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Canadian Science Advisory Secretariat | **Secrétariat canadien de consultation scientifique**

Research Document 2003/028 | **Document de recherche 2003/028**

Distribution and Abundance of Winter Skate*, Leucoraja ocellatta*, in the Canadian Atlantic.

Distribution et abondance de la raie tachetée, *Leucoraja ocellatta*, dans l'Atlantique canadien.

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ISSN 1499-3848 (Printed)

Canada

Abstract

Data derived from four principal sources in the Canadian Atlantic zone, spanning several decades, were examined for the occurrence of winter skate. The data reviewed included standardized research vessel (RV) surveys conducted by Fisheries and Oceans Canada (DFO), non-standard research vessel surveys and recent industry/science surveys. Some persistent areas of concentration were evident, notably Georges Bank and the eastern Scotian Shelf. Secondary concentrations are found in the Bay of Fundy, the Laurentian Channel, inshore waters of 4T and the southern flanks of the Grand Banks. Winter skate are not and have never been common in most of the Newfoundland area. This species appears to be adequately surveyed in the zone. Winter skate occur in areas deeper than the regular groundfish surveys but not in any great quantities. Given the distribution in 4T it is more likely that winter skate will be inshore of the areas surveyed.

Limited information exists on the biology of winter skate, however recent studies have shown that length at 50% maturity is 75 cm for females in Div. 4VsW. Given that no individuals greater than 70cm have been caught in Div. 4T during the 32 years of their survey it is unlikely that this value will hold for the entire range of the species.

In general, winter skates abundance in the southern part of the range has remained stable, while further north declines have been evident, especially larger individuals. Winter skate are the 3rd, 22nd and 13th most common species in the Georges, summer and spring RV surveys respectively. Overall the research vessel surveys have estimated the minimum total number of individuals to average over 3 million individuals in Div. 4TVWX. The decadal averages in Div. 4TVWX are all very close to 3 million, though the estimate in the last 5 years has been close to 1.5 million individuals. In the Canadian part of Div. 5Z the minimum average estimate is 1.8 million individuals. A skate industry/science survey in Div. 4VsW yielded biomass estimates that were 6-12 times greater than the summer RV survey in the same area, suggesting that these population numbers are most likely an underestimate of the population.

Résumé

On a examiné des données couvrant plusieurs décennies et provenant de quatre principales sources du Canada atlantique en vue d'établir si la raie tachetée y est présente. Ces données comprenaient des relevés normalisés de navire de recherche (NR) effectués par Pêches et Océans Canada (MPO), des relevés de NR spéciaux et des relevés récents effectués conjointement par l'industrie et des scientifiques. Quelques concentrations permanentes de raies tachetées ont été identifiées, notamment le banc Georges et le secteur est du plateau néo-écossais. Des concentrations secondaires ont aussi été trouvées dans la baie de Fundy, le chenal Laurentien, les eaux côtières de 4T et les pentes sud des Bancs de Terre-Neuve. La raie tachetée n'est pas commune dans la plus grande partie des eaux de Terre-Neuve et elle ne l'a jamais été. Les relevés effectués dans cette zone semblent couvrir l'espèce adéquatement. Celle-ci est retrouvée dans des eaux plus profondes que celles visées par les relevés réguliers du poisson de fond, mais pas en très grande quantité. Étant donné sa distribution dans 4T, il est davantage probable qu'elle se retrouvera en zones plus côtières que celles des relevés.

Bien que l'information disponible sur la biologie de la raie tachetée soit limitée, des études récentes ont révélé que 50 % des femelles sont matures à une longueur de 75 cm dans 4VsW. Étant donné qu'aucun individu de plus de 70 cm n'a été capturé dans la division 4T au cours des 32 ans de relevés, il est peu probable que cette valeur s'applique à l'ensemble de l'aire de répartition de l'espèce.

En général, l'abondance de la raie tachetée dans la partie sud de son aire de répartition est demeurée stable, tandis qu'elle a diminué plus loin au nord, en particulier pour les gros individus. Cette raie est respectivement la troisième, la vingt-deuxième et la treizième espèce la plus abondante dans le relevé du banc Georges, le relevé de NR d'été et le relevé de NR de printemps. Dans l'ensemble, les relevés de NR ont permis d'estimer que le nombre total minimum d'individus dans 4TVWX se situe en moyenne à plus de 3 millions. Les moyennes décennales pour ces divisions se rapprochent toutes de 3 millions d'individus, quoique l'estimation pour les cinq dernières années situe ce nombre à quelque 1,5 million. Dans le secteur canadien de la division 5Z, le nombre moyen minimum est estimé à 1,8 million d'individus. Un relevé de la raie effectué par l'industrie et des scientifiques dans 4VsW a donné une biomasse estimée de 6 à 12 fois plus élevée que celle établie dans le cadre du relevé de NR d'été effectué dans les mêmes eaux, ce qui donne à penser que cette dernière biomasse est fort probablement une sous-estimation des effectifs de la population.

Introduction

Under the proposed Species at Risk Act (SARA), the assessment of species status and designation of risk categories are the responsibility of the Committee on Status of Endangered Wildlife in Canada (COSEWIC). Fisheries and Oceans Canada (DFO) holds information and expertise that are essential to COSEWIC in assessing status and extinction risk for many aquatic species. This document was prepared as a review of DFO's holdings of information on winter skate held Dec 9-13th in Halifax, Nova Scotia in order to make them available to COSEWIC for their species evaluation. In addition to an inventory of data, we attempted to provide context to the data and also to address specific terms of reference, which were reviewed during a national DFO meeting. For the complete terms of reference and meeting proceedings see the CSAS proceedings for the meeting (Powles, 2003).

Winter skate (*Leucoraja ocellata*), also known as the big or eyed skate, have only been reported in the Northwest Atlantic. Its reported range extends from as far north as Gulf of St. Lawrence and southern Newfoundland coast southward to Cape Hatteras (Scott and Scott 1988). Within this broad geographic range, winter skate have been reported from less than 1m in depth (Bigelow and Schroeder 1953) to 371m by Scott and Scott (1988). Maximum length of this species is reported to be about 109cm (Scott and Scott 1988), while little skate *Leucoraja erinacea* (Bigelow and Schroeder 1953), a closely related species, grows to a maximum length of 53.3cm (Waring 1982). Winter and little skate are sympatric over most of their ranges and are often difficult to distinguish, especially when immature (Scott and Scott 1988).

Any examination of skate must take into account their low catchability in standard research vessel trawl gear (Edwards 1968) when calculating abundance. As well, basic biological information (i.e. fecundity, spawning, and growth) is sparse due in part to their relative lack of importance in the traditional fisheries on the east coast of Canada.

The document presented here represents a comprehensive examination of all DFO data sources that might provide information on the occurrence of winter skate in the broad geographic area between Georges Bank and northern Labrador (Figure 1). In Canadian waters the only directed fishery for winter skate is on the eastern Scotian Shelf (Simon and Frank 1998). Winter skate have been reported as by-catch in both domestic and foreign fisheries, monitored by the International Observer Program (IOP). One might think that the commercial fishery itself would provide information on the occurrence of winter skate. Unfortunately, the reporting requirements do not require a separation by species and our commercial fisheries database includes only "skate unspecified".

The data reviewed were derived from four principal sources: i) seasonal research vessel (RV) surveys conducted by DFO that have been in existence for decades using standard sampling protocols, ii) non-standard research vessel surveys, conducted prior to 1970, that preceded the standardized surveys iii) industry/science surveys that began in the mid-1990s using either fixed or mobile gear, and iv) information from a directed skate fishery in Northwest Atlantic Fisheries Organization (NAFO) Division 4VsW.

Generally, the data are composed of number or weight caught, latitude and longitude, depth of capture, date, time of day, and gear type. More detailed information such as individual length, weight, and sex are available from a subset of the surveys. The data are both tabulated and portrayed geographically in order to show the distribution patterns of the species.

Ecology

Skates are elasmobranchs with low fecundity and late maturity, life history characteristics that make them susceptible to over-exploitation. The life history characteristics of winter skate have only been examined in detail from the eastern half of the Scotian Shelf (Div. 4VsW).

Skate are oviparous depositing a single egg in a horny capsule (purse) which is extruded. The purse has adhesive mucus, which attaches to substrate materials. This helps maintain contact with the bottom, but after large storms, windrows of purses (most likely winter) have been noted on Sable Island (pers. comm. W. Stobo). Observations suggest that it may take as long as 22 months for these purses to hatch (Simon and Frank 1998). Length at hatching is approximately 12cm. Holden (1973) has shown that the annual number of purses produced is inversely proportional to length at birth, which would result in winter skate producing fewer than 50 purses per year.

Members of industry have reported that mature females were observed extruding purses west of Sable Island in late summer and early fall. They have not been observed in any of the other areas that the commercial fishery is prosecuted, or at other times of year. Timing coincides with observations by Scattergood (1951) that winter skate were observed in Maine with purses in September and they have also been reported with purses in December /January off southern New England (Bigelow and Schroeder 1953).

An unvalidated aging study was conducted in 1995 using cross-sections of vertebrae (Simon and Frank 1996). A single reader determined ages of fish ranging from 12 to 100cm, estimating the ages to be from 0 to 16 years. Predicted parameters from the von Bertallanffy growth model were L_∞= 114.01, k=.14405 and t_o=.00315. Maximum age was estimated to reach 21 years.

A maturity study was conducted from 1996 to 1998 in Div. 4VsW on females only. This study noted that onset of maturity began at 65cm (age 6) and 50% maturity was estimated to occur at a length of 75cm (ages 7-8).

In United States waters, a detailed study on the biology of winter skate is ongoing and new biological parameters for that area should be available shortly.

Methods

Data on the distribution of winter skate have been compiled from Canadian and American research vessel surveys up to 1994, under the East Coast of North America Strategic Assessment Project (ECNASAP). These data show that winter skate are found from Cape Hatteras to the coast of Labrador (Figure 2) . The highest concentrations were on Georges Bank and near Sable Island. The data in this document will update the information in this database and extend it with the new surveys that were not available at the time

Twelve different RV data sources, including both non-standard and standardized RV surveys, were examined for the presence of winter skate (Table 1). These surveys cover virtually all of the Canadian continental shelf waters, except untrawlable bottom and near shore waters, as well as the Gulf of St. Lawrence. Research vessel surveys have run uninterrupted since 1950 within the Newfoundland region. These data consist of a number of surveys that differ in their design, duration and gear. Other surveys notable for their duration include those from the Scotian Shelf and southern Gulf of St. Lawrence that commenced in 1970 and 1971 respectively. Details for each of the individual RV survey series, in terms of location, gear type, time of year, duration and sampling effort, and are given in Table 2.

An additional nine industry/science surveys were also evaluated (Table 3). These surveys are relatively new and are not widely accessible. These surveys each have different standard sampling designs so products are variable. The industry participants have undergone training for sampling methods and species identification and in addition, trained observers have been deployed on a majority of the participating vessels.

Information from the commercial fishery is also presented. A developmental directed fishery for skates in Div. 4VsW by Canada began in 1994, with a TAC of 2000t limited to four otter trawlers. Reductions in TAC have reflected increasing concerns about the impact of the directed fishery on stock status and has resulted in a reduction in the number of vessels prosecuting the fishery to 3 in 2001 and 1 in 2002. Landings have been primarily winter skate (>90%) with the majority of the fishery centred on Banquereau Bank. Commercial sampling of this fishery began in 1995.

The International Observer Program (IOP) has been collecting data from commercial fisheries since 1977. Data requirements unfortunately were to

concentrate on the major groundfish species and until recently most skates were coded as skates unspecified.

Results

Overall

DFO RV Surveys
The Georges Bank RV survey yielded the highest percent occurrence (%sets) with winter skate (70.5%). The RV surveys on the Scotian Shelf have yielded percent occurrences of between 6.5 to 32.9%, while further north in the Gulf of St. Lawrence the percent occurrence has ranged from 1-12%. In the Newfoundland region yields have been generally less than 1% and are much less as you go further north.

Industry/DFO Science Surveys
Information from the industry surveys is limited due to the directed nature of each survey towards their target species. Winter skate have tended to be lumped into skate unspecified making analyses problematic. Even the skate survey in Div. 4VsW had early difficulties in species identification, but these have been rectified in the database. Generally catch rates have been similar to the RV surveys in the same area, although the directed skate survey in Div. 4VsW caught skate in close to 50% of the sets.

Overview of individual surveys:

Research Vessel Surveys

Newfoundland surveys, Subarea 234

This was the most extensive database available for analysis in terms of duration and geographic scope, including sets on Georges Bank, the Scotian Shelf and in the Gulf of St. Lawrence. The earlier years in the series (pre-1970) were not associated with any particular survey design, however, a random stratified survey design was adopted in 1970, 1971 and 1978 in Div. 3LNO, 3P, and 2J3K respectively. A total of 58,677 sets were completed from 1947-2002 with winter skate occurring in 240 sets or 0.4%of the total. (Table 4).

The composite distribution based on the entire survey series shows concentrations of winter skate near Sable Island, north along the slope waters of the Shelf, extending along both sides of the Laurentian Channel to Anticosti Island. A minor concentration was noted on the southern part of the Grand Banks, while there were scattered occurrences in the nearshore areas of Newfoundland and in the deeper waters north to Div. 2G (Figure 3).

Decomposing the data into ten year time blocks (Table 4) revealed that the winter skate have never made up more than 1.5% of the total number of sets in any one block, though values in individual years or subdivisions, could be higher. The greatest occurrence of winter skate was in the Gulf (Div. 4T, 33.3%) but sample size was low. The longest time series in the database have been from Div. 3N, 3O, and 3P (Figure 4). Very few winter skate were caught in these surveys until the mid-1980's, which coincided with the change in fishing gear to the Campelen trawl.

Northern Gulf of St. Lawrence, 4RS

Two research vessel surveys have been conducted in the northern portion of the Gulf of St. Lawrence. A winter survey ran from 1978 to 1994, while a summer survey has been conducted since 1984. Skate were distributed primarily along the south side of the Laurentian Channel and off the southwest coast of Newfoundland (Figure 5). Overall they occurred in approximately 7% of the winter survey sets and less than 1% of the sets during the summer survey (Figure 6). Large sets of greater than 300 individuals occurred in 1979, 1983 and 1985. Length frequencies of winter skate were not consistently taken and therefore a cumulative length frequency of all the fish sampled was constructed This revealed that the majority of fish sampled were between 36 and 69cm, peaking near 50cm (Figure 7). Very few fish greater than 70cm were captured by the survey, while the fish less than 15cm that were captured indicates that spawning occurred in the survey area.

