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The Status of Spiny Dogfish (*Squalus acanthias*, Linnaeus) in the Bay of Fundy, Scotian Shelf and Southern Gulf of St. Lawrence (NAFO Divisions 4TVWX) in 1995

by

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ABSTRACT

Although spiny dogfish have historically been regarded as nothing more than a nuisance by many inshore fishers, the relatively recent development of markets for dogfish products from North America has resulted in the establishment of directed fisheries in the Northwest Atlantic, including the Southern Gulf of St. Lawrence and the Scotian Shelf.

Research vessel data from surveys of the Scotian Shelf (NAFO Div. 4VWX) suggest an increase in the abundance of spiny dogfish since 1981, whereas data from surveys of the Southern Gulf (NAFO Div. 4T) suggest an increase in abundance since 1987.

Analyses presented during the most recent (1994) assessment of spiny dogfish in the Northwest Atlantic (NAFO Subareas 2-6) indicate that this stock is stable at best. and has possibly begun to decline as a result of recent increases in exploitation (U.S. N.M.F.S. N.E.F.S.C. Ref. Doc. 1994).

RÉSUMÉ

Bien que l'aiguillat commun soit depuis longtemps considéré comme rien de plus qu'un nuisible par de nombreux pêcheurs côtiers, le développement relativement récents de marchés pour des produits de l'aiguillat de l'Amérique du Nord a donné lieu à l'établissement de pêches dirigées de l'espèce dans l'Atlantique nord-ouest, y compris le sud du golfe du Saint-Laurent et le plateau néo-écossais.

Des données recueillies dans le cadre de relevés de recherche effectués sur le plateau néo-écossais (division 4WX de l'OPANO) portent à croire à une augmentation de l'abondance de l'aiguillat commun dans cette région depuis 1981, tandis celles recueillies dans le sud du golfe (division 4T de l'OPANO) indiquent une augmentation de l'abondance depuis 1987.

Des analyses présentées lors de la plus récente évaluation de l'aiguillat commun de l'Atlantique nord-ouest, soit en 1994, indiquent que le stock est stable au mieux et qu'il a peut-être commencé à diminuer suite à de récentes poussées de l'exploitation. (U.S. N.M.F.S. N.E.F.S.C. Ref. Doc. 1994)

Introduction

The spiny dogfish (*Squalus acanthias*) is a small, highly migratory shark that occurs in the Northwest Atlantic between Labrador and Florida. Spiny dogfish have long been regarded as a nuisance by inshore fishers and have become an increasing menace to fixed gear fishers on the Scotian Shelf and in the Gulf of St. Lawrence, as their numbers have increased in Canadian waters. Hurley et al. (1987) concluded that spiny dogfish interfere with fishing operations more than any other species. Furthermore, spiny dogfish predation may be a significant source of mortality for commercially and recreationally important fish species (Salsbury, 1986).

Opinions about the extent of the "nuisance" caused by spiny dogfish have moderated to a certain extent with the establishment of markets and directed fisheries in certain areas of its range, especially during the recent declines and closures in traditional Northwest Atlantic groundfish fisheries. In fact, the spiny dogfish has been described as the largest underutilized finfish resource in the Northwest Atlantic (Walsh, 1982).

Historically though, directed fisheries for sharks have tended to be characterised as "boom and bust" enterprises, because populations have been rapidly reduced to levels that will not support a fishery. Populations impacted by shark fisheries are slow to recover, sometimes requiring decades to reach their former levels (Pratt and Casey, 1990). This has been attributed to their slow growth, considerable longevity and low reproductive capacity (i.e., long gestation period and low fecundity). Holden (1977) recommended that there is not enough resilience in even the most fecund and abundant elasmobranchs, the skates and spiny dogfish, to maintain intensive fisheries.

There is a small body of work on this species in the Northwest Atlantic, most notably Templeman (1944), Jensen (1966), Annand (1985) and Nammack et al. (1985). A much larger collection of papers is available for this species in European and western Pacific waters.

The first comprehensive assessment of spiny dogfish in the Northwest Atlantic management unit (NAFO Subareas 2-6) was completed by the U.S. National Marine Fisheries Service in 1994 (U.S. N.M.F.S. N.E.F.S.C. Ref. Doc. 94-22 1994). It contained descriptions of the life history, commercial fishery, and research data on spiny dogfish and included several innovative approaches for estimating stock size, F and biological reference points.

Increasing interest by industry in the exploitation of spiny dogfish stimulated Marine Fish Division staff at the Gulf Fisheries Center and at the Bedford Institute of Oceanography to initiate a modest research and assessment effort on this species. Hurlbut et al. (1995) conducted the first review of the status of spiny dogfish in the Southern Gulf of St. Lawrence and stock status reports (SSR's) were produced for the Gulf of St. Lawrence and the Scotian Shelf in 1995. In the fall of 1995 an Elasmobranch Assessment team (Table 1) was formed to produce the research documents and SSR's for spiny dogfish, porbeagle, blue and mako sharks and skates, as part of the Maritimes Regional Advisory Process (R.A.P.). The team met four times during January - June 1996 to review prepared material and compile reports.

This document summarizes the information compiled by the team on the status of spiny dogfish in the NAFO Subarea 2-6 management unit. Given that the research program was initiated recently, many of the analyses are preliminary and thus recommendations are made to further the research program. Notwithstanding the preliminary nature of the information, advice is provided to serve as the basis for management in the Canadian Zone. This document was externally reviewed as part of the Maritimes RAP.

Basic Life History Information

Distribution, Migrations and Stock Structure

Spiny dogfish occur on both sides of the North Atlantic, chiefly in temperate and subarctic waters (7° to 13°C) and in depths less than 360 m (Jensen, 1966). In the Northwest Atlantic, the range of dogfish extends from Labrador to Florida, but they are most abundant between Nova Scotia and Cape Hatteras.

Spiny dogfish in the Northwest Atlantic are highly migratory and undertake seasonal migrations northward in the spring and summer and southward in the fall and winter. Migration takes place in schools. Tagging and field observations by Templeman (1944), Bigelow and Schroeder (1953), Holland (1957), Jensen (1961; 1966) and Shafer (1970) indicate that spiny dogfish school by size until they reach sexual maturity after which they form schools based on size and sex.

Dogfish traditionally arrive off Nova Scotia and the Bay of Fundy in June and appear in the Gulf of St. Lawrence in July (Walsh, 1982). By late autumn (mid-October to mid-November) most of the migrants leave Canadian waters on their return migration southward to waters off the Carolinas and Virginia. Templeman (1944), suggested that some immature males and females, as well as some mature males, may over-winter in Newfoundland waters in deep channels and holes on St. Pierre Bank, in the Laurentian Channel, and in some of Newfoundland's south coast bays.

Tagging studies of spiny dogfish (Jensen, 1961 and Shafer, 1970) suggest that dogfish in the Northwest Atlantic comprise one stock. Annand and Beanlands (1986) examined the extent of genetic differentiation between dogfish from the Gulf of Maine and the Scotian Shelf using protein electrophoresis. The results of their study indicated that there is no genetic difference between spiny dogfish from the two areas and supported previous conclusions that there is one stock of dogfish which undergoes large seasonal migrations. Consequently, spiny dogfish in the Northwest Atlantic are considered to be a unit stock in NAFO Subareas 2-6.

Age, Growth and Natural Mortality

The spiny dogfish is a very long-lived and slow-growing species. Since they lack conventional scales or otoliths, age determinations are made by interpreting growth rings or zones on the second dorsal spine. Female dogfish grow larger and live longer than males. In the western Atlantic, spiny dogfish appear to live for approximately 40 years and reach a maximum theoretical length of 120 cm (approx. 7 kg) for females and 96 cm (approx. 3 kg) for males (Nammack et al., 1985). In contrast, ages as old as 70 years have been determined for spiny dogfish off British Columbia (McFarlane and Beamish, 1987).

In the most recent U.S. assessment of spiny dogfish in the NAFO Subareas 2-6 management unit (U.S. N.M.F.S. N.E.F.S.C. Ref. Doc. 94-22 1994), the Von Bertalanffy growth model was computed from parameters estimated by Nammack et al. (1985), that were subsequently revised by Silva (1993). The parameters used were:

Females	Males
$L_\infty = 105$ cm	$L_\infty = 81.32$ cm
$K = 0.1128$	$K = 0.1578$
$t_0 = -2.552$	$t_0 = -2.4523$

In the same assessment, an instantaneous natural mortality rate (M) of 0.092 was assumed for male and female spiny dogfish greater than 30 cm. long (U.S. N.M.F.S. N.E.F.S.C. Ref. Doc. 94-22 1994).

Reproductive Biology

There are three modes of reproduction in sharks - oviparity, ovoviviparity, and viviparity. These modes have markedly different implications for the life history strategy of the various species of sharks. Oviparity is the most primitive condition. Sharks, such as the Catsharks, that are oviparous, lay large eggs that contain sufficient yolk to nourish the embryo throughout development and allow it to emerge fully developed. These eggs are enclosed in leathery cases that are deposited on the sea bottom, usually attached to plants and rocks. The pups of oviparous sharks are usually small, due to the limitation in yolk supply. Ovoviviparity (aplacental viviparity) is the most common mode of reproduction and occurs in spiny dogfish. The eggs develop into embryos within the uterus, and are nourished by yolk stored in the yolk sack, without forming a placental connection with the mother. In some ovoviviparous sharks, after the yolk is used up, the embryos will ingest unfertilized eggs that the mother continues to produce (oophagy). In a few species (e.g. bigeye thresher), intra-uterine cannibalism occurs and smaller embryos are also consumed. Finally, viviparity (placental viviparity) is the most advanced form. The embryos are initially nourished by yolk stored in the yolk sac. The yolk stalk elongates and the yolk sac becomes modified. In some species, the yolk sac comes into contact with the uterine wall and the embryo is nourished through a placental connection.

