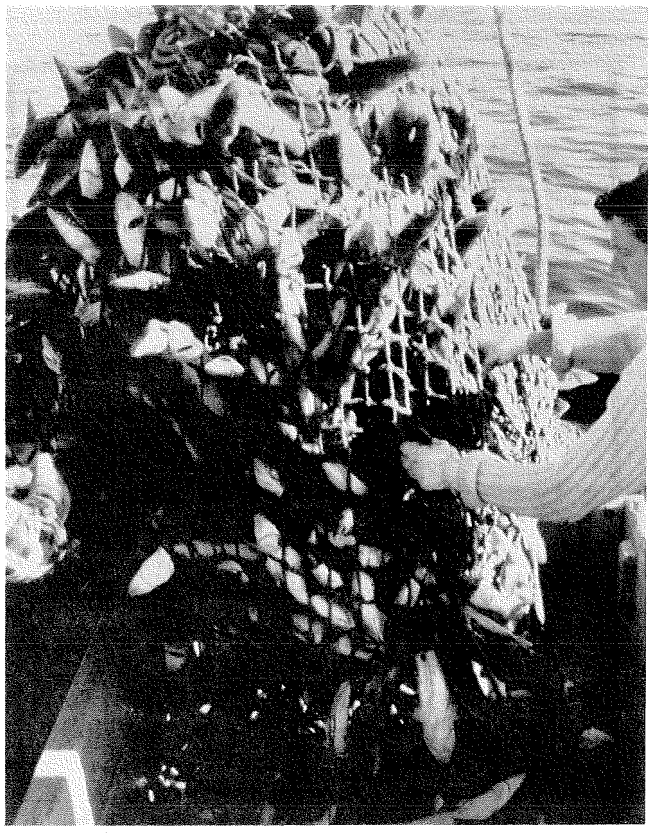
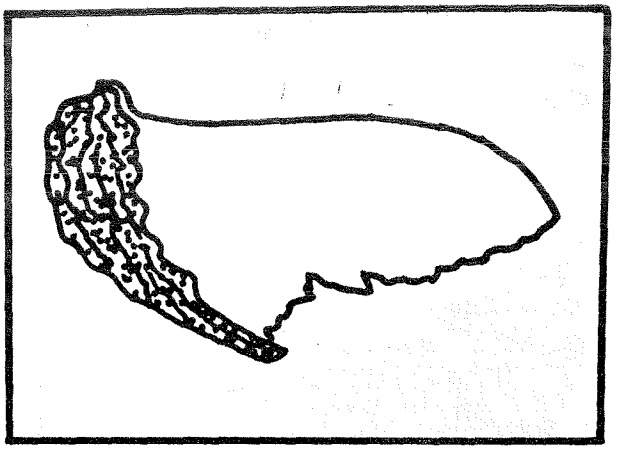


Figure 5

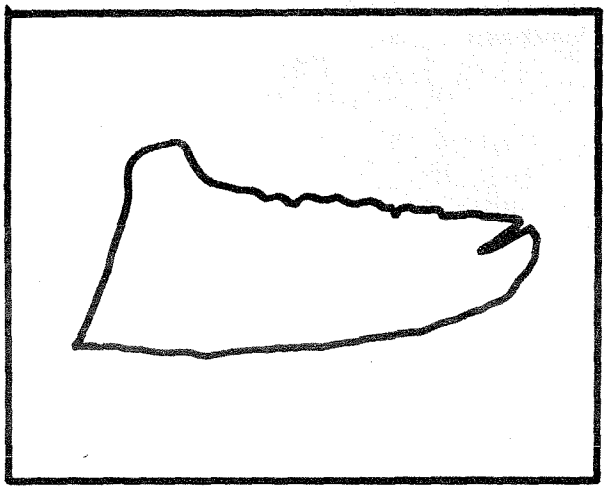
BELLY FLAPS (SCHILLERLOCKEN) ON DISPLAY IN GERMANY

Figure 6

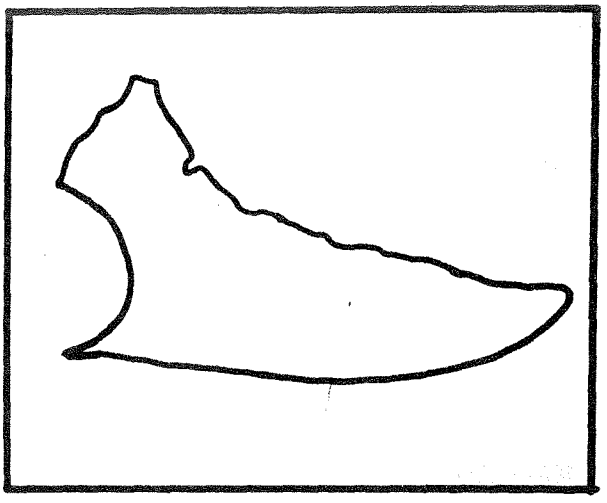
SHARK FIN CUTTING METHODS



CRUDE CUT



STRAIGHT CUT



HALF-MOON CUT

from: Ka-Keong (1983).

Figure 7

ESCAVECHE DISPLAYED IN BELGIUM