Southern Gulf of St. Lawrence, 4T

Data are from bottom-trawl surveys of the southern Gulf of St. Lawrence conducted each September since 1971. Surveys followed a stratified random design, with stratification based on depth and geographic area. Vessel changes occurred in 1985 and 1991, and a gear change occurred in 1985. Adjustments for differences in catchability between vessels and gear were not necessary for winter skate (Benoît and Swain, in prep). Winter skate in the southern Gulf of St. Laurence are relatively more catchable at night than during the day. Consequently catches made outside of daylight hours (19:00-06:59) were adjusted to daylight equivalents using equations derived separately for each fishing vessel (Benoît and Swain, in review).

Winter skate were concentrated in the near-shore areas of PEI and New Brunswick and east of Isles de la Madeleine (Figure 8). Stratified mean number per tow were aggregated into length groupings of 1-35, 36-59, 60-74, and 75+cm. These groups were chosen to correspond with the length groups used in the 4VsW skate assessments. The smallest group reflects the difficulty in distinguishing between little and winter skate. The 36-59cm size group are the fish below market size, while the next size range (60-74cm) is those fish which are of fishable size but have not reached the 50% mature length of 75cm. Total

estimates were highest in the mid-1970's, have steadily declined from a high of .6 fish and have been below .1 in 7 of the last 9 years (Figure 9). The length range that has shown the largest decline was the 36-59cm group. Annual length frequencies from the survey revealed that there has been fewer large individuals (>50cm) than the long-term mean (1971-2002) since 1994. No fish greater than 75cm has ever been caught in the survey (Figure 10). An examination of the stratified mean percent occurrence (area occupied) revealed that it was highest in 1980 and has since slowly declined. The estimate in 2002 survey was the lowest in the time series (3.8%)(Figure 11).

Non-standard (3OP4VWX5YZ) RV survey, 1958-1969

This series of surveys had wide geographic coverage but most of the sampling effort was restricted to the central and eastern Scotian Shelf. The vessels most commonly used during this period were the A.T. Cameron (Yankee 36), the Harengus (Yankee 36), and the E.E. Prince (Yankee 36). All data were standardized to a 1.75 nm tow. A total of 91 surveys were conducted between 1958 and 1969, with good seasonal coverage. Total number of standard sets was 2201 with 154 or 7.0% capturing winter skate (Table 2).

Winter skate were concentrated in the central Scotian Shelf, though catch rates were highest in 4T (Figure 12). This concentration in 4T came from a single cruise in April 1962 with only 54 sets. The highest annual proportion of sets with winter skate is about 14% with no trend evident in the data (Figure 13). An examination of the length frequency from these cruises suggests that the length range were from 32 to 111cm with a mode of 90cm.

Summer Survey of the Scotian Shelf, 4VWX

The summer survey is the longest running survey series in the Maritimes region. It has been conducted yearly in July since 1970. There was a vessel change (A.T. Cameron to Lady Hammond) in 1982 and the sampling gear was changed that same year from a Yankee 36 to a Western IIA. In 1983, the vessel again changed from the Lady Hammond to the Alfred Needler. Out of the 5621 sets completed from 1970-2002, 815 sets (14.5%) contained winter skate (Table 2).

The composite distribution pattern revealed areas of winter skate concentration, notably the upper Bay of Fundy, Brown’s Bank, the eastern banks and their adjoining slopes of the Scotian Shelf (Figure 14). The distribution data were decomposed into eight-year time blocks, showing the persistence of concentration in the noted areas. Abundance in the most recent time block in Div. 4X appears to be stable if not increasing, while the distribution of winter skate on the eastern shelf shows an overall reduction in abundance in Div. 4VsW (Figure 14)

Winter skate catch rates by length groups have exhibited a variable pattern of abundance over the course of the summer survey. The total mean number per tow has declined since the mid-1990's to 0.3, well below the survey series average of 0.6 fish per tow especially in the larger size groups (60-74 and 75+cm (Figure 15)).

Annual length frequencies revealed a size range from 9-121cm, with an overall peak of 49cm (Figure 16). Relatively few winter skate were captured with a body size in excess of 75cm. Winter skate reach sexual maturity at a body size of approximately 75cm, which leads to the conclusion that recent trawl surveys have captured only juvenile winter skate in significant quantities while adults were rarely captured.

The area occupied, or proportion of nonzero sets, displayed an increasing trend from the 1970's until the early 1990's (Figure 17). The area occupied has since declined. The resource concentration (density) or the proportion of the area with 75% of the log (1+numbers), showed a pattern similar to that of the area occupied.

Spring Survey of the Scotian Shelf, 4VWX

This survey was conducted from 1979 to 1984 in the early spring. A total of 790 sets were completed covering the entire Scotian Shelf and winter skate were present in 260 sets, or 33% (Table 2). The distribution pattern for the spring survey series also revealed areas of concentration in the Bay of Fundy, Brown's Bank, and eastern Scotian Shelf (Figure 18).

The mean catch per tow for the series declined from 3 fish per year to less than 1 per year in 1984 with all of the decline in the 36-59cm size group (Figure 19). The annual length frequencies (Figure 20) revealed that fish ranged from 13-121cm with a peak of 50cm

No trend in area occupied or density was evident from this short series though the 1984 estimates were the lowest seen (Figure 21).

4VWCOD Survey, 4VsW

The 4VWCOD survey began in 1986 and ran uninterrupted until 1997. The 1996 survey is not considered complete and was left out of analyses. There was no survey in 1998 but the survey resumed in 1999 and has continued since This survey has been restricted to the eastern half of the shelf and 1466 sets have been completed. Winter skate occurred in 346 sets, for a percent occurrence of 23.6%(Table 2). The distribution pattern has shown a reduction in abundance of winter skate on the eastern shelf for the time period of 1994-2002 (Figure 22).

Winter skate catch rates in this survey have been very low since 1997 (Figure 23). The anomalous 1994 survey estimate was due to a single set of 1500kg. Annual length frequencies revealed a size range from 9-110cm, with an overall peak of 50cm (Figure 24). Relatively few mature winter skate have been caught by the spring survey in recent years.

The area occupied by the resource from 1986 – 1995 averaged about 30% and since 1999 has been below 20% (Figure 25). The resource concentration shows a pattern similar to that of area occupied.

Fall Survey of the Scotian Shelf, 4VWX

This survey was restricted to the time period 1978-84. Winter skate were present in 145 sets of 944 sets or 6.5%(Table 2). Distribution patterns showed concentrations of winter skate similar to those observed in the spring and summer RV surveys (Figure 26).

No trend in the catch rates over the seven years of the survey (Figure 27). Annual length frequencies were similar to the other seasonal RV surveys with a peak of 50cm and a range of 13-107cm (Figure 28). The area occupied by winter skate averaged about 15% and did not change substantially during the series (Figure 29).

Winter Survey of Georges Bank, 5Z

The Georges Bank survey began in 1984 when a partial survey of the bank was conducted. In 1986 the survey was expanded to cover the entire bank and the geographic scope of the survey has remained unchanged to present. A total of 1556 sets have been completed since 1986, with 1098 (70.5%) containing winter skate (Table 2).

The distribution pattern revealed that winter skate is abundant throughout Georges Bank (Figure 30) with the highest concentrations on the USA side of the bank. No trend in winter skate number per tow in the Georges Bank survey is evident, though it has declined slightly in 2002 to 10.4, which is below the long-term mean of 17.9 fish per tow (Figure 31). The annual length frequencies showed a size range from 9-112cm, with an overall peak of 37cm (Figure 32). No decline in any size group was evident.
The area occupied and density series generally increased until 1999 and has fallen in the last 3 years to near average values. (Figure 33).

Redfish Survey of the Scotian Shelf

The deep-sea redfish surveys took place in the autumn of 1982 to 1988. The survey area focussed on the Gully, along the edge of Banquereau Bank and into the Laurentian Channel. The sampling design followed a stratified random

scheme. Sampling depths ranged from 100-700 fathom. Only total number and weight per set were recorded for skates. One spring survey was conducted in 1982. This survey was omitted from the analyses due to potential seasonal effects.

Of the 655 sets completed, 96 or 14.7% caught winter skate (Table 2). These fish were caught almost exclusively in the Gully (Figure 34). Only 5 sets caught winter skate outside the Gully in deeper water. Total numbers of winter skate caught during a survey ranged from a minimum of 3 to a maximum of 175. The average catch per tow ranged from 0.2 to 5.5 fish per tow (Figure 35).

Industry/Science Surveys

ITQ Survey of the southwestern Scotian Shelf (Div. 4X Otter trawl)

This survey has been conducted each July since 1995 using four industry trawlers equipped with rockhopper footgear. A total of 1436 sets have been completed with winter skate occurring in 59 or 4.1% (Table 5). Winter skate were captured on Browns Bank, in the deep waters off German Bank , and north along the Nova Scotian side of the Bay of Fundy (Figure 36). It was noted that winter skate were caught in the inshore strata that are not covered by the summer RV survey. Inconsistent identification of skates makes the calculation of catch rates problematic for this survey.

Monkfish Survey (Div. 4X/5Z Otter trawl)

This survey ran from 1995-1999 and was conducted each year in October by five industry trawlers equipped with rockhopper footgear. A total of 1062 sets were completed but winter skate were not recorded in all years and so it is not possible to perform any useful analyses

5Z Fixed Gear

The 5Z fixed gear is a longline survey on the Canadian portion of Georges Bank. It has taken place every summer since 1995. Standardization is difficult due to inconsistent survey design among years. Also, not all data are currently available. As a result, no analyses were performed

Northern Gulf Surveys

Sentinel Fishery surveys have been conducted in the northern Gulf in July and October since 1995. Only 5 winter skate have been recorded in the 14 surveys to date (Figure 5)

Halibut Survey and Index Fishery (Div. 3NOP4VWX Longline)

Members of industry have conducted the halibut survey in Div. 3PO4VWX consisting of a fixed station survey and an index fishery, since 1998. A total of 2354 sets have been completed with winter skate occurring in 79 or 3.4% of the sets (Table 5), though data issues has limited some of the analyses that can be done. Winter skate were captured primarily south of the Grand Banks, east of Cape Breton and on the central Scotian Shelf (Figure 37) from the fixed station part of the survey.

Sentinel Survey of the eastern Scotian Shelf (Div. 4VsW Longline)

The sentinel survey began in September of 1995 and has continued to present. Skates were not identified to the species level until the 1996 survey and our analysis begins there. A total of 1749 sets have been completed with 208 or 11.9% of the sets having winter skate present (Table 5).

Winter skate catches were concentrated on Sable Island Bank (Figure 38). A secondary concentration was found on the eastern shoal of Banquereau Bank

Stratified mean catch per tow estimates from this series showed a decreasing trend in the abundance of winter skate, although the survey series is relatively short (Figure 39). The percentage of sets with winter skate increased from 1997 to 2000, though it did decrease again in 2001 (Figure 40).

Length measurements for this species were not made on a regular basis for each survey.

4VsW Skate Surveys (otter trawl)

As part of the Conservation Harvesting Plan for skates established in 1994, industry agreed to conduct two industry/science skate surveys per year (spring and fall) in Div. 4VsW. Historical background on these surveys is available from the assessment documents that have been published since the inception of the fishery (Simon and Frank, 1995,1996,1998,2000). The 2000 stock assessment determined that continued monitoring was required and the 2001 Harvesting Plan required that only the spring survey be continued.

A total of 378 sets have been completed within the survey area (Figure 41) during the spring surveys with 182 or 48.2% of the sets capturing winter skate. A total of 229 sets were completed during the fall with 113 or 49.3% of the sets catching winter skate.

The distributions from the two surveys are shown in Figures 42 and 43. The spring survey had most of the fish on the edges of the banks and on the slopes

of the surveyed area. A similar pattern was seen in the fall survey, but in addition there was a concentration of fish west of Sable Island. The 2002 assessment of winter skate noted some inconsistencies between the distribution of winter skate from the spring industry/science surveys in 2001 and 2002 and the spring and summer RV surveys. Most of the fish were found in Div. 4Vs with a lesser amount on the slope waters of Div. 4W by the industry survey, while winter skate were found almost exclusively in Div. 4W by the RV surveys.

Winter skate total biomass estimates from the spring industry survey ranged from a low of 4900t in 1997 to a high of 20500t in 1996 (Figure 44). The 2002 estimate was 5600t. The fall industry survey biomass estimate ranged from a low of 9400t in 1995 to a high of 47800t in 1999 (Figure 44). Average biomass estimates from the spring, fall industry and since 1995 have been 10,000t, 20,00t respectively, which contrasts with a biomass estimate from the summer RV survey of 1300t for the same time period and area. The industry estimates are 6-12 times greater than the summer RV biomass reflecting the increased catchability of the rockhopper gear used.

Decadal biomass averages for the summer survey were calculated to be approximately 6000t in the 1970's, 3800t in the 1980's and 1300t in the 1990's to present. Of note are the extremely low estimates in 2001 and 2002 from the summer RV (200t, 50t respectively). The spring industry survey suggests there has been little change in biomass since 1996.

The percentage of sets with winter skate has similar for both the spring and fall surveys (Figure 45). The estimates have averaged close to 50% and are increasing slightly.

Overview from Commercial Fishery

Observer Data

The International Observer Programs (IOP) of the different regions on the East Coast of Canada have been collecting data from commercial fisheries since 1977. Data requirements for each region have differed, until recently many skates were not identified consistently to the species level and therefore are presented separately by region.

An examination of the distribution of winter skate from the Newfoundland IOP 1980-2001 (Figure 46) found the highest concentration of winter skate on the eastern Scotian Shelf, with scattered catches in Div. 3OPs. Of interest are the reports of winter skate in the waters around the Flemish Cap. The IOP from the Quebec Region reported (1990-2001) that winter skate were found primarily in the Bay of Chaleur, the deep water at the mouth of the St. Lawrence River with another concentration off the west coast of Cape Breton (Figure 47). The distribution of winter skate as reported by the IOP from the Scotian Shelf Region is shown from 1995-2002 (Figure 48). This pattern is similar to that noted by the

research vessel surveys with the highest concentrations on Georges Bank, and on the eastern Scotian Shelf. As well fish were found on the south side of the Grand Banks in Div. 3OPs and on the eastern shoal area of the Grand Banks.

Commercial Fishery

A developmental directed fishery for skates in Div. 4VsW by Canada began in 1994, with a TAC of 2000t limited to four otter trawlers. Landings by the directed fishery have declined from 2152t in 1994 to less than 400t in 2001, reflecting progressive reductions in TAC (Figure 49). The reductions in TAC have reflected increasing concerns about the impact of the directed fishery on stock status and has resulted in a reduction in the number of vessels prosecuting the fishery to 3 in 2001 and 1 in 2002. These landings have been primarily winter skate (>90%) with the majority of the fishery centred on Banquereau Bank (Figure 50). Foreign landings prior to 1994 were identified as skate unspecified and were entirely in the silver hake box, which is located on the slopes of Western and Sable Island Banks. Anecdotal information indicates that these landings were approximately 60% winter skate.