Sexual maturity occurs at a median length and age of about 60 cm and 6 years for males and 80 cm and 12 years for females (Nammack et al., 1985). As is characteristic of most elasmobranchs, spiny dogfish are characterised by low fecundity and a long gestation period. The gestation period ranges from 18 to 22 months with 2 to 15 pups (average of 6) being produced. Reproduction occurs offshore in the winter (Bigelow and Schroeder 1953), and female dogfish give birth to live young.

Food and Feeding

Spiny dogfish are opportunistic feeders that consume whatever organisms are most readily available, with small fishes usually predominating (Scott and Scott, 1988). On the Scotian Shelf and in the Gulf of Maine, some of the species that are commonly consumed include herring, mackerel, sand lance, cod, silver hake, white hake, haddock, pollock, Atlantic salmon, menhaden, winter flounder, and longhorn sculpin, as well as squid and several other invertebrate species (Jensen, 1966). Bowman and Eppi (1984) concluded that predation mortality by spiny dogfish is a significant source of mortality for commercially important species. Preliminary calculations indicate that the biomass of commercially important species consumed by spiny dogfish may be comparable to the amount harvested by man (U.S. N.M.F.S. N.E.F.S.C. Ref. Doc. 1994).

Description of Fisheries

Landings and Description of the Fisheries in the NAFO Subareas 2-6 Management Unit

In addition to spiny dogfish, the current (1960-1992) NAFO fishery statistics for Subareas 2-6 contain landings of "dogfish unspecified", but the quantity in this category has diminished substantially since 1978. Although there are several other species of dogfish that occur in this zone, notably the black dogfish (*Centroscyllium fabricii*) and the smooth dogfish (*Mustelus canis*), it is thought that the majority of the landings in this category are probably spiny dogfish (personal communication Dr. Emory Anderson, Northeast Fisheries Science Center, Woods Hole, Mass.). As a result, the landings for both categories were combined during the most recent assessment of this resource by the U.S. National Marine Fisheries Service (U.S. N.M.F.S. N.E.F.S.C. Ref. Doc. 94-22) and in the present document.

In the course of compiling the landings of dogfish for this document, it was noted that the final NAFO data files for 1991-1992 do not contain all foreign landings of dogfish, which are substantial and are predominately American since 1979. Provisional landings, including foreign landings for 1991-1993 were published in the most recent U.S. assessment of this resource (U.S. N.M.F.S. N.E.F.S.C. Ref. Doc. 94-22) and were therefore used here.

From 1930 to 1950, spiny dogfish were fished mostly for the vitamin A-rich oil contained in their livers. During the second world war, when a restriction was placed on imports of vitamin A from fish liver oil, a dogfish fishery bloomed in both the Atlantic and Pacific oceans, but it declined rapidly after vitamin A was synthesised (Walsh, 1982).

After 1965, total landings within NAFO Subareas 2-6 grew rapidly and peaked at about 24,650 t in 1974, after which they declined rapidly until 1978 (Table 2 and Figure 1). During this time period, the majority of the landings were made by foreign nations, principally the U.S.S.R. (Figure 1). The landings were stable at about 5,250 t per year from 1979-89, after which they increased to over 16,500 t in 1990 and further to approximately 21,800 t in 1993 (U.S. N.M.F.S. N.E.F.S.C. Ref. Doc. 1994).

Canadian landings in NAFO Subareas 2-6 were insignificant before 1979 when about 1,300 t were landed (Figure 1). Since then, landings have been sporadic, reaching about 1,300 t again in 1990. The 1992 Canadian landings were about 800 t, and increased to an estimated 1,000 t in 1993 (U.S. N.M.F.S. N.E.F.S.C. Ref. Doc. 1994).

The principal gear used by U.S. fishers to catch spiny dogfish has been otter trawls and gill nets, whereas dogfish caught by other foreign fleets have almost entirely been taken by otter trawl. Recent Canadian landings have been mainly by gillnets and longlines (U.S. N.M.F.S. N.E.F.S.C. Ref. Doc. 1994).

The vast majority of the dogfish caught in both directed and traditional fisheries, are discarded and represent a significant source of mortality for the population. Much of the information on the practice is anecdotal but some limited quantitative data is available for Canadian waters and the U.S. have been collecting more detailed information since 1989. The Canadian data on discarding was collected by the Fisheries Observer Program which covers approximately 97% of foreign vessels, 50-70% of larger Canadian vessels, no 65-100' vessels and only 3% of the vessels that are less than 65' long. The U.S. data was collected by research programs dedicated to examining the dogfish fishery.

The current directed fishery targets mature females, discarding smaller males and immature fish. The discard rate for dogfish in the Canadian fishery is as high as 40-76% for otter trawls and 2-65% for gillnets (although most <20%), but the fishery is small in comparison to the U.S. fishery. The data also differs spatially, reflecting the schooling and migratory habits of this species. Estimates from the U.S. fishery show similar variability, with an average rate of 13% for gillnets and 97% for otter trawls.

In most other fisheries, all spiny dogfish are discarded and this is often a large proportion of the landed catch. Estimates by Canadian fishery observers indicate the discard range to be from 3-30%, while U.S. estimates range from 11-174% of the total landings of all species. These values vary greatly depending on the gear, area, season and target species, making it difficult to assess the total impact on the resource.

The Canadian data is too sparse to reliably estimate the biomass lost due to discarding, but U.S. investigators have obtained estimates of mortality due to discarding of 13,800 t in 1993 (using estimates of discard mortality of 50% for otter trawls and 75% for gillnets). Including this estimate of the discard mortalities with the landings for NAFO Subareas 2-6 in 1993, the estimated total catch would be 36,000 t. This suggests that total catches in previous years may have been 2/3 higher than the reported landings, however the lack of quantitative discard estimates from earlier years make it impossible to reliably estimate (U.S. N.M.F.S. N.E.F.S.C. Ref. Doc. 1994).

Landings and Description of the Fisheries in the Bay of Fundy, Scotian Shelf and Southern Gulf of St. Lawrence (NAFO Divisions 4TVWX)

The NAFO statistics for NAFO Subarea 4 also include landings of "dogfish unspecified", which were also assumed to represent spiny dogfish (Figure 2). Canadian landings in NAFO Subareas 3 and 4 were negligible prior to 1978. Foreign landings over the same period were predominant, peaking at 6,882 t in 1974 and declining to 11 t by 1978. The foreign landings, which did not exceed 400 t throughout the 1980's, were taken primarily from NAFO Division 4W. Since 1989, foreign landings in NAFO Subarea 4 have been insignificant. Canadian landings began increasing in 1987, with increased landings from NAFO Division 4X and jumped to 1,300 t in 1990, with the first significant landings from Division 4T (615 t).

The ZIFF (Zonal Interchange File Format) data files, which contain individual purchase slip records, were examined for the period 1989-95, to assess gear type and temporal and spatial variability in the landings (Tables 3 and 4). In the process, it was discovered that the ZIFF data files do not include landings of "dogfish unspecified" and thus will not agree with the NAFO statistics for all years. From 1989-1995, 97% of the Canadian landings were taken by fixed gears. The type of fixed gear used varied between the Southern Gulf and the Scotian Shelf. In NAFO Division 4T, 73% of the landings of spiny dogfish were taken by gillnets and of the remaining landings, 17% were taken by longline and 6% were taken by otter trawl (Table 3). In contrast, in NAFO Division 4X, 93% of the landings were by longline, 6% by gillnet and 1% by otter trawl. From 1989-1995, 93% of the Canadian landings were recorded in the summer and early fall. Eighty-eight percent of the landings of spiny dogfish in NAFO Division 4X were taken between June and August, and 71% of the landings in NAFO Division 4T were taken in the months of September and October (Table 4).

Management Measures Relevant to the Dogfish Fishery in the Bay of Fundy, Scotian Shelf and Southern Gulf of St. Lawrence (NAFO Divisions 4TVWX)

At present, the dogfish fishery is not under any management control (i.e., no quotas or TACs) in Canada, or elsewhere throughout the rest of the management unit for spiny dogfish (NAFO Subareas 2-6).

In the Southern Gulf of St. Lawrence, where landings of spiny dogfish have increased significantly since 1990, directed fishing for cod and white hake was closed in 1995 and a daily by-catch limit of 10% by weight, for cod and white hake was imposed by the DFO on fisheries targeting other species. In addition to the by-catch protocol, the DFO enforced a small fish protocol, in which, if a fleet sector exceeded 15% in number of "small" fish, the groundfish fishery would be closed (the target fish size agreed to by industry for spiny dogfish was 76 cm).

On the Scotian Shelf (NAFO Divisions 4VWX), there were no management measures enforced specifically for spiny dogfish in 1995.

Information received by the DFO in 1994 indicated that a large proportion (> 80%) of the dogfish that was landed on P.E.I. that year, was caught by fishers using sunken, mackerel gillnets (mesh size of 73 to 76 mm). Conversations with fishers that used this gear indicated that no cod by-catch occurred when it was used and that the small mesh nets were much easier to handle with dogfish.

In response to a request from the P.E.I. Fishermen's Association, a pilot project was conducted on P.E.I. in 1995 to determine the selectivity of the small mesh and traditional groundfish gillnets (140 mm) for dogfish, and to evaluate the by-catch of cod and white hake in each mesh size. Fishing by participants in the pilot project was restricted to two rectangular zones off the west and east coasts of P.E.I. Approval was granted for 25 fishers to participate in each zone. The participants agreed to a restrictive by-catch limit of not more than 5% by weight, for cod and white hake, for the duration of the pilot project and all participants were subject to mandatory dockside monitoring. A scientific protocol for this project was prepared by Science Branch (Moncton) and the sampling was conducted by observers.

Unfortunately, only one day of length frequency sampling was actually completed, which precluded a quantitative comparison of the selectivity of the three mesh sizes of gillnets. Nevertheless it is apparent that the traditional groundfish gillnets retained the largest dogfish of either sex and that the modal size of the dogfish retained decreased with mesh size (Figure 3). Furthermore, all three mesh sizes retained dogfish that were smaller than the "small fish protocol size" of 76 cm, that was agreed to by fishers and processors.