An examination of commercial catch rates of winter skate in spring revealed no significant changes since the beginning of the directed fishery, with average catch rates of 1.7t/hour (Figure 51)

Sampling of winter skates from the directed fishery landings began in 1995. The length frequency in 1995 peaked at 76cm and included many fish up to and greater than 100cm. In 1996, the peak shifted to 71cm and has remained there since. This is slightly below the 50% maturity of 75cm. The percentage of fish greater than 90cm declined from 25% in 1995 to 6% in 1996 and less than 4% since 1997. Length frequency observations by the International Observer Program (IOP) from the commercial phase of the directed fishery showed a similar loss of larger individuals from the population as seen in the sampled landings, but there was some indication of improvement in the percentage of fish greater than 76cm (Figure 52). The percentage of fish greater than 90cm decreased from 22% in 1995 to less than 3% from 1996 to 2000. In 2001 and 2002, the percentage increased to 4% and 5% respectively. Winter skate caught commercially in Div. 4VsW are much larger than those caught by the RV surveys in the same area of the Scotian Shelf.

Discards of winter skate in Div. 4VsW by Canadian groundfish fisheries prior to their closures in 1994 had been estimated to be greater than 1000t (Simon and Frank 1996,1998). Since 1994, discards were estimated to have been generally less than 100t in Div. 4VsW.
To better understand the total removals by all fisheries we examined the total landings of the major groundfish (cod, haddock, pollock and redfish) and flatfish (witch, place, yellowtail, winter flounder and unspecified flounder) fisheries in the areas where winter skate were most abundant. Groundfish landings in all divisions has dropped substantially with the greatest decline in Div. 4VW (Figure 53). Flatfish

landings have also sharply declined except in Div. 5Z (Figure 53). Observer reports indicate that winter skate bycatch in the groundfish fisheries is less than 5%, but could be as high as 25% in some flatfish fisheries. These estimates are anecdotal so the estimation of total winter skate removal by all fisheries is inexact. If the by catch estimate in the groundfish fisheries was 1% and 5% in the flatfish fisheries, total removals in Div. 4T have declined from 700t to 140t since 1986. In Div. 4VW the decline has been from 1400t to less than 100t and in Div. 4X5Y the decline was from 900t to 300t. In Div. 5Z there was no decline in the bycatch estimates. The recording of skate discards by species needs to be a priority to understand the total removals by all fisheries in the area.

Terms of reference

Evolutionarily significant units

There is insufficient data to determine if there are separate evolutionarily significant units for winter skate within Atlantic Canada. Winter skate are distributed in a contiguous manner from Georges Bank north on the Scotian Shelf, into the Gulf of St Lawrence and on the southern parts of the Grand Banks. Scattered concentrations have been observed near the Flemish Cap and north along the Labrador coast, but very few individuals occur north of Subarea 3. We are unable to determine if the fish from the different areas are from different populations. No known genetic research has been done to compare winter skate from different areas in Atlantic Canada. The data suggests local movement, for example the fish in 4T appear to be moving into shallow water possible to spawn, but no tagging data are available to confirm this observation. Research into winter skate genetics and life history is required to resolve the question of distinct ESU's for winter skate in the Northwestern Atlantic.

Trends in distribution

The reported range of winter skate extends from as far north as the Gulf of St. Lawrence and southern Newfoundland coast to Cape Hatteras (Scott and Scott 1988). Two analyses of changes in area occupied were performed. The first was the percent occurrence of winter skate in a survey and the second was resource concentration (density) calculated as the fraction of the area surveyed containing 75% of the total catch in a survey. Both analyses are correlated to abundance and may not be true measures of changes in distribution.

The proportion of nonzero sets in the summer RV survey in Div. 4VWX displayed an increasing trend from the 1970's until the early 1990's (Figure 17). It has since declined. The area occupied or the proportion of the area with 75% of the log (1+numbers), showed a pattern similar to that of the area occupied increasing to a peak of 11% in 1991-1993 and then decreasing to approximately 6% in recent years (Figure17). The current area occupied is comparable to the values seen in the 1970's. The area occupied and resource concentration series from the

Georges Bank survey in Div. 5Z generally increased until 1999 and has fallen in the last 3 years to near average values. (Figure 33). In 4T an examination of the stratified mean percent occurrence revealed that it was highest in 1980 (17%) and has since slowly declined. The estimate in 2002 survey was the lowest in the time series (3.8%) (Figure 11). These indices are correlated to abundance and so any changes may partly reflect a change in abundance and not distribution.

The utility of the industry surveys is limited by the inconsistent sampling effort except for two surveys. In the skate survey in Div. 4VsW the percent occurrence (percent of sets where skate occur) has increased both in the spring and fall series since the beginning of the survey in 1995 (Figure 45) and has averaged about 50%. The Sentinel Survey since 1996 has sampled the entire area of Div. 4VsW. Since this includes areas where winter skate have not been observed before you might expect that the percent occurrence would be lower. The survey results have been about 10% since the longline survey began.

Trends in abundance of mature individuals

In Div. 4VsW winter skate are considered 50% mature at 75cm. The southern Gulf survey has never caught individuals greater than 75cm, though young of the year (i.e.< 15cm) are caught in the survey suggesting that spawning occurs in the area. In Div. 4VsW, mature fishable biomass as calculated from the summer RV survey in Div 4VsW has declined progressively from the beginning of the series (SSR A3-29, 2000). In 2001 and 2002, no fish greater than 75cm were caught.

The summer RV survey estimates for the entire Scotian Shelf revealed that the minimum population numbers for all lengths (calculated as the product of the stratified mean numbers per tow and the number of trawlable units) peaked in the early to mid 1990's and has been below the long-term average (2.6 million) in the last five years (1.4 million) The dynamic range of the data has been from 750 000 in 2001 to 8 million in 1979 (Figure 54). Decal averages were 2.6, 2.5 and 2.76 million for the 1970’s, 1980’s and 1990’s to present respectively.

The spring/4VWcod time series of population numbers revealed that winter skate has averaged about 4.8 million individuals in Div. 4VW excluding the anomalous 1994 estimate of 43 million (Figure 55). The summer RV estimate for the comparable area averaged 1.7 million. In the last 11 years the spring RV estimate was 3.8 million while the summer RV estimate was 1.5 million.

The Georges Bank RV surveys revealed population numbers ranging from 6.9 million in 1994 to 48 million in 1990 (Figure 56) in Div. 5Z. When considering only the Canadian side of the bank population numbers have ranged from 600,000 to 3.8 million averaging 1.8 million. No trend in the data was evident.

The southern Gulf (4T) estimate has ranged from 50,000 to 1 million individuals. The overall average has been 400,000(Figure 57). The decadal averages have

been 650, 450 and 170 thousand individuals in the 1970's, 80's and 90's respectively.

Overall the research vessel surveys have estimated the minimum total number of individuals to have averaged over 3 million individuals in Div. 4TVWX (Figure 58). The decadal averages in Div. 4TVWX are all very close to 3 million, though the estimate in the last 5 years has been closer to 1.5 million. In Div. 5Z (Canadian portion) the estimate is 1.8 million. Given that the skate industry survey in biomass estimates are 6-12 times greater than the summer RV biomass estimates in Div. 4VsW any numerical estimates from the RV must be considered highly underestimated.

Discussion/Conclusions

Winter skate are widely distributed in the Canadian Atlantic zone from Georges Bank north into the Gulf of St. Lawrence. They are also found in lower concentrations, south of Newfoundland and along the south side of the Grand Banks. Scattered areas of distribution are in the deeper waters around the Flemish Cap and north in the warmer waters along the Labrador coast. Abundance in the northern Gulf of St. Lawrence appears to be stable while in the Southern Gulf abundance has declined steadily since 1971. On the Scotian Shelf overall abundance peaked in the early 1990's and has fallen in the last 5 years, especially on the eastern Scotian Shelf. On Georges Bank, winter skate are common and no trend in abundance was evident. On examination of these 3 RV surveys it was observed that winter skate was the third most common species caught in the Georges Bank survey (113 species), the 22nd most common from the summer RV (195 species) and the 13th most common during the spring RV (153 species). Only longhorn sculpin and cod were caught more often than winter skate during the Georges survey. During the summer RV winter skate were caught more often that lumpfish, shad, longfin hake and mackerel and was caught as often as halibut. During the spring survey winter skate were caught more often than sea raven, halibut, red hake and monkfish.

Winter skate occur in areas deeper than the regular groundfish surveys but not in any great quantities. Given the distribution in 4T it is more likely that fish are inshore of the areas surveyed.

Limited information exists on the biology of winter skate, however recent studies have shown that length at 50% maturity is 75 cm for females in Div. 4VsW. Given that no individuals greater than 70cm have been caught in Div. 4T during the 32 years of their survey it is unlikely that this value will hold for the entire range of the species.

The utility of industry/science surveys in the examination of the status of winter skate is variable. Many of the surveys have had difficulties in species

identification. The Sentinel survey in Div. 4VW and the directed skate survey in Div. 4VsW are the most complete, with few data errors. When comparing catch rates from the summer RV and the skate survey, the rates in the industry survey is 6-12 times higher than the summer RV. This is an indication of the low catchability of the RV survey gear and makes any population estimates derived from that source highly underestimated.

Overall the research vessel surveys have estimated the minimum total number of individuals to have averaged over 3 million individuals in Div. 4TVWX (Figure 54). The decadal averages in Div. 4TVWX are all very close to 3 million, though the estimate in the last 5 years has been close to 1.5 million individuals. In the Canadian part of Div. 5Z the minimum average estimate is 1.8 million individuals. Given the differences in biomass estimates from the skate survey in Div. 4VsW all estimates from the RV must be considered highly underestimated.

Acknowledgements

We thank Dave Kulka, Marthe Berube, and Doug Swain for provision of data from the Newfoundland and Gulf of St. Lawrence regions. Hugues Benoit provided analysis and text for the 4T surveys.

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Table 1. Temporal and spatial extent of data used in examining the distribution and abundance of winter skate in Canadian waters from DFO research vessel surveys. OT-otter trawl; various-all gear combined.

	Gulf 3P4V Jan. OT	Georges 5Z Feb/Mar OT	Spring 4VWX Mar OT	4VWcod 4VsW Mar OT	Summer 4VWX July OT	S. Gulf 4T Sept OT	Fall 4VWX Oct/Nov. OT	Pre 70's 3OP4VWX5Z Jan-Dec OT	Nfld Subarea 234 Jan-Dec various	Redfish 4VWX Oct/Nov OT	N.Gulf 3PN4RST winter OT	N. Gulf 3Pn4RST summer OT
1947									X			
1948									X			
1949												
1950									X			
1951									X			
1952									X			
1953									X			
1954									X			
1955									X			
1956									X			
1957									X			
1958								X[1]	X			
1959								X[1]	X			
1960								X[1]	X			
1961								X[1]	X			
1962								X[1]	X			
1963								X[1]	X			
1964								X[1]	X			
1965								X[1]	X			
1966								X[1]	X			
1967								X[1]	X			
1968								X[1]	X			
1969								X[1]	X			
1970					X				X			
1971					X	X			X			
1972					X	X			X			
1973					X	X			X			
1974					X	X			X			
1975					X	X			X			
1976					X	X			X			
1977					X	X			X			
1978					X	X	X		X		X	
1979			X		X	X	X		X		X	
1980			X		X	X	X		X		X	
1981			X		X	X	X		X		X	
1982			X		X	X	X		X	X	X	
1983			X		X	X	X		X	X	X	
1984		X	X		X	X	X		X	X	X	X
1985			X		X	X			X	X	X	X
1986		X		X	X	X	X		X	X	X	X
1987		X		X	X	X			X	X	X	X
1988		X		X	X	X			X	X	X	X
1989		X		X	X	X			X		X	X
1990		X		X	X	X			X		X	X
1991		X		X	X	X			X		X	X
1992		X		X	X	X			X		X	X
1993		X		X	X	X			X		X	X
1994	X	X		X	X	X			X		X	X
1995	X	X		X	X	X			X			X
1996	X	X		X	X	X			X			X
1997	X	X		X	X	X			X			X
1998		X			X	X			X			X
1999		X		X	X	X			X			X
2000		X		X	X	X			X			X
2001		X		X	X	X			X			X
2002		x		X	X	X			X			

X[1] These are non-standard surveys. Area, season and sampling effort varied from year to year.

Table 2. Details of the individual survey series from Table 1 showing gear type, season, sampling effort (number of sets) and percent occurrence of winter skate.

Survey	NAFO Area	Gear Type	Season (month)	Years	Total Number of Sets	Number of sets with winter skate	Percent Occurrence
RV(Nfld)	Subareas 23	Various	All year	1947-50	711	10	1.4
RV(Nfld)	Subareas 23	Various	All year	1951-60	2411	3	0.1
RV(Nfld)	Subareas 23	Various	All year	1961-70	3410	21	0.6
RV(Nfld)	Subareas 23	Various	All year	1971-80	9083	40	0.4
RV(Nfld)	Subareas 23	Various	All year	1981-90	20480	31	0.2
RV(Nfld)	Subareas 23	Various	All year	1991-00	20567	119	0.6
RV(Nfld)	Subareas 23	Various	All year	2001-02	1985	16	0.8
				Sum	58677	240	0.4
RV (n Gulf)	3Pn4RST	OT	winter	1978-94	1849(1983-94)	128	6.9
RV (n Gulf)	3Pn4RST	OT	summer	1984-01	2434(1990-01)	22	0.9
RV (s Gulf)	4T	OT	Fall	1971-02	4260	497	11.7
RV (pre 70's)	3PO4VWX5Z	OT	All year	1958-69	2201	154	7.0
RV, Summer	4VWX	OT	summer	1970-02	5621	815	14.5
RV, Spring	4VWX	OT	March	1979-85	790	260	32.9
RV, 4VWCOD	4VsW	OT	March	1986-02	1466	346	23.6
RV, Fall	4VWX	OT	Fall	1978-84	944	145	6.5
RV, Georges	5Z	OT	Winter	1986-02	1556	1098	70.5
RV, Redfish	4VWX	OT	Fall	1982-88	655	96	14.7

Table 3. Temporal and spatial extent of data used in examining the distribution and abundance of winter skate in Canadian waters from industry/science surveys.
OT-otter trawl; LL Longline.

	ITQ 4X July OT	Monkfish 4WX5Z Fall OT	Halibut 3PO4VWX June/July LL	Sentinel 4VsW Fall LL	Skate 4vSW April/May OT	Skate 4VsW October OT	Yellowtail 5Z summer LL	Sentinel 3PN4RST July OT	Sentinel 3Pn4RST October OT
1994									
1995	X	X		X	X	X	X	X	X
1996	X	X		X	X	X	X	X	X
1997	X	X		X	X	X	X	X	X
1998	X	X	X	X	X	X	X	X	X
1999	X	X	X	X	X	X	X	X	X
2000	X		X	X	X		X	X	X
2001	X		X	X	X		X	X	X
2002	X		X	X	X		X	X	X

Table 4. Details of the total number of sets and sets in which winter skate were caught by decade from the Newfoundland based RV surveys.

All sets Year	Subarea 0,1	Subarea 2,3	Div. 4RST	Div. 4VWX	Div. 5Z	Total
1947-1950	-	596	87	28	-	711
1951-1960	7	2140	211	50	9	2441
1961-1970	73	2730	295	203	98	3410
1971-1980	116	7077	1871	1	18	9083
1981-1990	194	18934	560	614	178	20480
1991-2000	135	19745	564	123	-	20567
2001-2002	36	1947	-	-	-	1985
Total	561	53169	3588	1019	303	58677

Sets with winter skate Year	Subarea 0,1	Subarea 2,3	Div. 4RST	Div. 4VWX	Div. 5Z	Total
1947-1950	-	-	-	10	-	10
1951-1960	-	2	-	1	-	3
1961-1970	-	15	5	1	-	21
1971-1980	-	7	33	-	-	40
1981-1990	-	29	2	-	-	31
1991-2000	-	84	5	30	-	119
2001-2002	-	16	-	-	-	16
Total		153	45	42		240

Table 5. Total number of sets and number of sets with winter skate from the industry/science surveys in Div. 4VWX5Z.

	sets	skate sets	sets	skate sets	sets	skate sets	sets	skate sets	sets	skate sets	sets	skate sets
trip type	7050	7050	7050	7050	7050	7050	7050	7050	7050	7050	7051	7051
set type	1	1	4	4	5	5	6	6	10	10	4	4
1994												
1995					221						139	
1996					237	29	15	2	251	13	179	25
1997					378	31	15	2	201	51	179	5
1998					302	25	27	8	61	8	191	20
1999					266	42	20	7	29	1	187	
2000					283	56	30	13	10	1	189	1
2001	16		10		245	21	35	3	8		187	
2002	17		19	2	38	4	8		17	4	185	8
Grand Total	33	0	29	2	1970	208	150	35	577	78	1436	59

	sets	skate sets	sets	skate sets	sets	skate sets	sets	skate sets	sets	skate sets	sets	skate sets	sets	skate sets
trip type	7053	7053	7053	7053	7053	7053	7054	7054	7054	7054	7054	7054	7054	7054
set type	1	1	4	4	9	9	1	1	5	5	6	6	9	9
1994							55	44					119	51
1995	318	54	139		11		60	56	80	29	26	15	3	1
1996	401	27	235	29	2		182	174	94	44	21	14	1	
1997	250	17	230		2		84	77	95	43	11	6		
1998	66	1	229	24	2		37	36	95	40	16	10	1	
1999	154	3	229	12	2		41	39	86	55	22	13		
2000							21	21	64	36	16	8		
2001							32	32	50	22	4	4		
2002							7	7	43	26			1	
Grand Total	1189	102	1062	65	19	0	519	486	607	295	116	70	125	52

	sets	skate sets	sets	skate sets	sets	skate sets	sets	skate sets	sets	skate sets	sets	skate sets
trip type	7055	7055	7055	7055	7055	7055	7055	7055	7057	7057	7057	7057
set type	1	1	4	4	5		6	6	4	4	10	10
1994												
1995							79	2				
1996							62					
1997												
1998							43	9	210	9	640	7
1999	15	12	38	1	2				181	9	166	3
2000			54						222	6	276	
2001			46	6			11	1	197	25	88	2
2002			20	9	25				197	16	177	2
Grand Total	15	12	158	16	27	0	195	12	1007	65	1347	14

SET_TYPE

1 COMMERCIAL
2 TEST FISHERY - LENGTH
3 TEST FISHERY - BYCATCH
4 SURVEY - FIXED
5 SURVEY - RANDOM
6 SURVEY - FISHERS CHOICE
7 COMMERCIAL - C AND P
8 EXPLORATORY
9 EXPERIMENTAL
10 COMMERCIAL INDEX

TRIP_TYPE

7050 4VSW SENTINEL PROGRAM
7051 4X MOBILE GEAR SURVEY
7053 4X MONKFISH SURVEY
7054 4VsW SKATE SURVEY
7055 5Z FIXED GEAR SURVEY
7057 4VWX HALIBUT SURVEY

Note that not all sets were included in the analysis, due to data inconsistencies in some surveys.

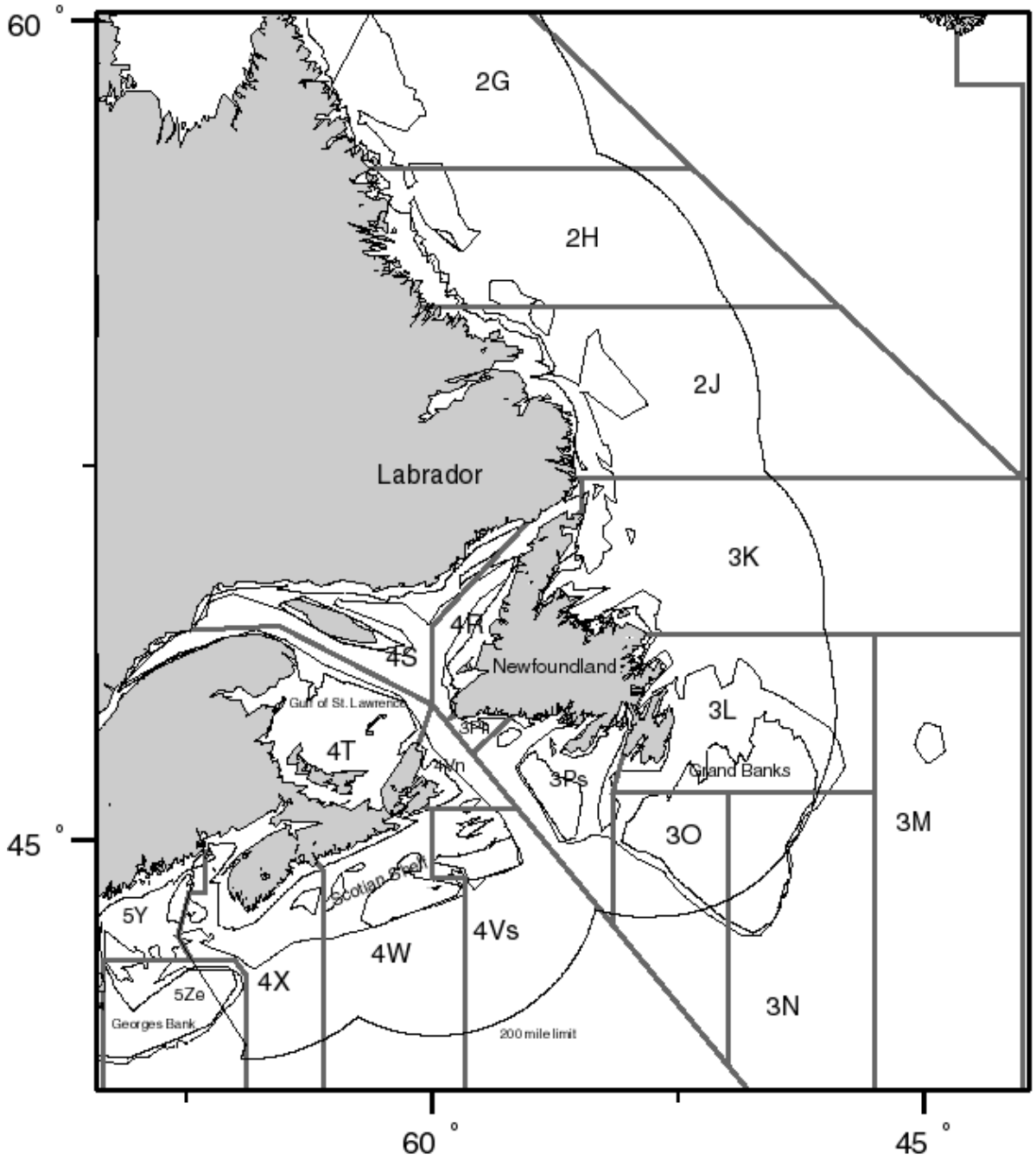

Figure 1 Geographic display of the areas and NAFO divisions mentioned in this document.

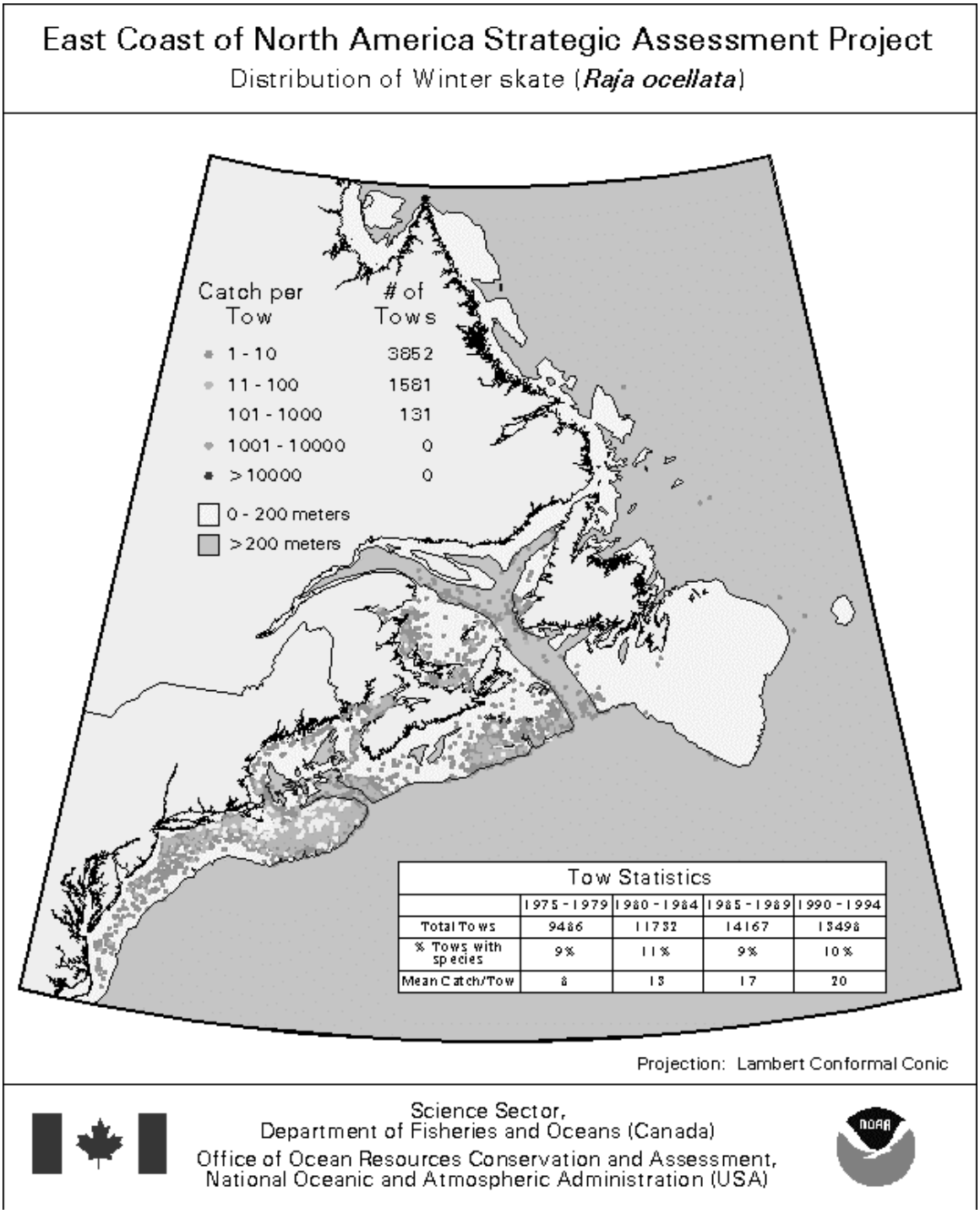

Figure 2. Distribution of winter skate from the ECNASAP database.

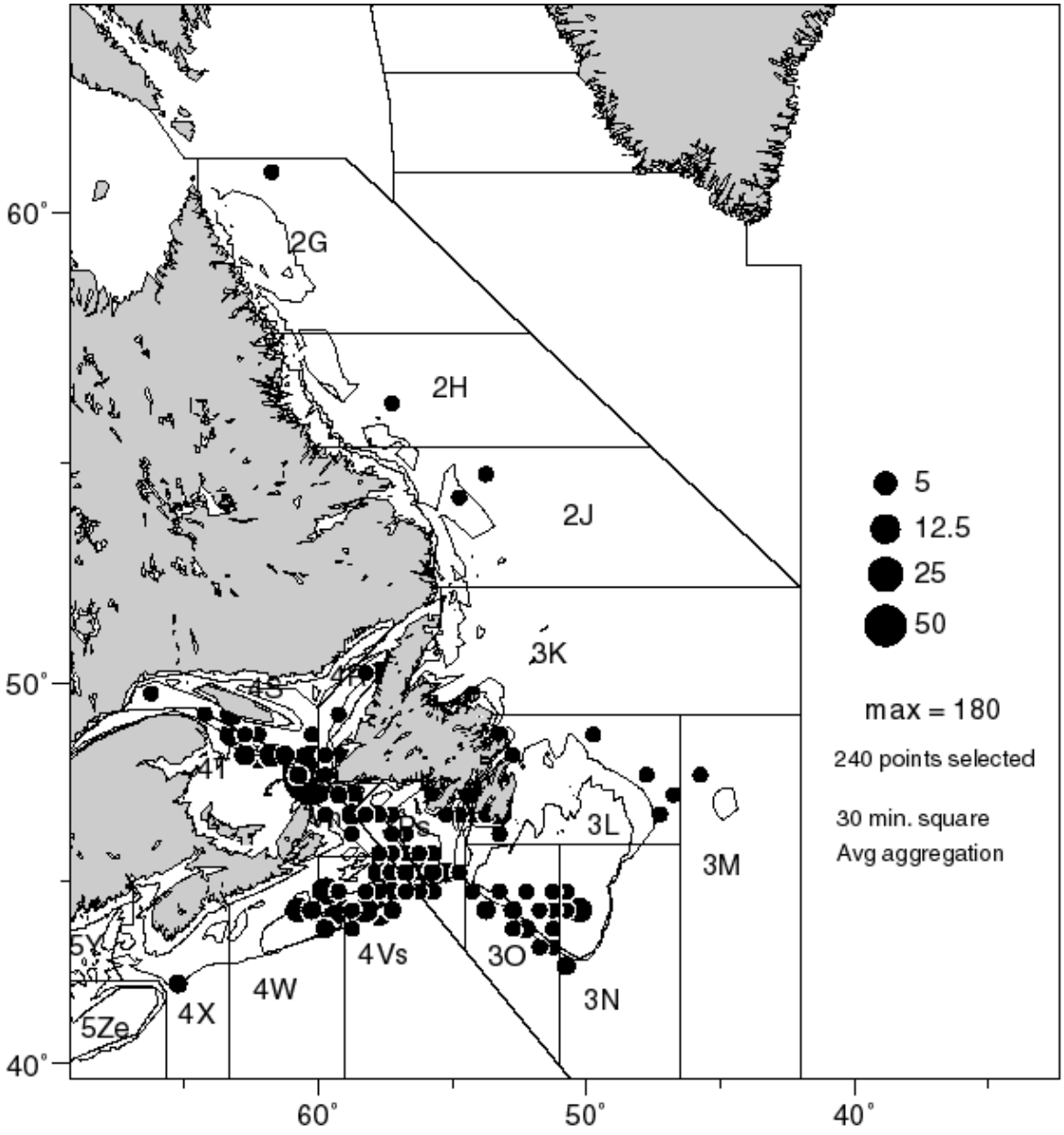

Figure 3. Distribution of winter skate from the Newfoundland RV surveys, 1947-2002.