Information on the by-catch of cod and hake was obtained on only three trips made by observers at the beginning of the pilot project (Table 5). Cod and white hake were retained in all three mesh sizes of gillnets used (73, 76 and 104 mm). The traditional groundfish gillnets consistently retained significantly more hake than the two smaller mesh sizes, in which the by-catch proportion exceeded 5% on only one occasion (5.3% in the 73 mm mesh on 08/09/95). For cod the results were less consistent: the 73 mm mesh gillnets retained more cod (6.3%) than the 76 and 104 mm mesh gillnets on 06/09/95, but on the two following days, the 104 mm mesh gillnets retained the most cod. All cod that were caught in the 104 mm mesh gillnets were larger than the "small fish protocol size" of 41 cm, but both of the small mesh gillnets retained some cod that were less than the "small fish protocol size" (Figure 4).

The fishers that participated in the pilot project confirmed that they preferred to use the small mesh gillnets because it was easier to remove dogfish from them and they indicated that the majority of the dogfish retained in them were still alive when hauled, resulting in a better quality product.

Apparently, there was a similar evaluation of small mesh gillnets conducted in the Gaspé in 1995. Although the results of this project are not available for examination, conversations with the principals involved indicate that large quantities of small cod (< 41 cm) were retained in the small mesh nets that were used. Although unconfirmed, these contradictory results, and the incomplete results from the pilot project on P.E.I. in 1995, suggest that additional evaluation is warranted before approving the use of small mesh gillnets on a larger scale.

Fishery Data

Commercial Samples

There was no sampling conducted on spiny dogfish landed in NAFO 4TVWX in 1995.

- **It is recommended that representative biological sampling be conducted on spiny dogfish landed in NAFO 4TVWX (including sexed length frequencies)**

- **It is recommended that size and sex specific differences among catches in the Gulf and the Scotian Shelf be investigated**

Research Data

Groundfish Surveys in the Bay of Fundy, Scotian Shelf and Southern Gulf of St. Lawrence (NAFO Divisions 4TVWX)

Research vessel surveys have been conducted in NAFO divisions 4TVWX since 1970. These surveys have been held in the spring, summer and fall and are of variable durations. The two most important surveys and the longest time series are the summer survey on the Scotian Shelf (1970-1995) and the autumn survey of the Southern Gulf of St. Lawrence (1971-1995). These two surveys have been the principal sources of indices of abundance for demersal fish species in these areas. A stratified random survey design was initially adopted and has been maintained, except for a four year period (1984-1987) in the Southern Gulf survey, when randomly chosen fixed stations were surveyed. The survey stratification scheme for NAFO divisions 4TVWX is shown in Figure 5.

The U.S. has conducted spring and fall surveys of their waters since 1967. Data from these surveys is only available up to 1993 and was used to calculate an index of abundance for the stock (U.S. N.M.F.S. N.E.F.S.C. Ref. Doc. 1994).

GEOGRAPHIC DISTRIBUTION

The distribution of spiny dogfish catches in Canadian surveys has been extremely variable, with few consistent patterns apparent, however, composite plots of the catches at different times of the year show evidence of the annual migration pattern. The plots (U.S. N.M.F.S. N.E.F.S.C. Ref. Doc. 1994) show spiny dogfish located primarily in the Southern mid-Atlantic, extending onto Southern Georges Bank in the winter and spring. In summer, their distribution shifts northward to Canadian waters, where they are reported to move into bays and estuaries, where they remain until the waters cool in the fall. There is evidence of limited overwintering in the Cabot Strait from surveys conducted in this area from 1994-1996 and from strandings of animals near Sydney, N.S. in December 1995 and January 1996. Templeman (1944) had suggested that dogfish may overwinter along the edge of the shelf in the Cabot Strait.

During the early years of the Canadian surveys, the distribution of spiny dogfish extended from the Carolinas to the Bay of Fundy and the Southern Scotian Shelf. Stock abundance estimates increased over time and the distribution expanded northward over the Scotian Shelf and into the Gulf of St. Lawrence. Research data collected over this period show the change in areas of greatest concentration from off New England and Georges Bank in the mid 70's to the Gulf of Maine, Bay of Fundy, onto the Scotian Shelf and into the Gulf of St Lawrence in recent (Figures 6 and 7). Throughout this period, spiny dogfish have been consistently found along the north side of the Laurentian channel and in later years scattered over the Grand Banks.

EVIDENCE OF A UNIT STOCK

Spiny dogfish in the Northwest Atlantic are generally considered to constitute a single stock but some limited intermingling with northeastern Atlantic stocks does occur (Scott and Scott 1988). Spatial and temporal abundance patterns, evident from research surveys, also provide evidence of a single stock. Spring and winter surveys show that most of the population is present in the Southern portion of the range whereas summer and fall surveys show them to be found farther north. The U.S. assessments have determined that the spring N.E.F.S.C. surveys are the most accurate index of spiny dogfish abundance because most of the population is resident in the area of their survey during the spring. Although the abundance indices for all surveys are highly variable, the U.S. spring survey exhibits an upward trend that is not apparent in the U.S. fall survey. Abundance indices from Canadian surveys also show an upward trend. If spiny dogfish are a single stock, then abundance indices from U.S. spring surveys should be consistent with the sum of the estimates from the Canadian and the U.S. autumn surveys, which only sample portions of the stock. For this to be true, the Canadian abundance indices should explain and be proportional to the differences in the U.S. spring and fall abundance estimates. Investigators in the U.S. N.M.F.S. tested this hypothesis (U.S. N.M.F.S. N.E.F.S.C. Ref. Doc. 1994) and found that their model was highly significant and that only negligible differences in survey catchabilities existed. These results collectively suggest that the sum of the Canadian and the N.E.F.S.C. autumn survey indices provide estimates consistent with the N.E.F.S.C. spring survey and evidence that spiny dogfish in the Northwest Atlantic constitute a unit stock.

ABUNDANCE INDICES AND BIOMASS ESTIMATES

The research vessel stratified mean catch (numbers and weight) per tow, and estimates of population abundance and biomass were calculated using the RVAN or STRAP analysis programs for the Canadian summer and autumn surveys for the years 1984-1995 (Table 6). For spiny dogfish, which are predominately pelagic and highly migratory, these estimates from a bottom trawl survey should be regarded as minimum estimates.

Canadian estimates of abundance and biomass were relatively low during the 1970's but increased steadily throughout the 1980's to a peak in 1987, after which they declined sharply in 1989 and 1990 and then recovered again during the early 1990's (Table 6 and Figure 8). The estimates are highly variable and the standard error of the estimates averages 42% (19-83% range). The drop in 1995 may indicate a decline in abundance but with the history of this dataset, it may simply reflect the variance. Spiny dogfish were not captured in the surveys of the Southern Gulf conducted from 1971 - 83 (only one specimen was caught in 1984). Estimates of the abundance of spiny dogfish for the Southern Gulf have generally increased since the late 1980's but remain variable (Table 6 and Figure 9).

American bottom trawl surveys conducted off the east coast of the United States documented a steady increase in both abundance and biomass of dogfish since the early 1970's, but total biomass indices in the last several years and abundance indices of large fish (i.e., females > 80 cm - which constitute the bulk of the fishery landings) show no evidence of increase (U.S. N.M.F.S. N.E.F.S.C. Ref. Doc. 1994 - Figure 8).

- **It is recommended that the U.S. and Canadian survey data on spiny dogfish be combined into one dataset**

Assessment Results

Research vessel data from surveys of the Scotian Shelf (NAFO Div. 4VWX) suggests an increase in the abundance of spiny dogfish since 1981, whereas data from surveys of the Southern Gulf (NAFO Div. 4T) suggests an increase in abundance since 1987.

Data and analyses presented during the most recent (1994) assessment of spiny dogfish in the Northwest Atlantic (NAFO Subareas 2-6) indicate that total landings from this resource have increased five-fold since 1987 and that total catches may have been 2/3 or more higher than the reported landings, when recent estimates of discard rates in U.S. fisheries are considered. Consequently, they concluded that this stock is stable at best and has possibly begun to decline as a result of the recent increases in exploitation. They suggested that this stock may be fully utilised with respect to the level of fishing mortality and that the current fishery which mainly targets mature females will result in reduced long-term recruitment (U.S. N.M.F.S. N.E.F.S.C. Ref. Doc. 1994).

Future Prospects

Analyses presented during the most recent (1994) assessment of spiny dogfish in the Northwest Atlantic (NAFO Subareas 2-6) indicate that given the relatively stable level and distribution of the exploitable stock, and recent increased targeting, landings in 1995 will likely exceed the 1993 landings of 22,000 t. However, they cautioned that the strategy of the current fishery which mainly targets mature females will result in reduced long-term recruitment (U.S. N.M.F.S. N.E.F.S.C. Ref. Doc. 1994).

Management Considerations

Given the evidence for a single unit stock in the Northwest Atlantic (NAFO Subareas 2-6), joint assessment and management of this resource by Canada and the U.S. should be considered (U.S. N.M.F.S. N.E.F.S.C. Ref. Doc. 1994).

- **Joint assessment and management of this resource by Canada and the U.S. should be considered**

Research Recommendations

Throughout this document, recommendations have been made to fill knowledge gaps and thus lead to improved assessment of spiny dogfish in the long term. These recommendations are consolidated here to allow for a logical and coherent implementation of these recommendations.

- **It is recommended that representative biological sampling be conducted on spiny dogfish landed in NAFO 4TVWX (including sexed length frequencies).**
- **It is recommended that size and sex specific differences among catches in the Gulf and the Scotian Shelf be investigated.**
- **It is recommended that the U.S. and Canadian survey data on spiny dogfish be combined into one dataset.**
- **Joint assessment and management of this resource by Canada and the U.S. should be considered.**

Acknowledgments

We would like to thank Kees Zwanenburg for his assistance in the preparation of plots of the ECNASAP data for spiny dogfish.

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Table 1. Members of the Maritimes Region Elasmobranch Assessment Team.