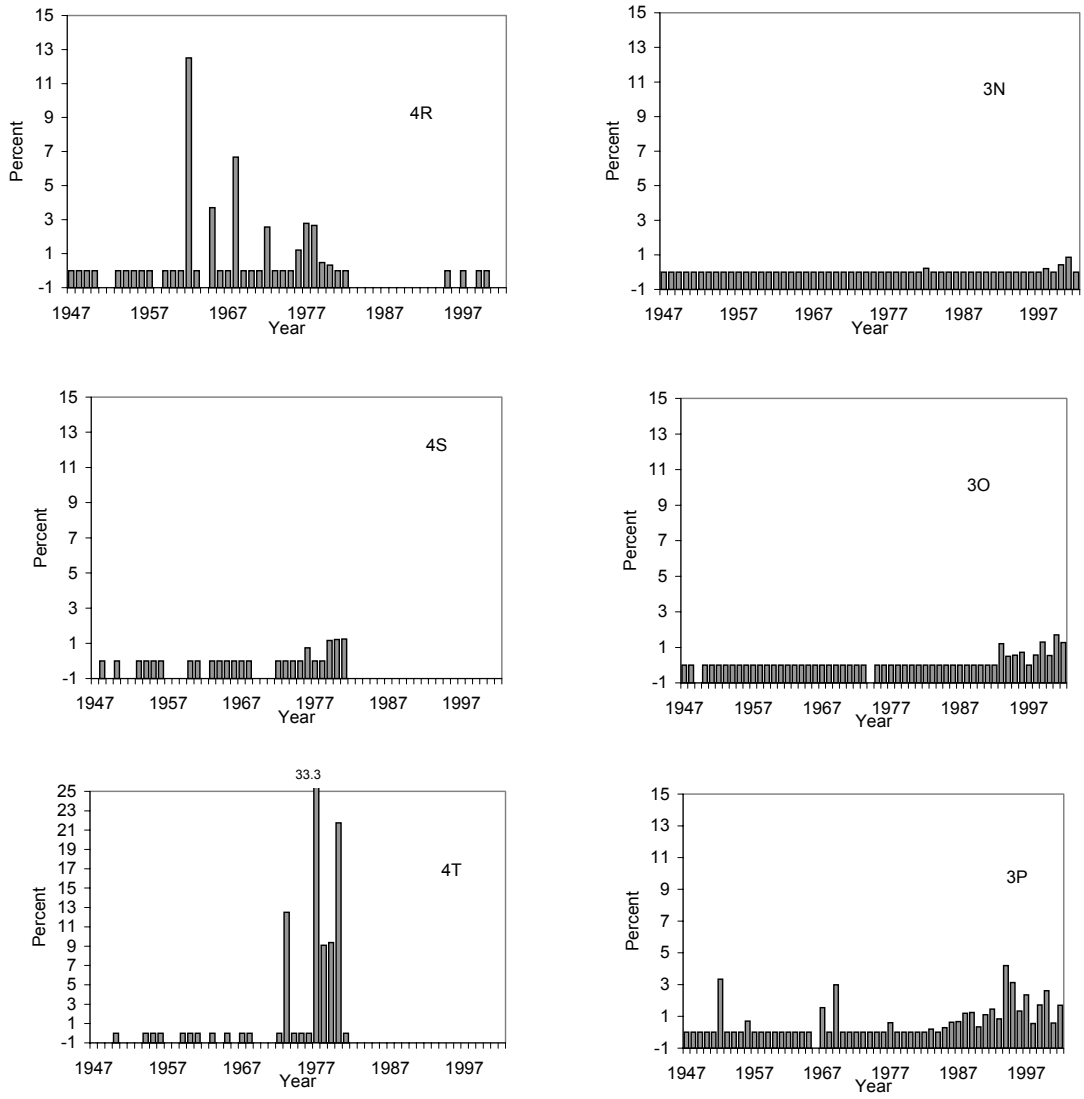

Figure 4. Percentage of sets with winter skate from the Newfoundland RV surveys by division from 1947-2002. Note the y-axis begins at -1 so the years where there were sets but no catch (0%) may be shown.

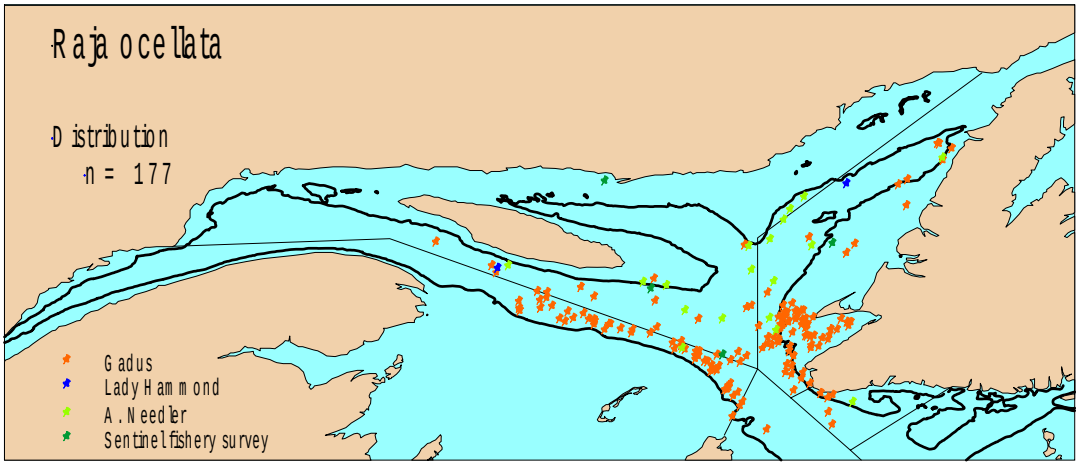

Figure 5: Distribution of winter skate in Div. 3Pn, 4RS and part of 4T from scientific surveys, 1983-2001

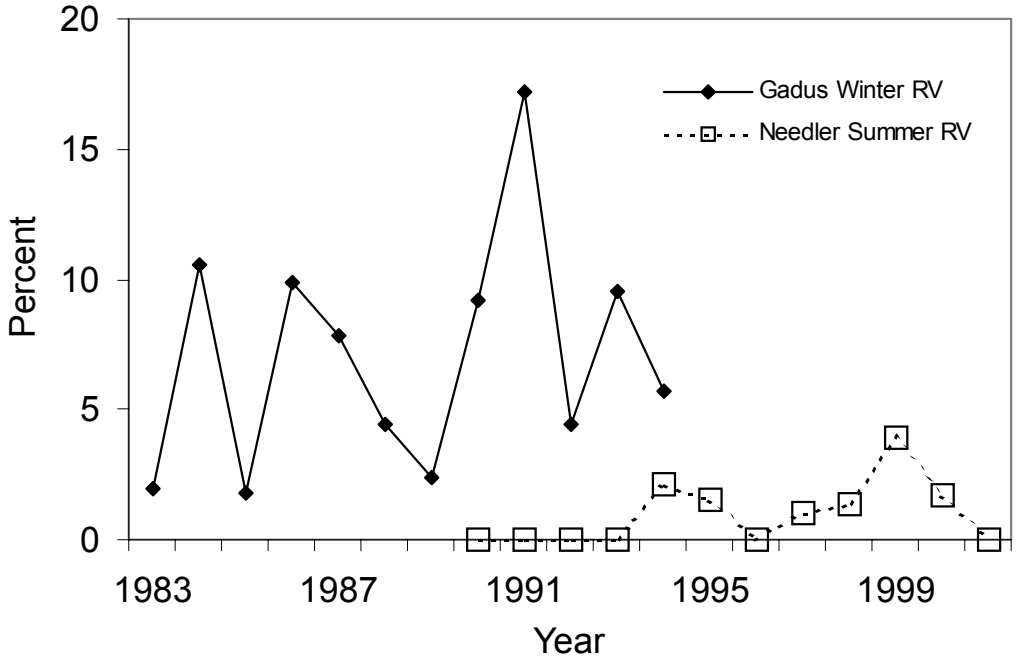

Figure 6. Percent occurrence of winter skate from the RV surveys in the Div. 3Pn, 4RS and part of 4T.

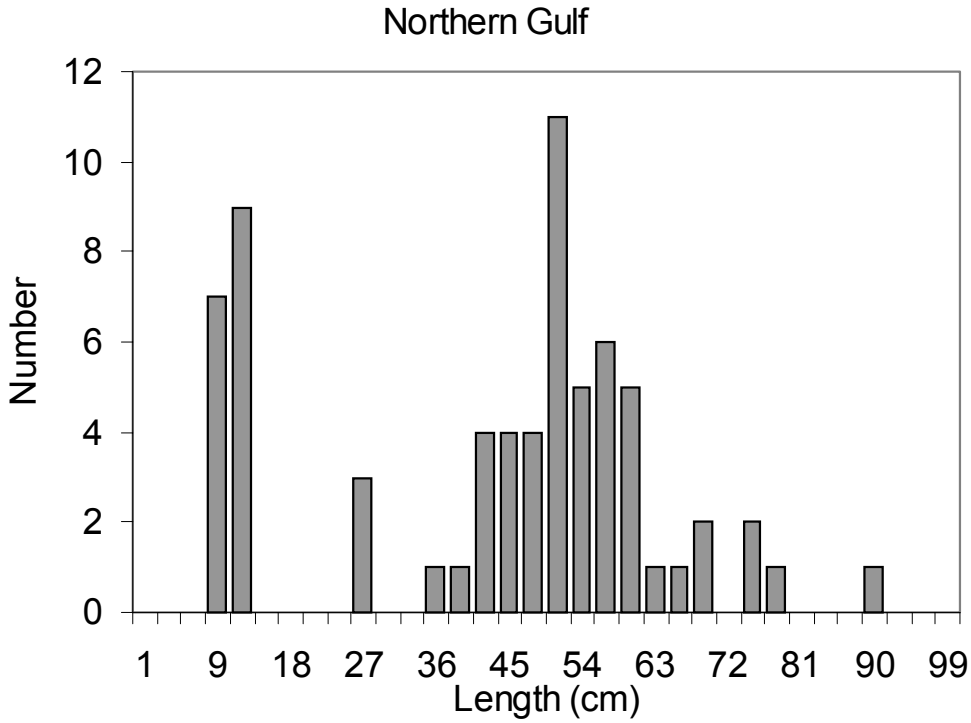

Figure 7. Combined length frequency of winter skate from the RV surveys in Div. 3Pn 4RS and part of 4T.

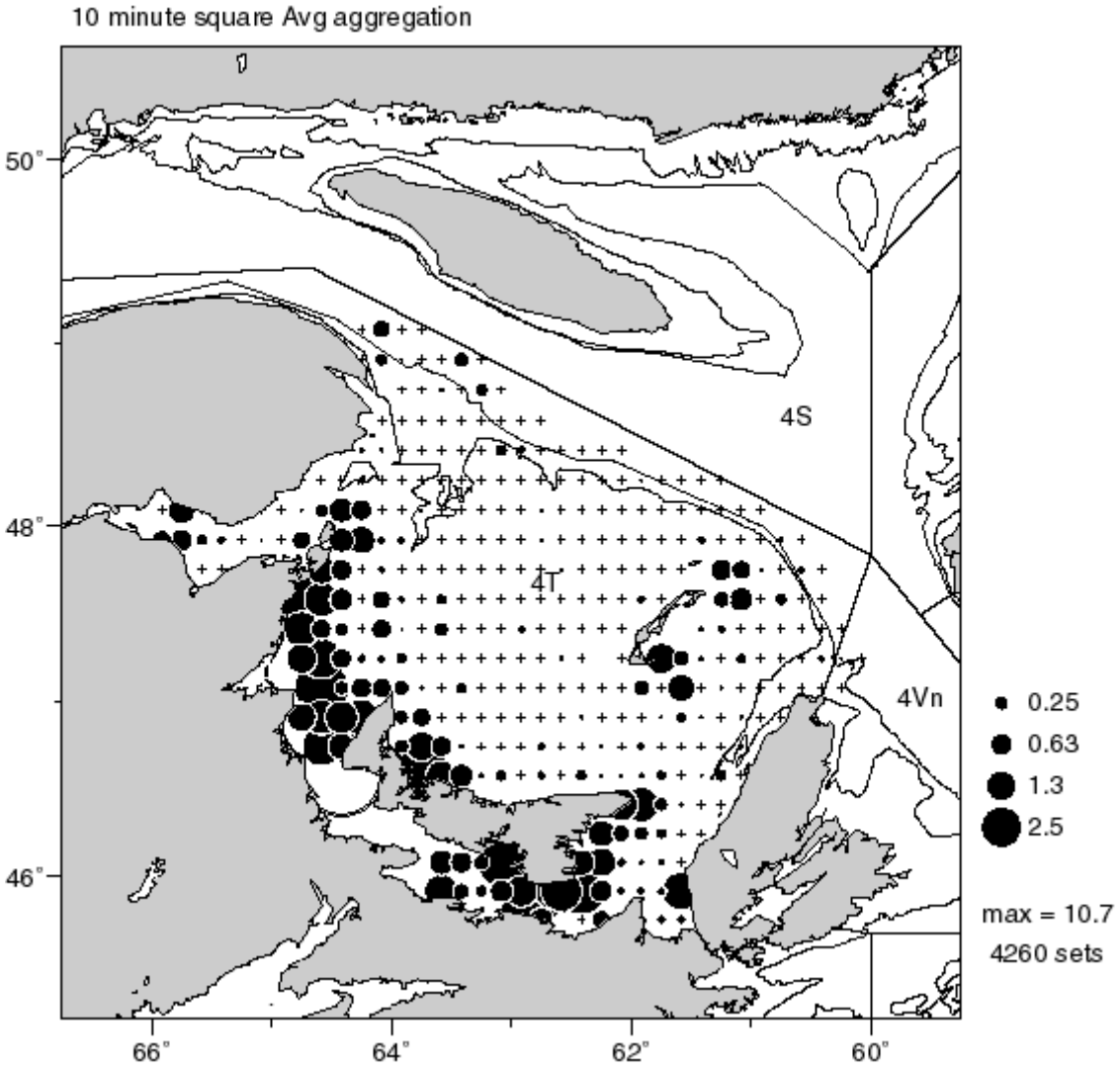

Figure 8. Distribution of winter skate from the fall RV survey in Div. 4T, 1971-2002.