Expertise	Member	Affiliation	Telephone No.
Shark Catch Rates	Comeau, P.	MFD,BIO,DFO	902-426-4136
Shark Recreational Fishery	Crawford, R.	Dep of Fisheries, NS	902-424-0350
Shark Fishery Statistics and CPUE Analysis	Fowler, M.	MFD,BIO,DFO	902-426-3529
Elasmobranch Life History	Frank ,K.	MFD,BIO,DFO	902-426-3498
Spiny Dogfish Biology and Assessment	Hurlbut, T.	MFD, GFC, DFO	506-851-6216
Shark Reproduction and Biology	Hurley, P.	MFD,BIO,DFO	902-426-3520
Shark Management	Jones, C.	FMB, MC, DFO	902-426-1782
Spiny Dogfish Biology and Assessment	McRuer, J.	MFD,BIO,DFO	902-426-3585
Shark Population Models	O'Boyle (Chair), R.	MFD,BIO,DFO	902-426-4890
Tuna and Swordfish Biology and Assessment	Porter, J.	MFD, SABS, DFO	506-529-8854
Shark Recreational Fishery Management	Rodman, K.	FMB, MC, DFO	902-426-6074
Observer Program Data Analysis	Showell, M.	MFD,BIO,DFO	902-426-3501
Skate Biology and Assessment	Simon, J.	MFD,BIO,DFO	902-426-4136
Finfish Distribution and Tagging	Stobo, W.	MFD,BIO,DFO	902-426-3316

Table 2. Total landings (Canadian, U.S. and Foreign) of spiny dogfish and dogfish unspecified in the NAFO Subareas 2-6 management unit.
(Note: 1. Final NAFO statistics including foreign landings are not yet available for 1993-1995).
(Note: 2. The landings for 1993-1995 are Canadian landings obtained from the latest ZIFF Data).

Year	2	3	4R	4S	4T	4Vn	4Vs	4W	4X	5	6	US Recreational	Totals for NAFO 2-6
1960	43	21	0	0	0	0	0	0	0	455	0	0	519
1961	0	0	0	0	0	0	0	0	0	438	0	0	438
1962	0	0	0	0	0	0	0	0	0	296	0	0	296
1963	1	0	0	0	0	0	0	0	0	0	0	0	1
1964	0	15	0	0	0	0	0	0	0	1	0	0	16
1965	0	32	0	0	0	0	0	34	0	141	0	0	207
1966	0	39	0	0	0	79	0	1451	4	5254	2601	0	9428
1967	0	25	0	0	0	0	3	0	0	2058	643	0	2729
1968	0	0	0	0	0	0	0	0	0	3431	677	621	4729
1969	0	0	0	0	0	0	27	223	0	6955	2097	453	9755
1970	0	686	0	0	0	0	0	12	6	4367	588	705	6364
1971	0	0	0	0	0	0	0	0	4	8030	3526	561	12121
1972	0	0	0	0	0	0	258	2194	16	12842	8684	820	24814
1973	5	25	0	0	0	0	437	2288	746	11909	3425	890	19725
1974	8	126	0	0	0	0	0	4324	2504	12254	5435	969	25620
1975	0	116	0	0	3	0	146	3529	533	16312	2053	789	23481
1976	0	0	0	0	0	16	1605	954	284	12891	1590	707	18047
1977	0	54	0	0	0	8	8	326	92	5781	1860	563	8692
1978	0	122	0	0	0	0	0	9	9	1206	212	700	2258
1979	0	1314	0	0	0	1	7	38	2	4232	675	426	6695
1980	0	641	0	0	0	0	0	367	27	3625	769	284	5713
1981	0	603	0	0	0	0	5	467	29	5244	2053	1856	10257
1982	0	367	0	0	0	0	0	27	25	3288	3676	700	8083
1983	0	31	0	0	0	0	0	334	47	4762	196	745	6115
1984	0	5	0	0	0	36	2	286	1	4302	212	663	5507
1985	0	325	0	0	0	2	2	372	11	3960	384	1591	6647
1986	0	11	0	0	11	14	2	221	8	2560	227	1438	4492
1987	3	35	0	0	11	9	5	85	264	2633	109	1053	4207
1988	5	27	0	0	0	1	1	545	0	2872	316	1336	5103
1989	8	61	0	0	8	1	3	157	166	4559	65	1829	6857
1990	8	2	2	18	615	41	1	329	724	11724	3128	1662	18254
1991	3	0	2	0	143	0	15	210	143	8926	4483	1677	15602
1992	0	0	3	0	501	0	0	44	517	10237	7009	1197	19508
1993	0	0	0	0	702	0	4	32	696	0	*20360	1212	23006
1994	0	2	0	1	974	15	6	11	806	0	0	0	1815
1995	0	0	0	0	464	1	0	10	367	0	0	0	842

Table 3. Total landings of spiny dogfish in NAFO Divisions 4TVWX by gear from 1989-1995.

Year	Area	GNS	LLS	OTB	SNU	Misc	All Gear
1989	4T	4.2	0.0	0.3	0.0	0.0	4.5
	4VN	0.0	0.0	0.0	0.0	0.0	0.0
	4VS	0.0	0.0	0.0	0.0	0.0	0.0
	4W	0.0	0.0	0.0	0.0	0.0	0.0
	4X	3.8	123.0	37.2	0.0	0.0	164.0
	Total	8.0	123.0	37.5	0.0	0.0	168.5
1990	4T	320.4	102.3	146.0	6.4	32.2	607.3
	4VN	0.0	9.5	0.0	0.0	0.0	9.5
	4VS	0.0	0.0	0.0	0.0	0.0	0.0
	4W	0.0	0.0	0.0	0.0	0.0	0.0
	4X	12.2	559.8	8.0	0.0	0.0	580.1
	Total	332.6	671.7	154.0	6.4	32.2	1196.9
1991	4T	0.2	126.5	1.0	6.1	8.8	142.6
	4VN	0.0	0.0	0.0	0.0	0.0	0.0
	4VS	0.0	0.0	0.0	0.0	0.0	0.0
	4W	0.0	0.0	0.0	0.0	0.0	0.0
	4X	0.0	143.2	0.5	0.0	0.0	143.7
	Total	0.2	269.7	1.5	6.1	8.8	286.3
1992	4T	127.5	173.9	1.8	1.0	5.2	309.4
	4VN	0.0	0.0	0.0	0.0	0.0	0.0
	4VS	0.0	0.0	0.0	0.0	0.0	0.0
	4W	1.8	0.3	0.0	0.0	0.0	2.1
	4X	0.0	514.8	0.5	0.0	0.0	515.3
	Total	129.3	688.9	2.3	1.0	5.2	826.8
1993	4T	583.9	94.4	12.9	1.5	9.6	702.3
	4VN	0.0	0.0	0.0	0.0	0.0	0.0
	4VS	0.0	0.0	0.0	0.0	0.0	0.0
	4W	0.0	21.5	0.0	0.0	0.0	21.5
	4X	95.7	575.0	0.0	0.0	0.0	670.7
	Total	679.6	690.9	12.9	1.5	9.6	1394.5
1994	4T	869.1	54.3	17.9	8.1	25.1	974.5
	4VN	0.0	9.9	0.0	0.0	0.0	9.9
	4VS	0.0	5.3	0.0	0.0	0.0	5.3
	4W	0.0	8.3	0.0	0.0	0.0	8.3
	4X	38.9	769.9	0.0	0.0	0.0	808.7
	Total	908.0	847.8	17.9	8.1	25.1	1806.8
1995	4T	442.2	0.8	8.5	0.3	12.6	464.4
	4VN	0.0	1.0	0.0	0.0	0.0	1.0
	4VS	0.0	3.3	0.0	0.0	0.0	3.3
	4W	0.0	7.6	0.0	0.0	0.0	7.6
	4X	28.6	315.7	0.1	0.0	0.0	344.4
	Total	470.8	328.3	8.6	0.3	12.6	820.6

Table 4. Total landings of spiny dogfish in NAFO Divisions 4TVWX by month from 1989-1995.

Year	Area	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
1989	4T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.3	0.0	0.0	4.4
	4VN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4VS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4W	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4X	0.0	0.0	0.0	0.0	2.0	7.9	24.5	114.2	9.6	4.0	0.0	0.0	162.2
	Total	0.0	0.0	0.0	0.0	2.0	7.9	24.6	114.2	13.7	4.3	0.0	0.0	166.8
1990	4T	0.0	0.0	0.0	0.0	0.0	0.0	1.9	2.8	204.6	257.7	140.2	0.0	607.2
	4VN	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	14.2	26.8	0.0	41.1
	4W	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.4	0.2	26.6	29.0
	4X	0.0	0.0	0.0	0.5	13.6	157.4	156.6	163.2	41.9	47.7	5.0	33.9	619.9
	Total	0.0	0.0	0.0	0.5	13.6	159.4	158.5	166.0	246.5	319.9	172.2	60.5	1297.2
1991	4T	0.0	0.0	0.0	0.0	0.0	0.0	56.8	32.8	28.0	24.4	0.5	0.0	142.6
	4VS	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
	4W	0.0	1.2	2.6	0.6	0.5	0.0	0.0	9.2	0.0	0.0	0.4	0.0	14.6
	4X	0.0	0.0	2.3	0.0	0.0	37.0	49.2	50.2	0.3	1.7	0.0	2.7	143.4
	Total	0.0	1.2	5.0	0.6	0.9	37.0	106.0	92.2	28.3	26.1	0.8	2.7	300.9
1992	4T	0.0	0.0	0.0	1.1	0.0	0.0	12.7	52.1	56.4	87.8	99.4	0.0	309.4
	4VS	0.1	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
	4W	0.2	0.0	0.0	0.1	6.2	23.3	0.0	8.0	2.1	0.0	0.0	0.0	40.0
	4X	0.2	0.0	0.0	0.0	0.0	66.8	255.3	189.5	3.4	0.0	0.4	1.2	516.8
	Total	0.4	0.0	0.0	1.2	6.5	90.2	268.0	249.6	61.8	87.8	99.8	1.2	866.5
1993	4T	0.0	0.0	0.0	0.0	0.0	5.1	107.3	180.7	316.3	92.7	0.0	0.0	702.2
	4VS	0.0	0.0	0.4	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
	4W	0.0	0.0	0.1	0.0	1.1	5.7	9.7	13.9	0.4	0.8	0.0	0.0	31.6
	4X	0.0	0.0	0.1	1.5	7.4	70.4	320.8	269.6	24.6	1.6	0.3	0.0	696.4
	Total	0.0	0.0	0.6	1.5	8.6	81.2	437.8	464.2	341.3	95.1	0.3	0.0	1430.6
1994	4T	0.0	0.0	0.0	0.0	0.0	1.5	21.8	156.4	427.3	367.4	0.0	0.0	974.4
	4VN	0.0	0.0	0.0	4.7	0.1	0.0	3.2	6.7	0.0	0.0	0.0	0.0	14.7
	4VS	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	1.2	0.0	0.0	0.0	3.6
	4W	0.0	0.0	0.0	0.4	2.7	0.8	0.1	0.0	7.1	0.0	0.0	0.0	11.1
	4X	3.2	0.0	0.0	1.6	0.1	142.3	311.6	207.4	127.4	4.5	3.8	3.6	805.5
	Total	3.2	0.0	0.0	6.7	2.9	144.6	339.0	370.5	563.0	371.9	3.8	3.6	1809.3
1995	4T	0.0	0.0	0.0	0.0	0.0	0.1	4.1	42.2	277.6	140.2	0.0	0.0	464.3
	4VN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.7	0.0	0.0	0.8
	4VS	0.0	0.0	0.0	2.4	1.3	1.0	1.4	0.3	0.2	0.0	0.0	0.0	6.4
	4W	0.0	0.0	0.0	0.5	4.9	1.1	3.0	0.0	0.0	0.1	0.0	0.0	9.7
	4X	2.4	0.1	0.1	11.0	13.9	40.8	176.4	117.1	5.2	0.0	0.0	0.0	366.9
	Total	2.4	0.1	0.1	13.8	20.0	43.0	184.9	159.6	283.1	141.0	0.0	0.0	848.1

Table 5. Comparison of the by-catch of cod and white hake in three different mesh sizes of gillnets used during the spiny dogfish pilot project on P.E.I. in 1995 (Note: The by-catch is expressed as a percentage of the weight of spiny dogfish caught).

Date (dd/mm/yy)	Mesh Size	By-catch % Cod	By-catch % W. Hake
6/9/95	73	6.3	1.7
"	76	2.4	1.2
"	140	2.7	16.7
7/9/95	73	1.8	1.7
"	76	2.4	1.8
"	140	7.3	14.9
8/9/95	73	3.7	5.3
"	76	6.8	0.0
"	140	14.9	20.8

Table 6. Research vessel estimates of the stratified mean catch per tow (numbers and weight), population numbers and population biomass for spiny dogfish in NAFO Divisions 4TVWX.

	NAFO Division 4T			
Year	Stratified Mean Number Per Tow	Stratified Mean Wt. (kg.) Per Tow	Estimated Population Numbers (000's)	Estimated Population Biomass (t)
1984	0.00	0.02	7	35
1985	0.32	0.50	574	899
1986	0.29	0.59	532	1064
1987	0.15	0.39	275	696
1988	2.90	4.71	5158	8373
1989	7.36	11.90	13010	21038
1990	0.58	1.31	1042	2358
1991	2.06	4.08	3639	7221
1992	1.94	4.22	3508	7626
1993	11.81	22.55	21333	40738
1994	2.70	4.80	4766	8490
1995	5.39	11.09	9530	19614

	NAFO Division 4VW			
Year	Stratified Mean Number Per Tow	Stratified Mean Wt. (kg.) Per Tow	Estimated Population Numbers (000's)	Estimated Population Biomass (t)
1984	1.47	1.81	3913	4821
1985	27.89	33.78	74380	90097
1986	2.21	2.95	5887	7865
1987	1.05	1.11	2760	2915
1988	1.89	2.74	5038	7322
1989	0.66	0.70	1763	1878
1990	0.21	0.23	533	584
1991	0.48	0.36	1281	955
1992	1.80	3.01	4794	8021
1993	7.10	10.56	18933	28170
1994	0.35	0.53	926	1420
1995	2.20	3.14	5862	8364

	NAFO Division 4X			
Year	Stratified Mean Number Per Tow	Stratified Mean Wt. (kg.) Per Tow	Estimated Population Numbers (000's)	Estimated Population Biomass (t)
1984	26.67	37.59	41566	58592
1985	52.65	67.96	82792	106864
1986	58.40	75.08	91836	118062
1987	119.24	170.96	187494	268835
1988	96.93	140.63	152422	221142
1989	26.93	41.85	42348	65808
1990	31.23	46.34	49115	72873
1991	64.13	84.02	100847	132124
1992	65.47	95.38	102943	149981
1993	71.35	99.60	112196	156620
1994	99.60	112.07	156620	176218
1995	49.98	62.82	84069	105672

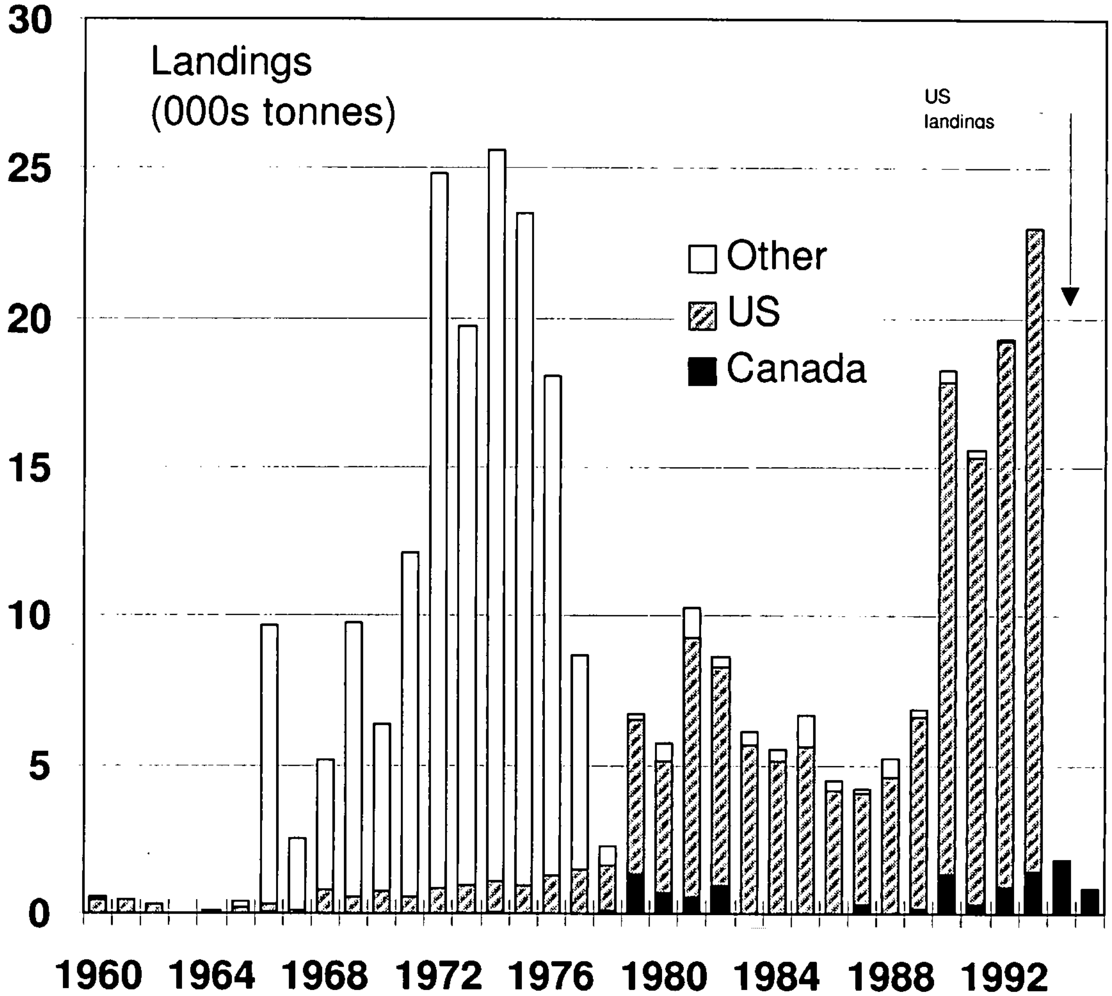

Figure 1. Landings of all dogfish in the NAFO Subarea 2-6 management unit from 1960-1995 by Canada, the U.S. and foreign nations..