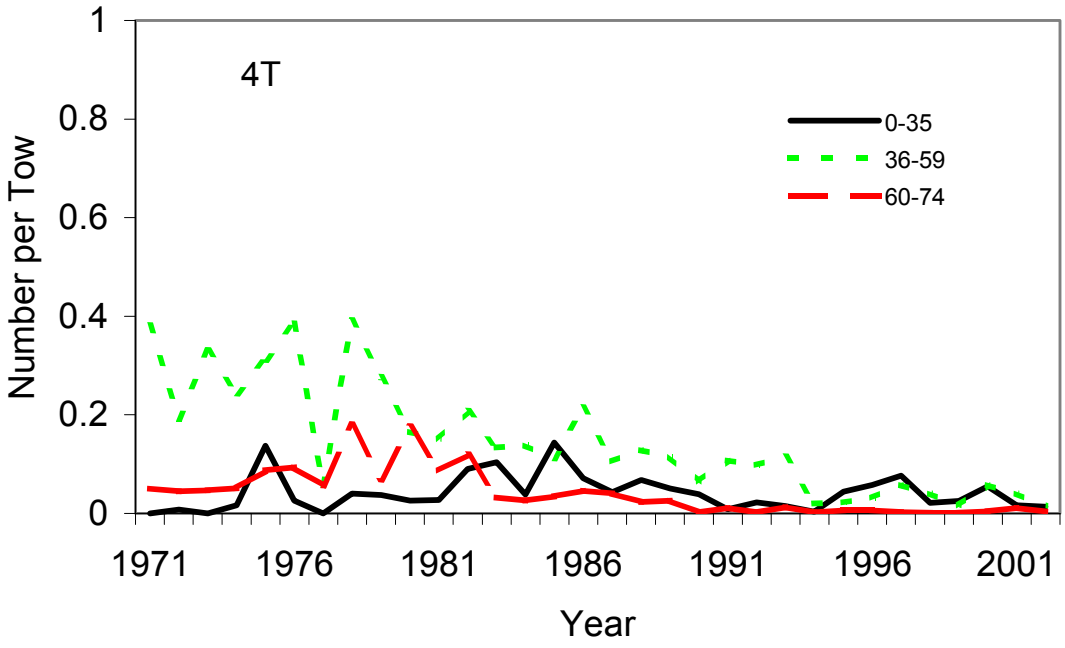

Figure 9. Stratified mean number per tow by length groupings of winter skate from the fall RV survey in Div. 4T.

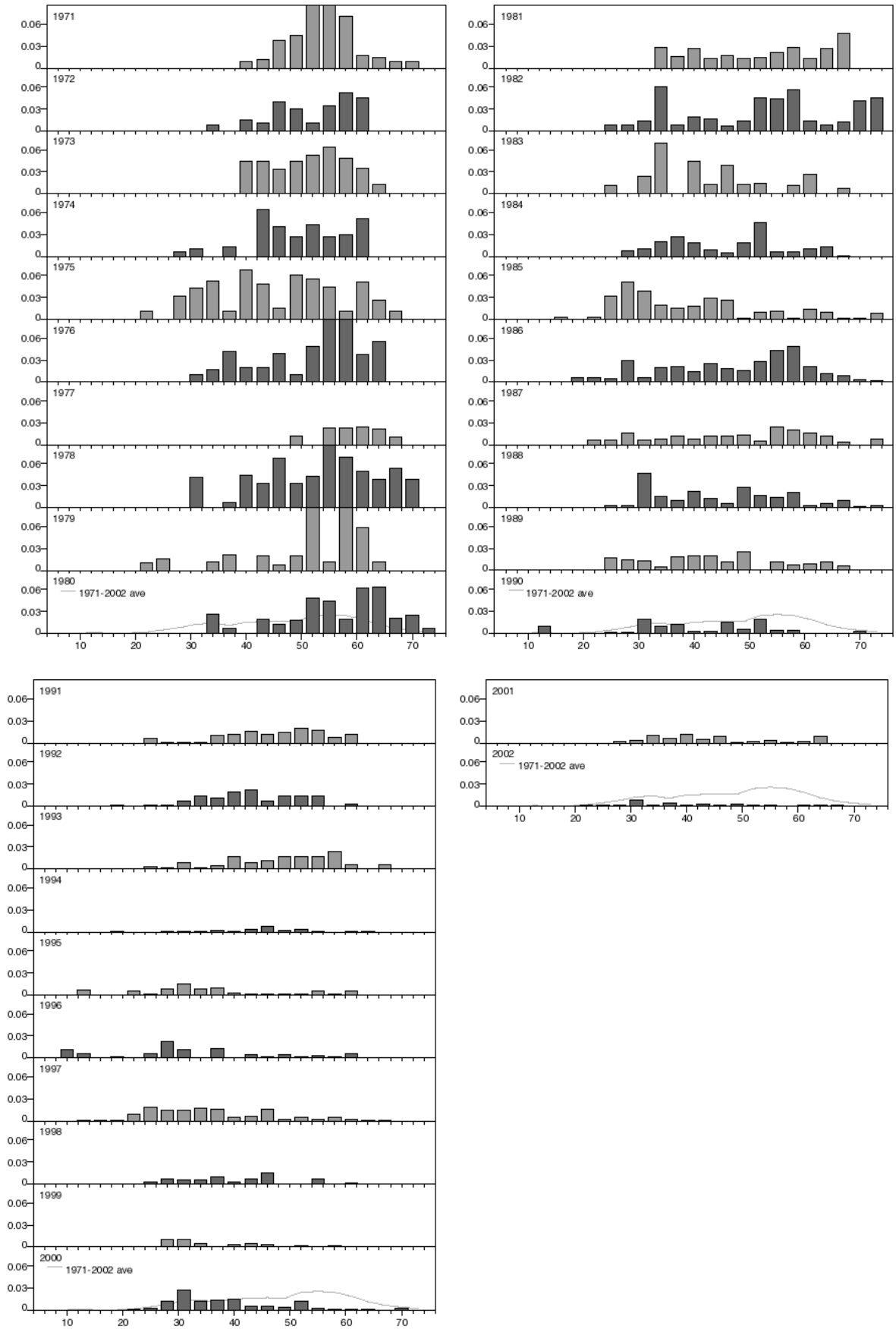

Figure 10. Catch numbers at length from the Div. 4T Fall RV survey. The line represents the 1971-2002 average.

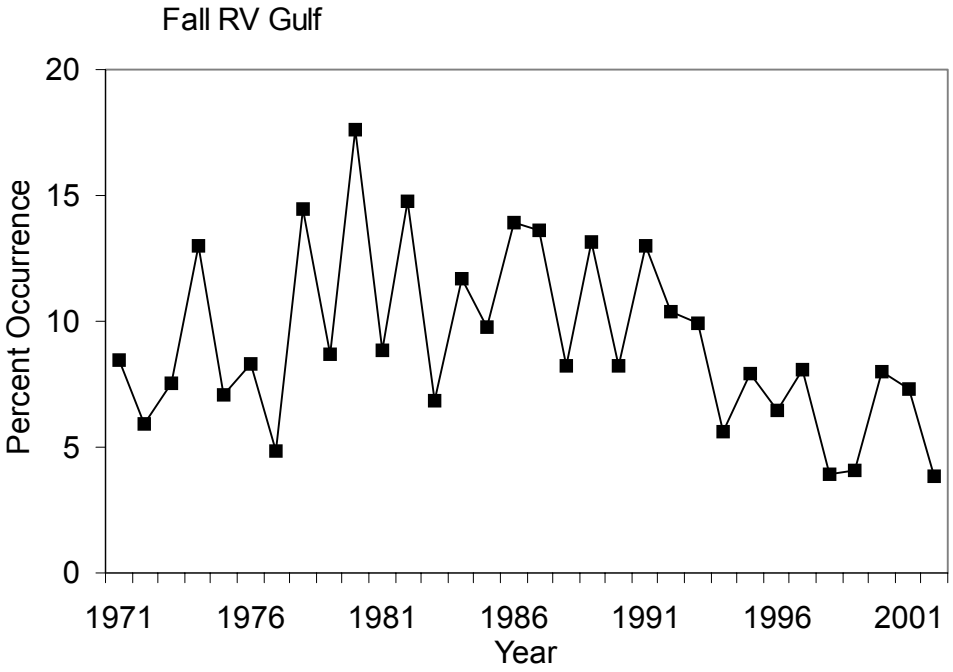

Figure 11. Stratified mean percent occurrence (area occupied) of winter skate from the Fall RV survey in the southern Gulf of St. Lawrence (Div. 4T).

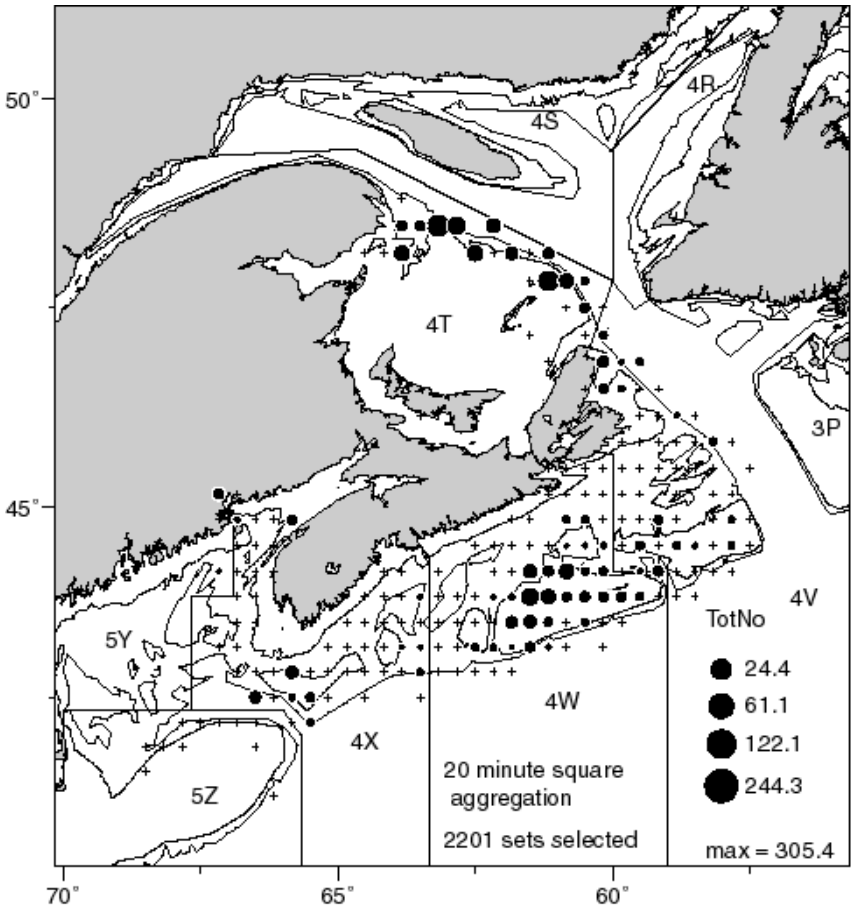

Figure 12. Distribution of winter skate (#/tow) from the pre-1970's research vessel surveys aggregated by 20 minute squares.

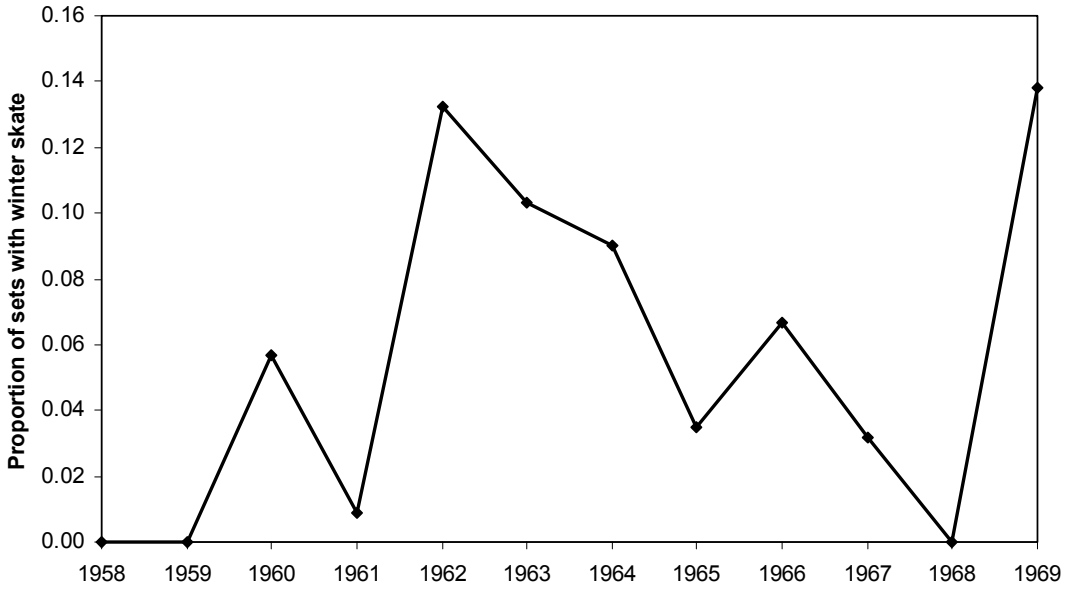

Figure 13. Proportion of sets in all pre-1970's surveys where winter skate were caught.