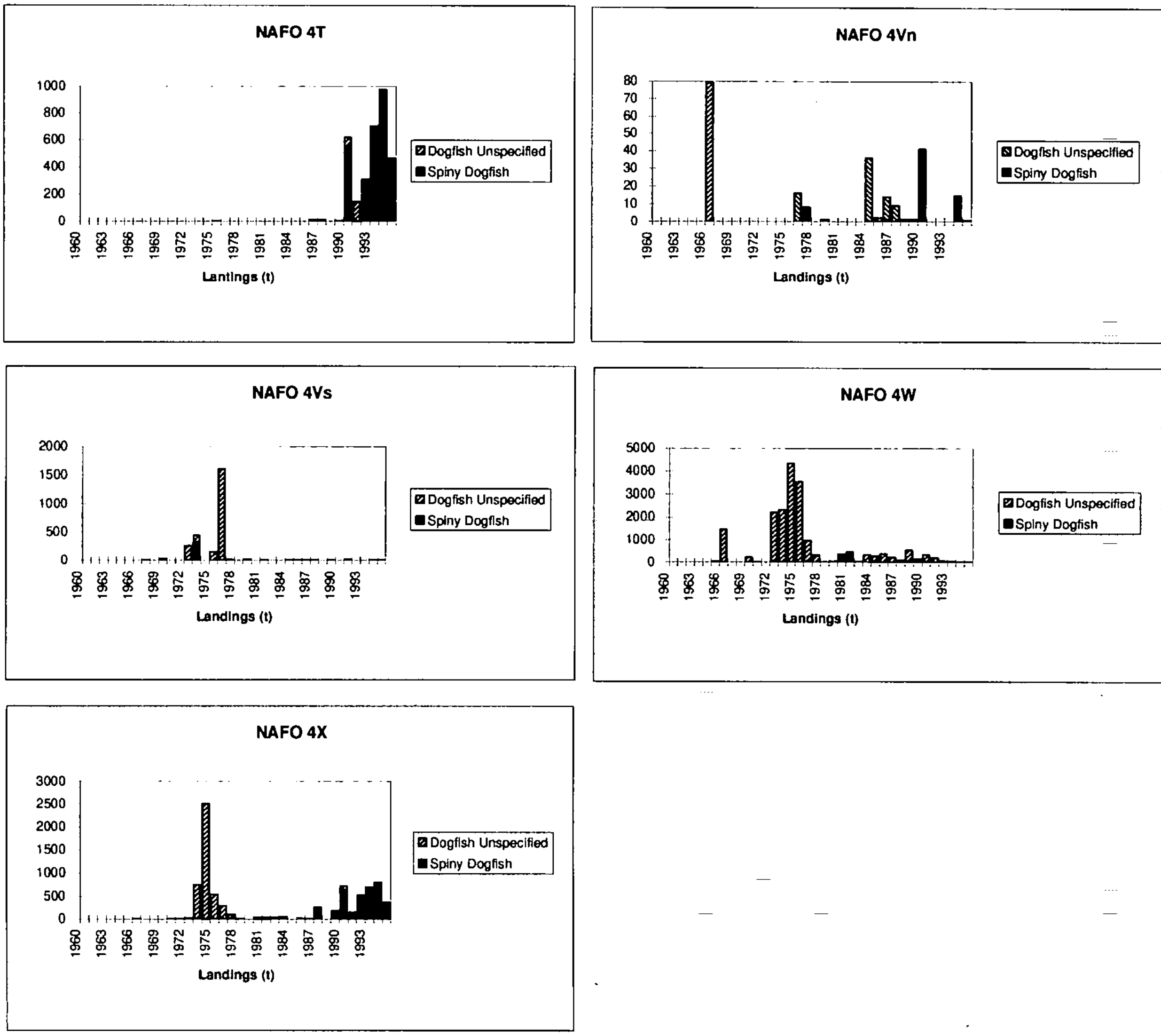

Figure 2. Landings of all dogfish in NAFO Divisions 4T, 4Vn, 4Vs, 4W and 4X from 1960-1995.

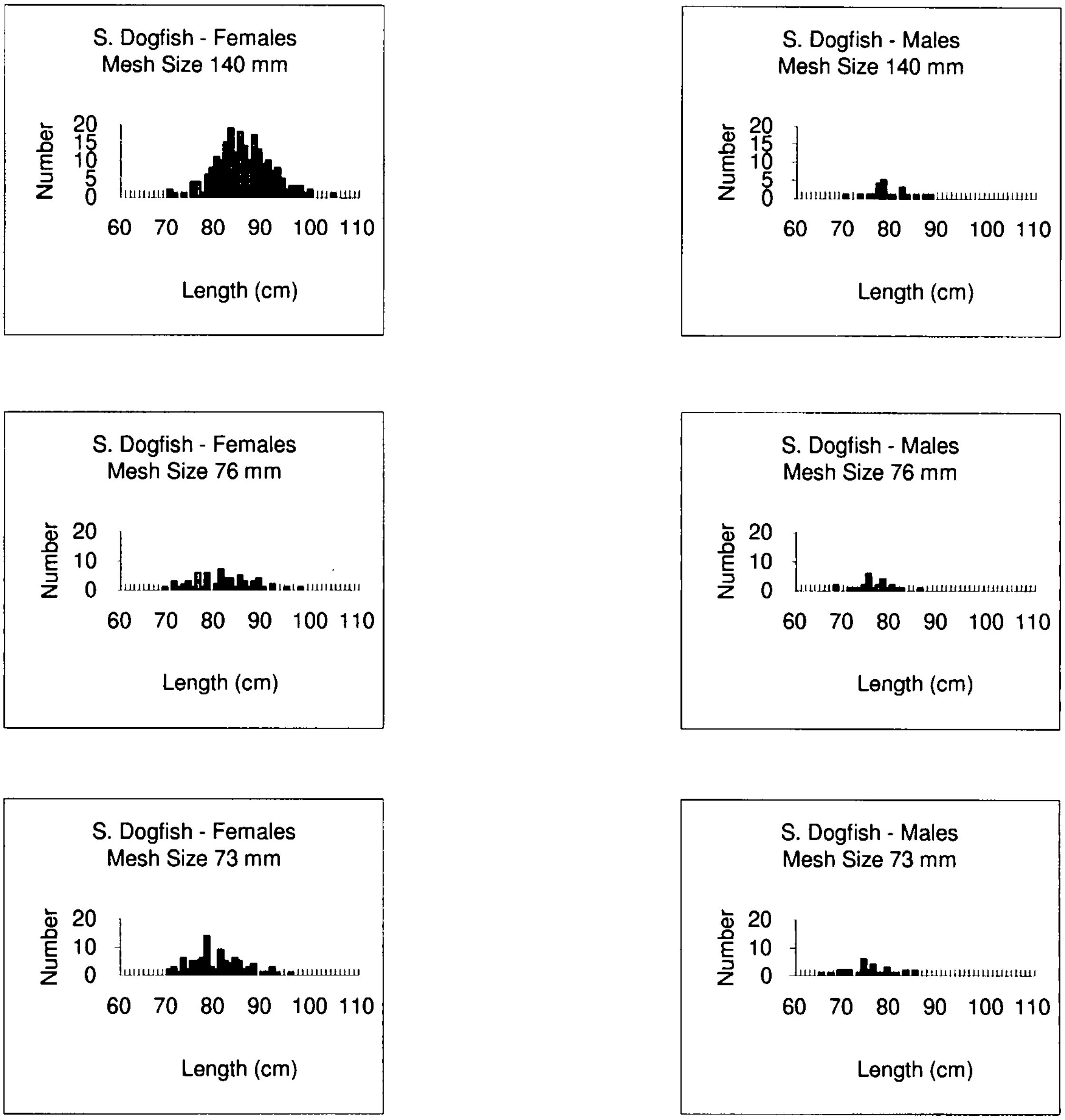

Figure 3. Actual length frequencies for spiny dogfish caught in three different sizes (mesh sizes) of gillnets used during an experimental fishery for spiny dogfish on P.E.I. in September 1995.

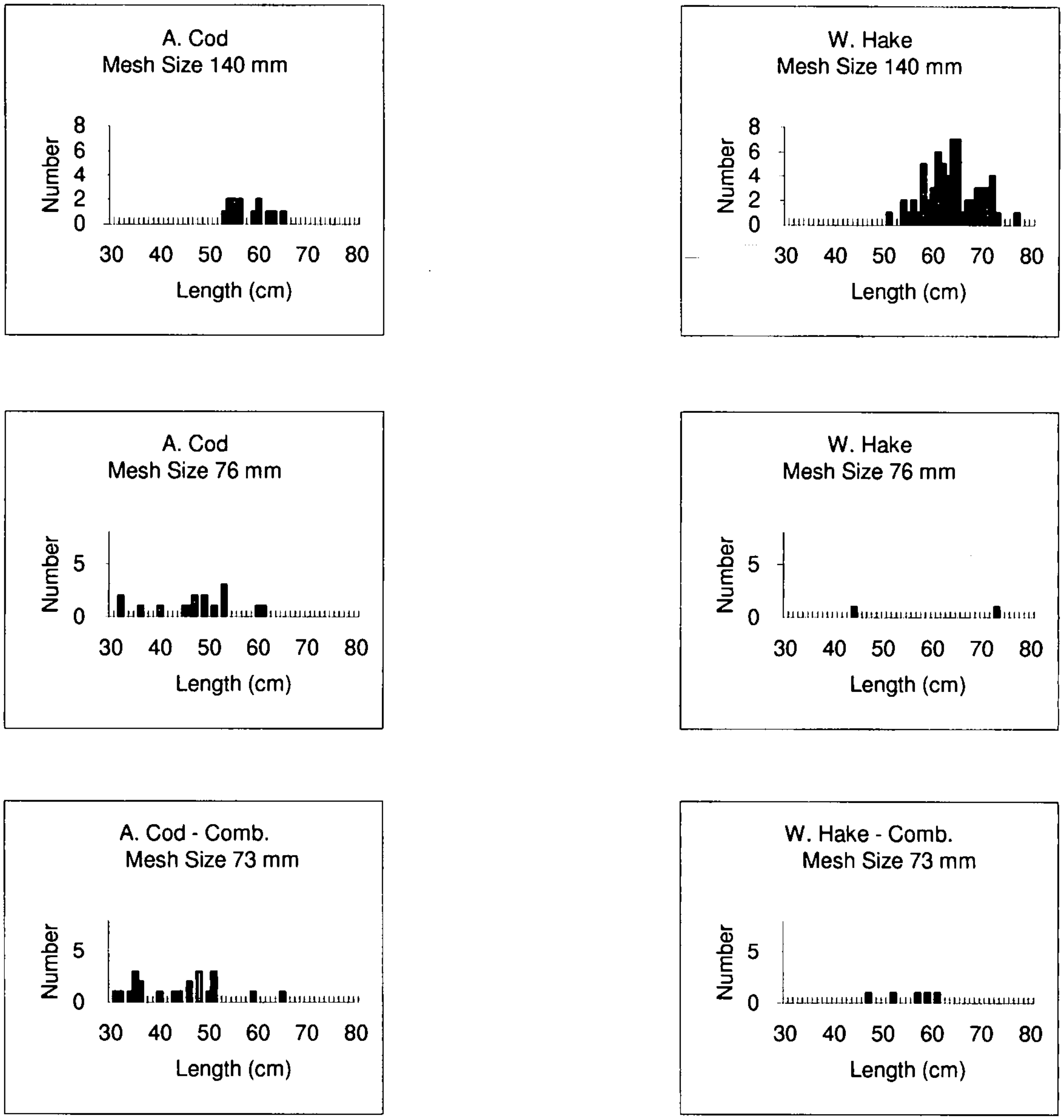

Figure 4. Actual length frequencies for cod and white hake caught in three different sizes (mesh sizes) of gillnets used during an experimental fishery for spiny dogfish on P.E.I. in September 1995.

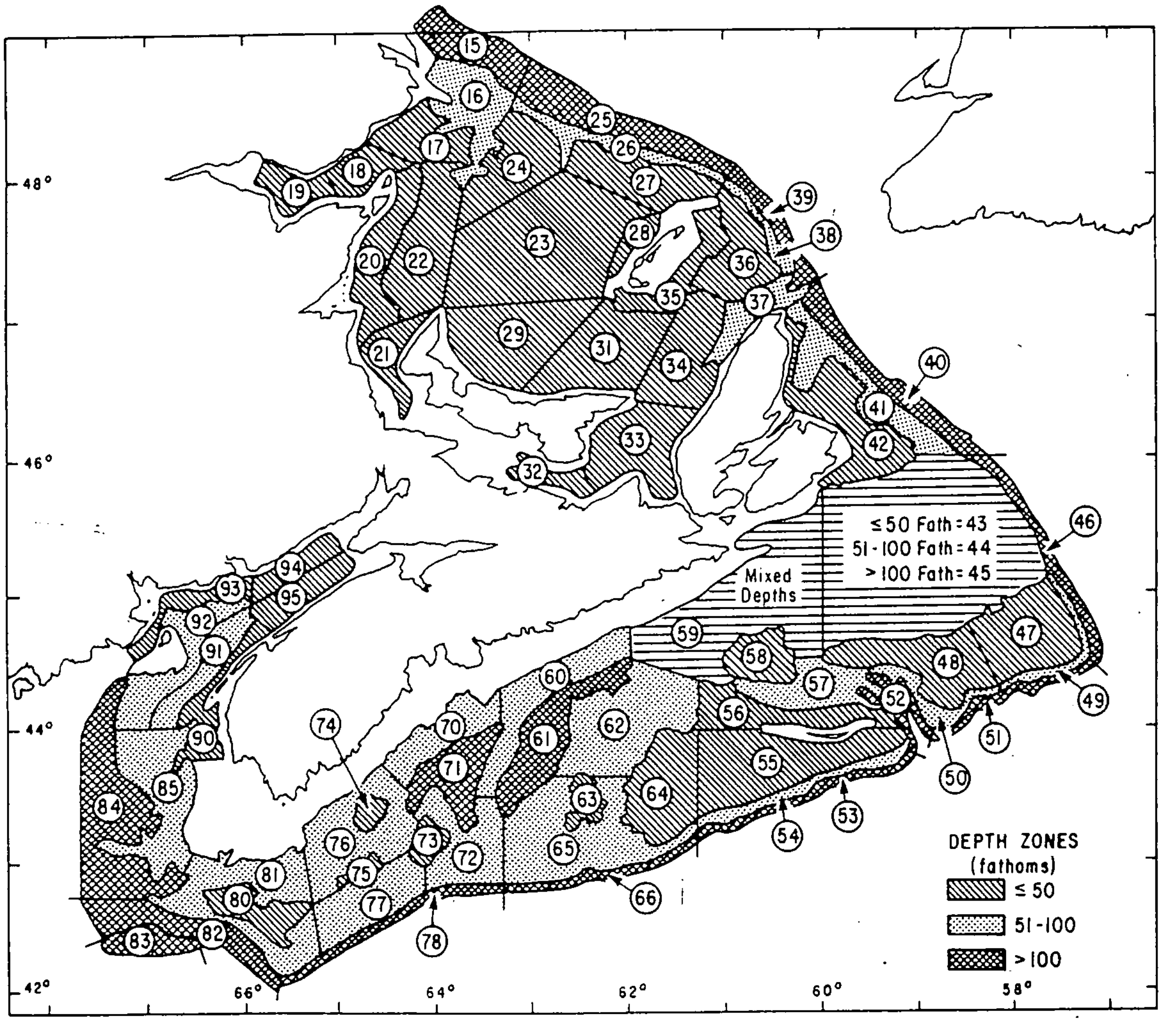

Figure 5. Stratification scheme for research vessel surveys of NAFO Divisions 4TVWX.

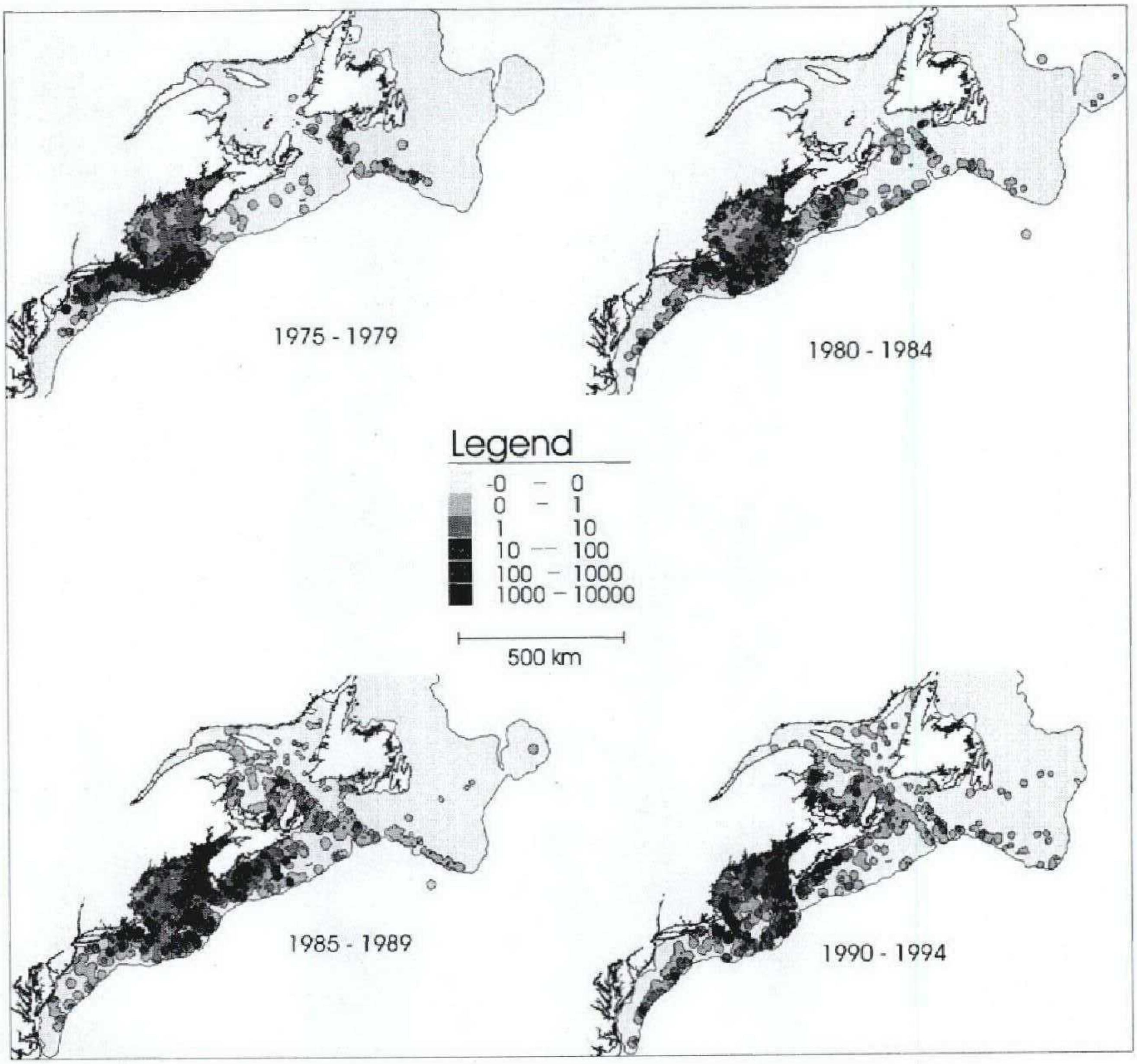

Figure 6. Composite map of the distribution of research vessel captures of spiny dogfish throughout the NAFO Subarea 2-6 management unit in five year time intervals from 1975-1994.