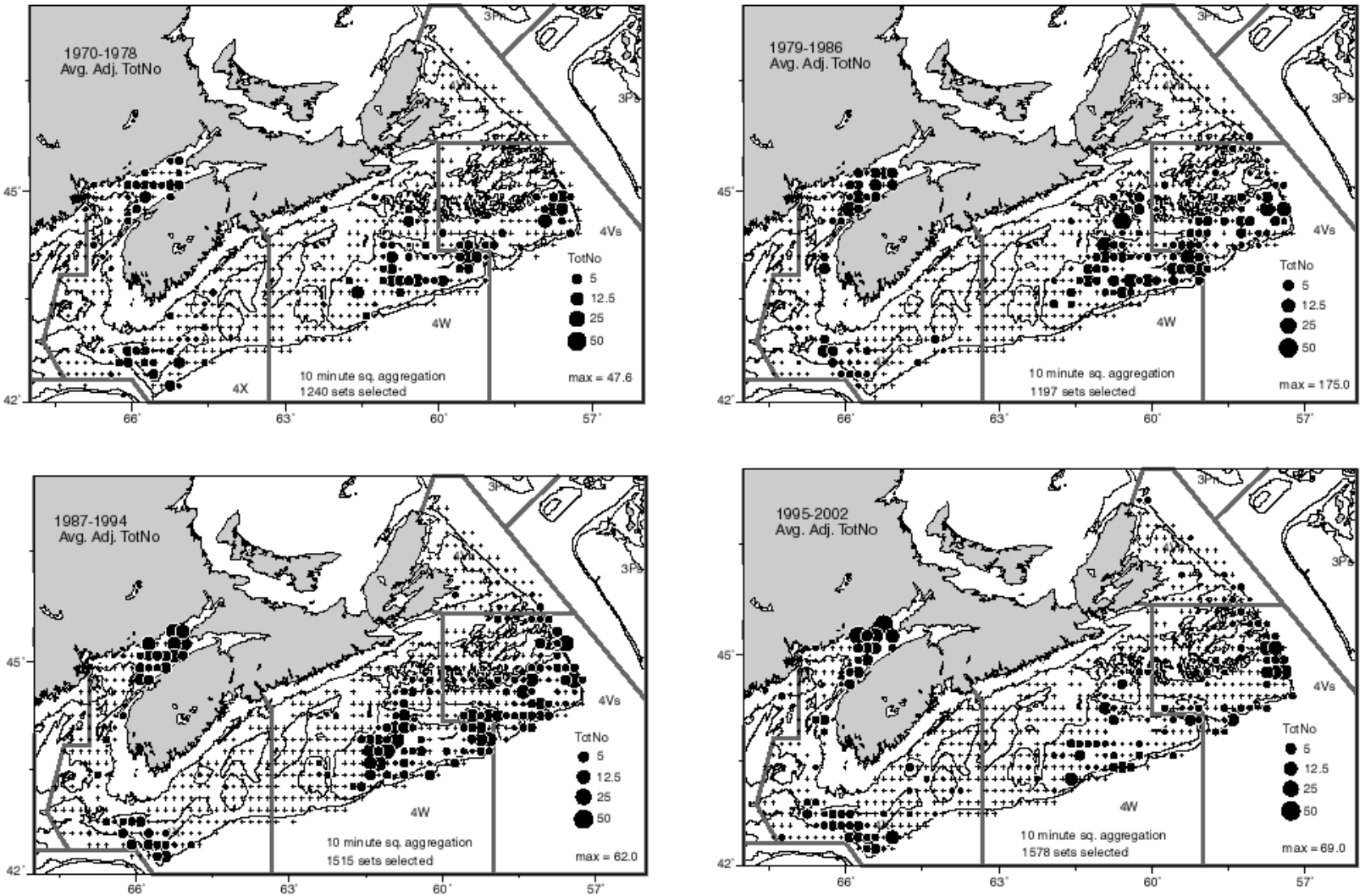

Figure 14. Distribution of winter skate (#/tow) from the summer RV surveys (1970-2002), average catch aggregated into eight year time blocks.

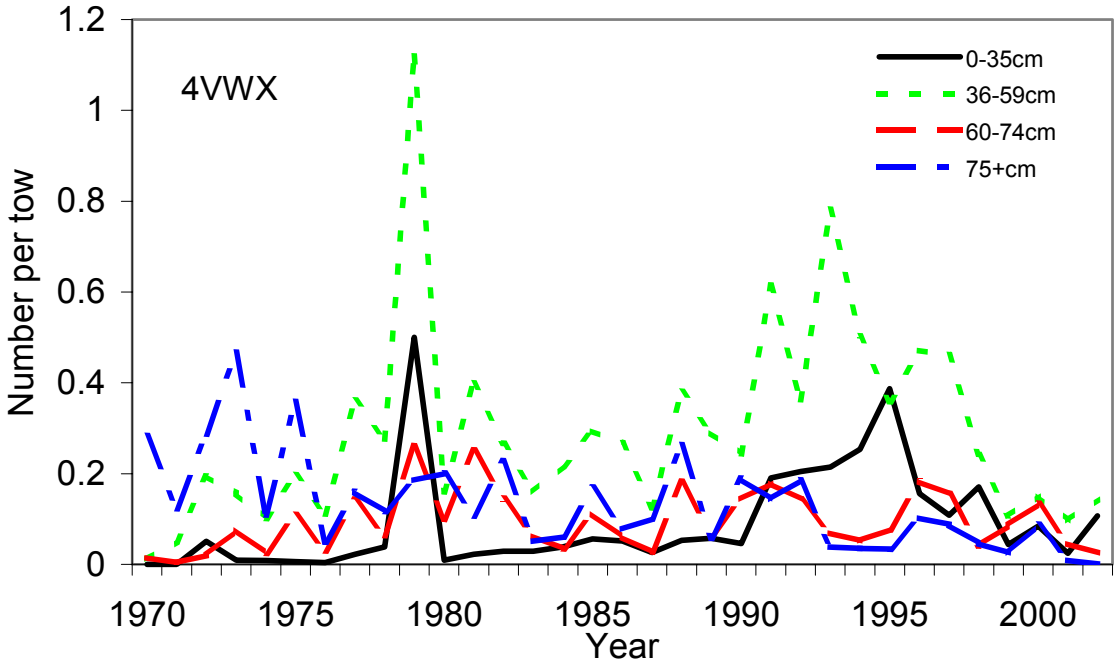

Figure 15. Stratified mean number per tow by length groupings of winter skate from the summer RV survey in Div. 4VWX.

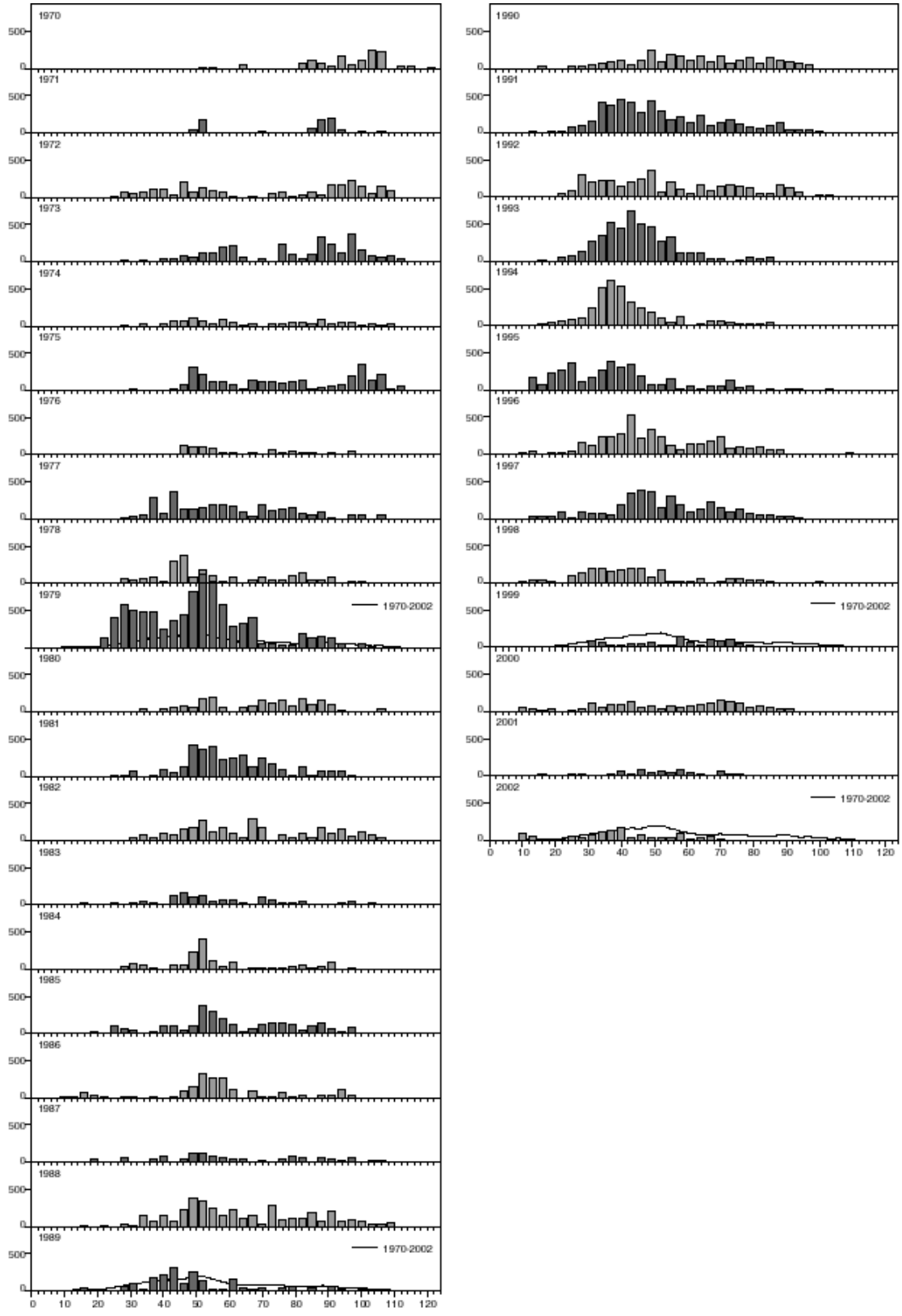

Figure 16. Annual catch numbers at length from the summer RV survey in Div. 4VWX. The line represents the 1970-2002 average value.

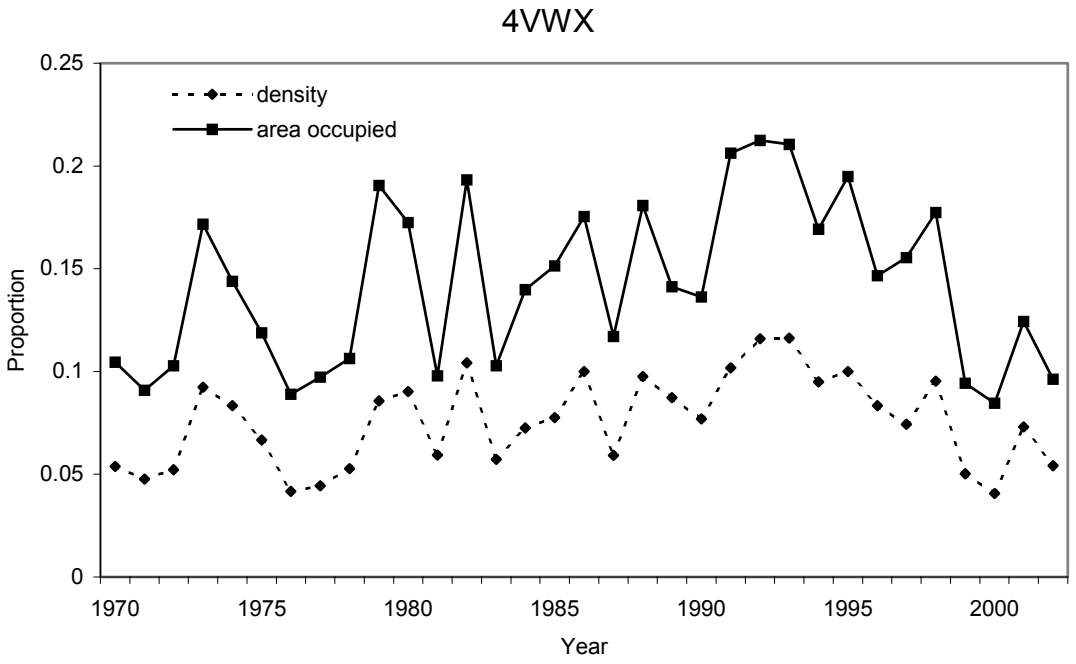

Figure 17. Distribution indices (area occupied and resource concentration) of winter skate from the summer RV survey on the Scotian Shelf.

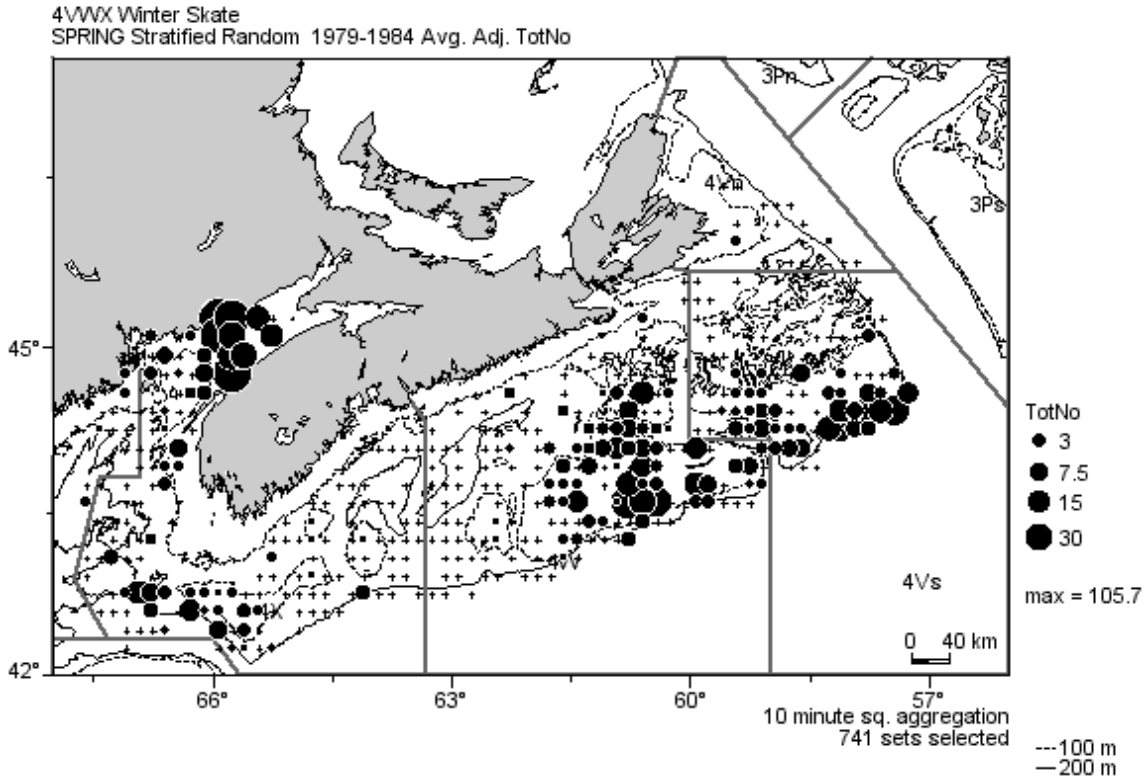

Figure 18: Distribution of winter skate (#/tow) from the Spring Research survey (1979-1984), average catch aggregated for all years.