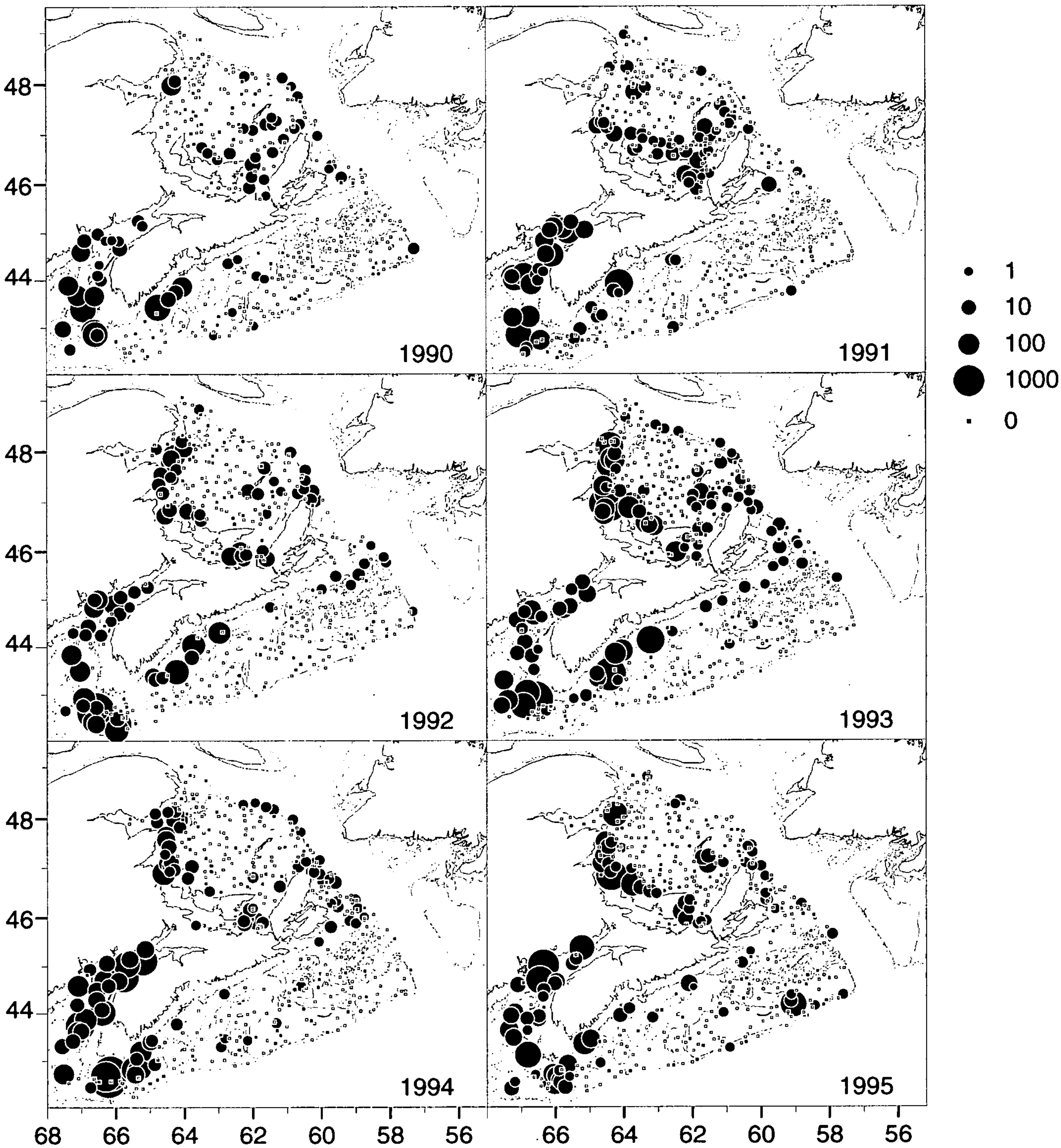

Figure 7. Location of spiny dogfish catches (kg) during research vessel surveys of NAFO Divisions 4TVWX conducted from 1990-1995.

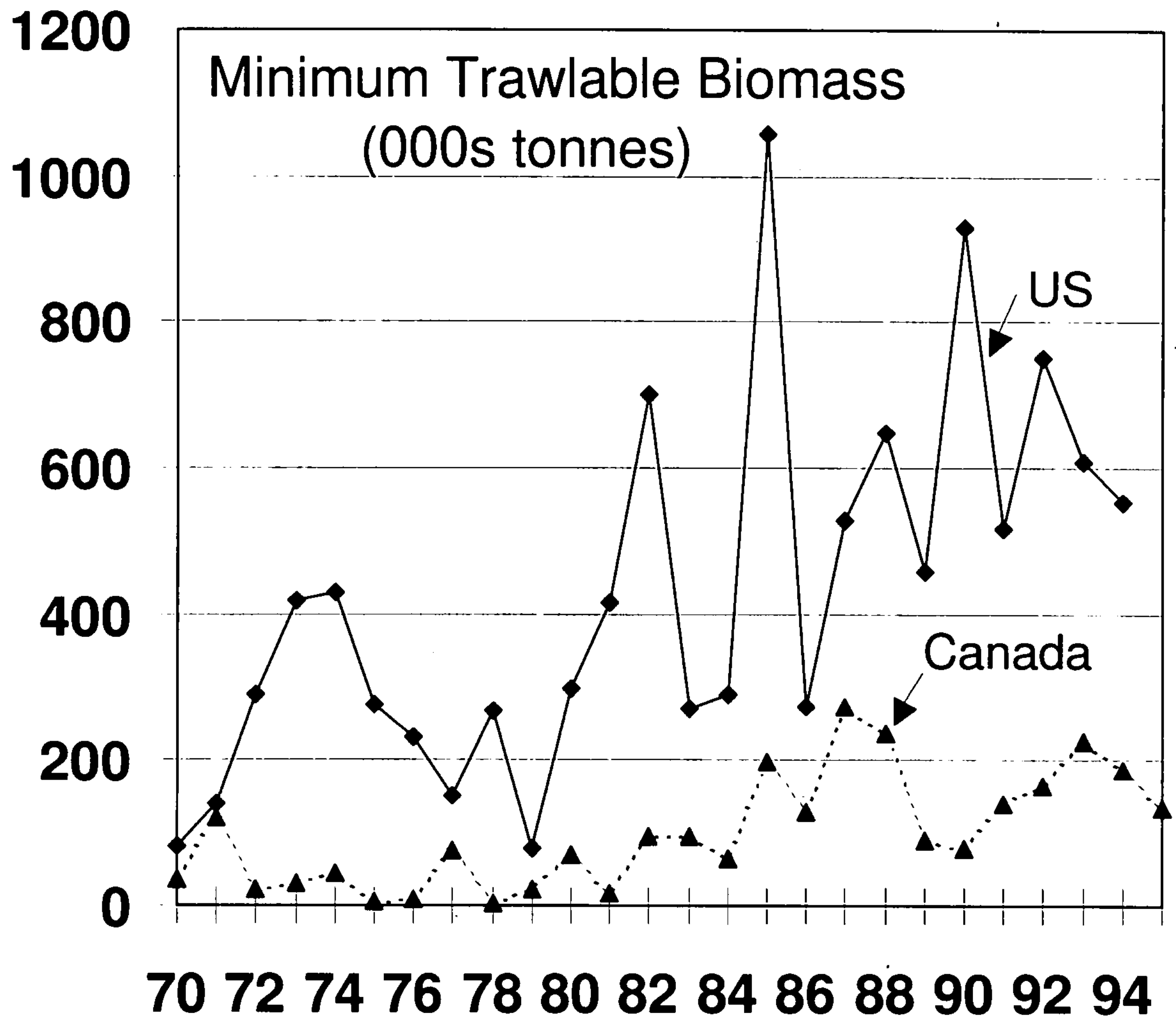

Figure 8. Estimates of the minimum trawlable biomass of spiny dogfish from Canadian and U.S. research vessel surveys.

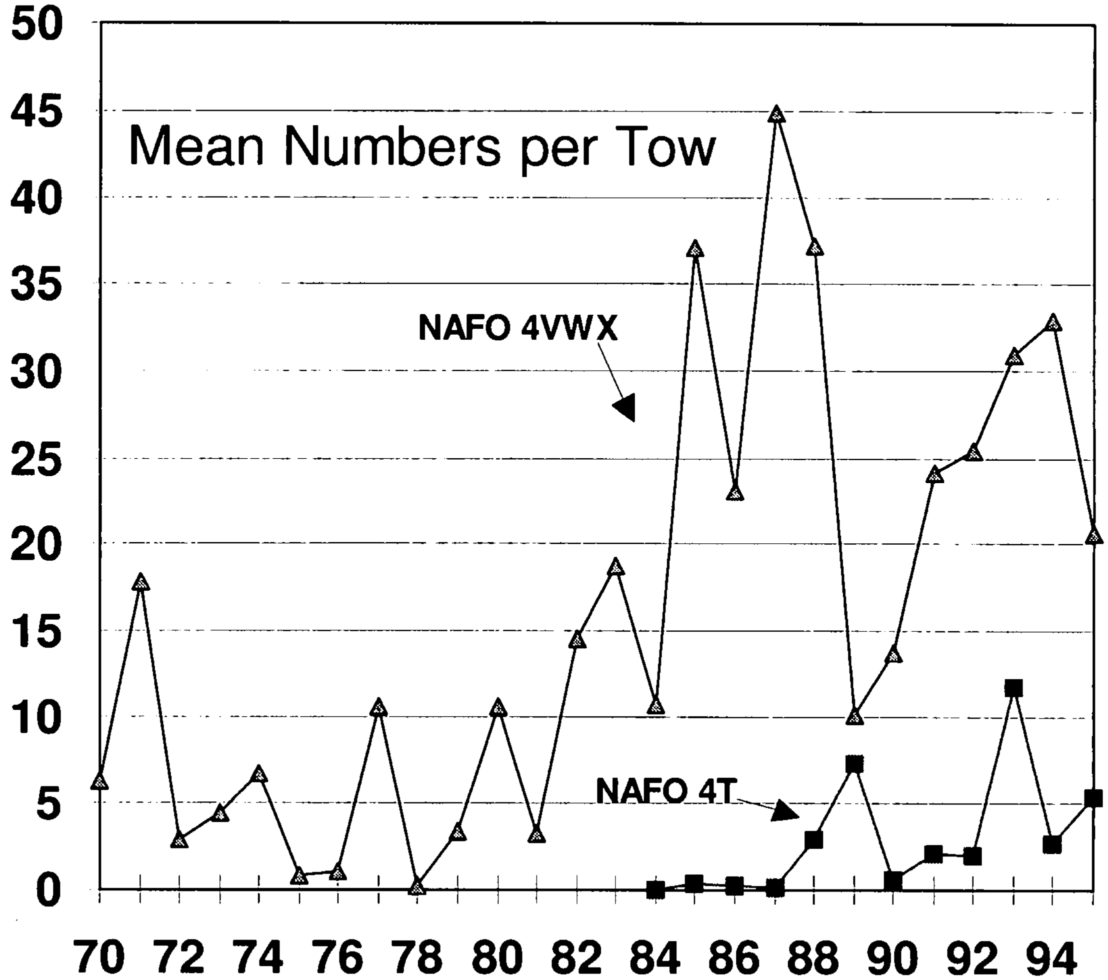

Figure 9. Research vessel stratified mean number per tow (#'s) for spiny dogfish in NAFO Divisions 4TVWX.