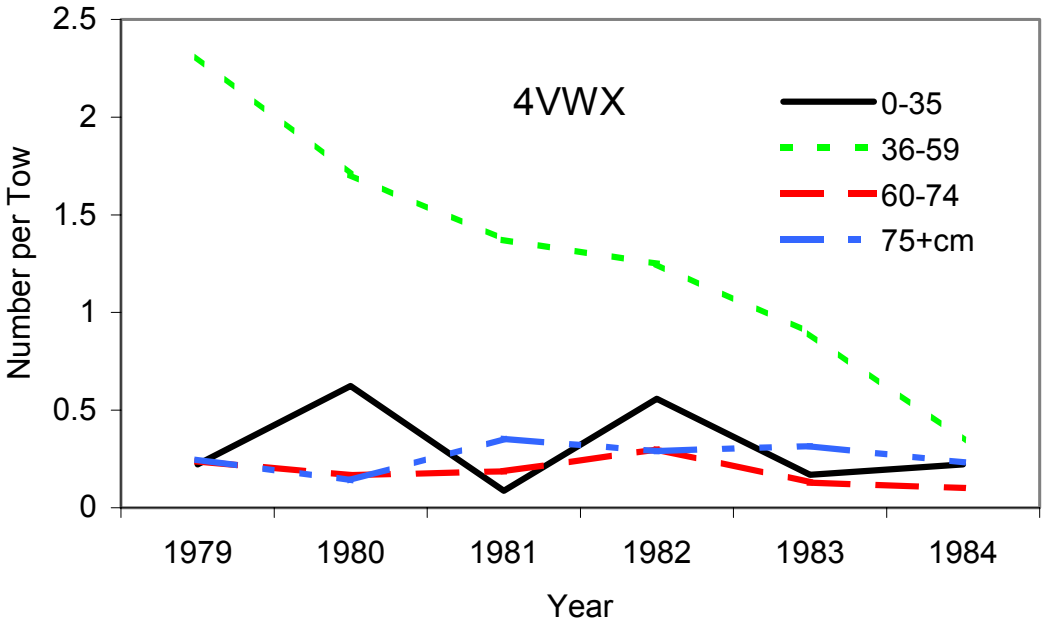

Figure 19. Stratified mean number per tow by length groupings of winter skate from the spring RV survey in Div. 4VWX

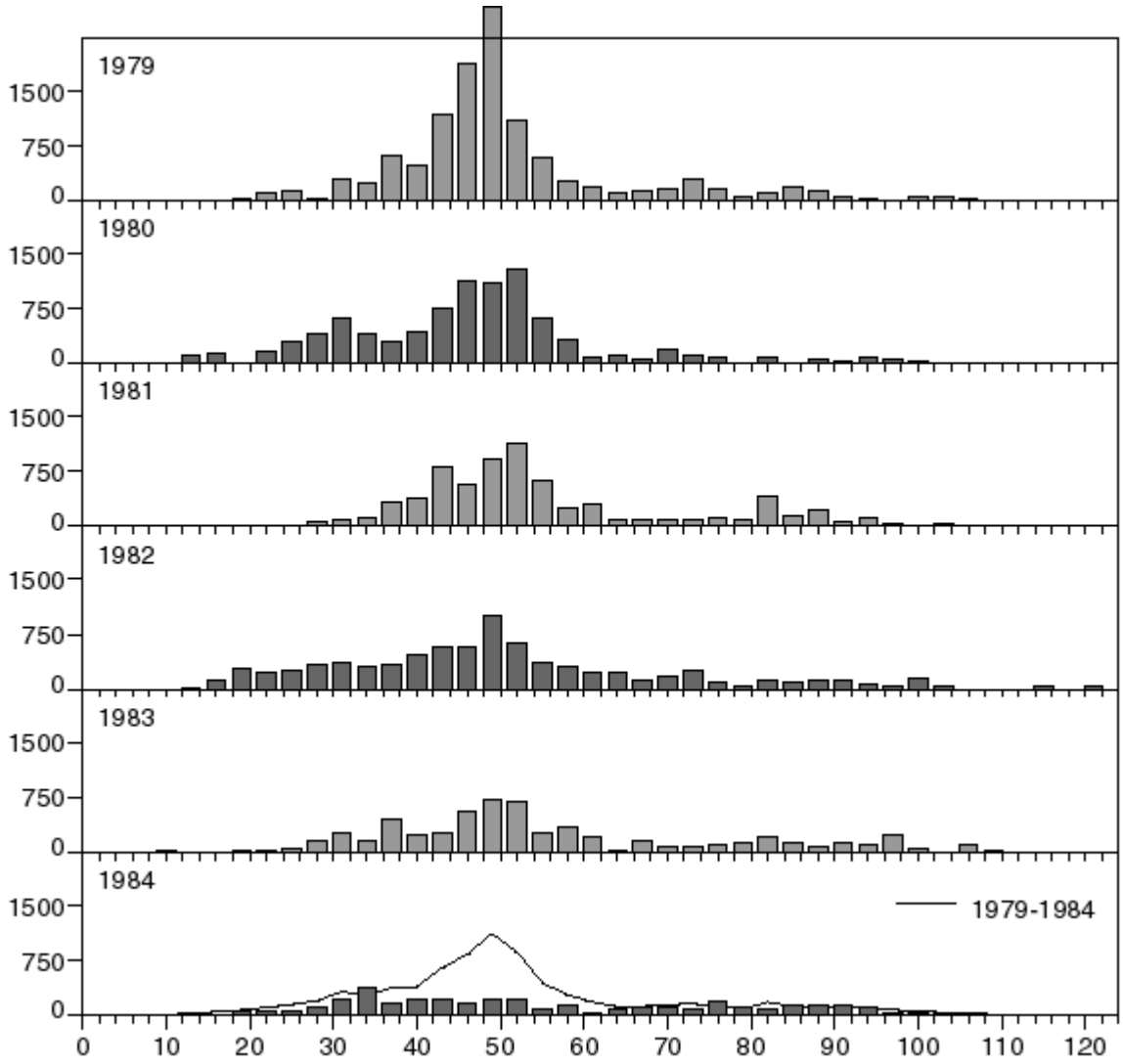

Figure 20. Annual catch numbers at length from the spring RV survey in Div. 4VWX. The line represents the 1979-1984 average value.

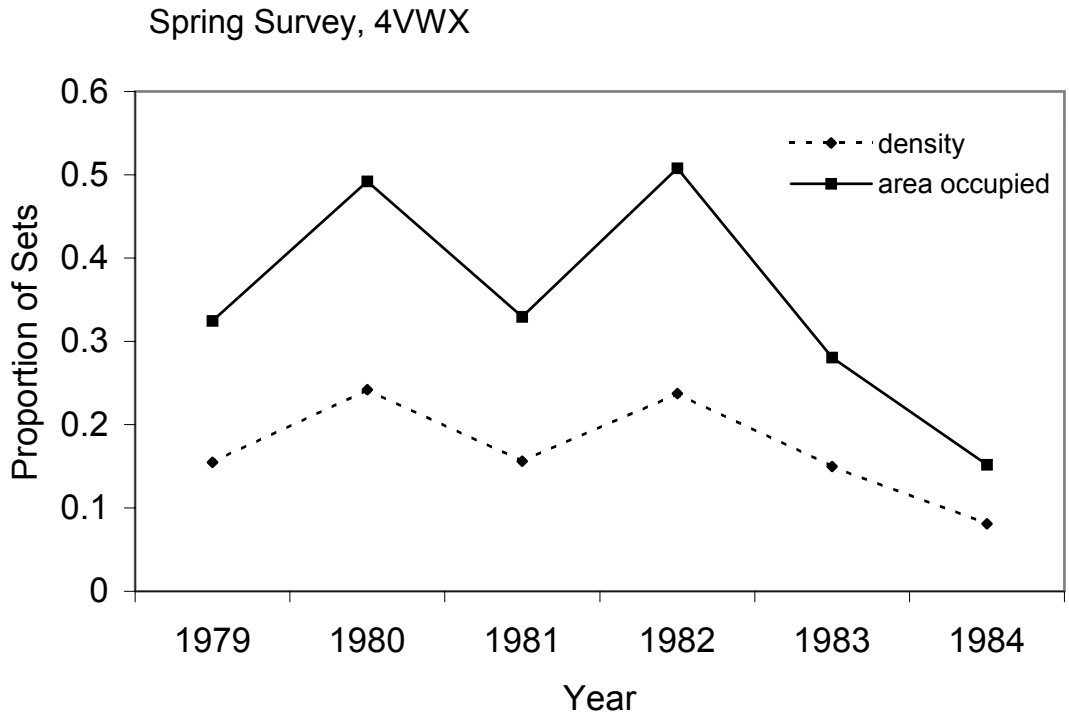

Figure 21. Distribution indices (area occupied and resource concentration) of winter skate from the spring RV survey on the Scotian Shelf.

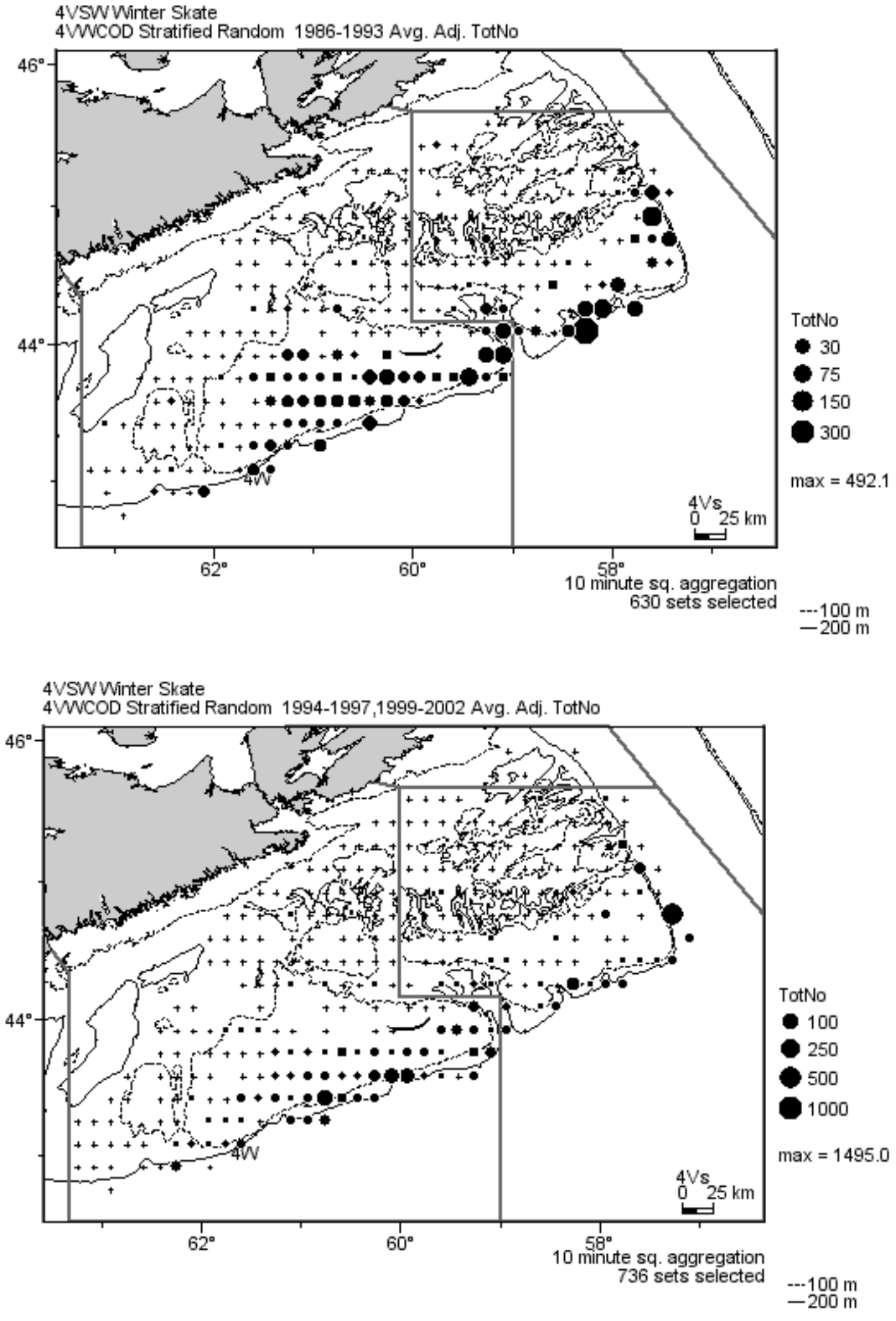

Figure 22: Distribution of winter skate (#/tow) from the 4VWCOD RV survey (1987-2002), average catch aggregated into eight-year time blocks.

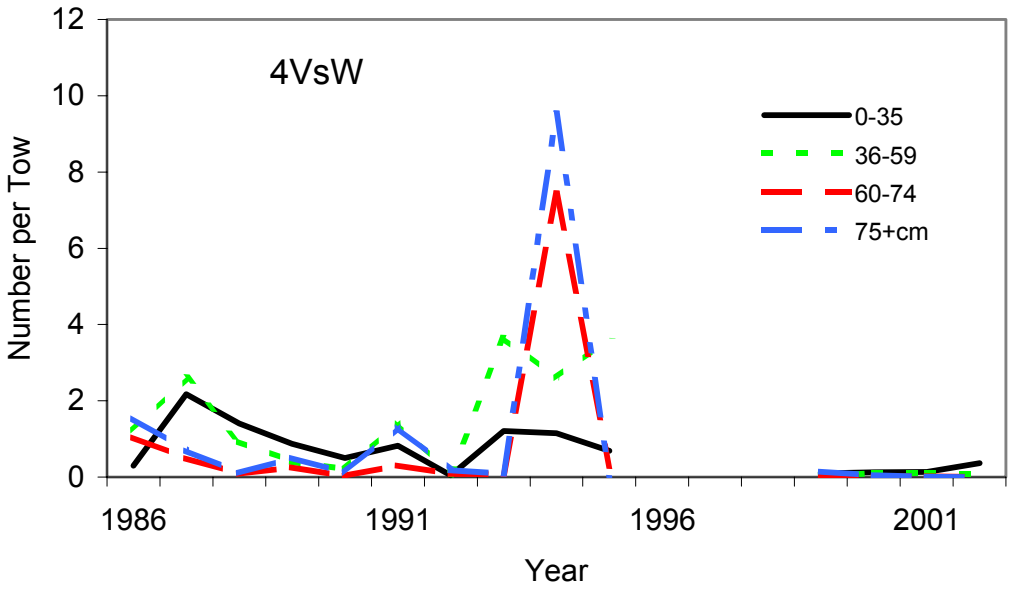

Figure 23. Stratified mean number per tow by length groups of winter skate from the 4VWCOD RV (1986 – 2002) surveys in Div 4VsW.

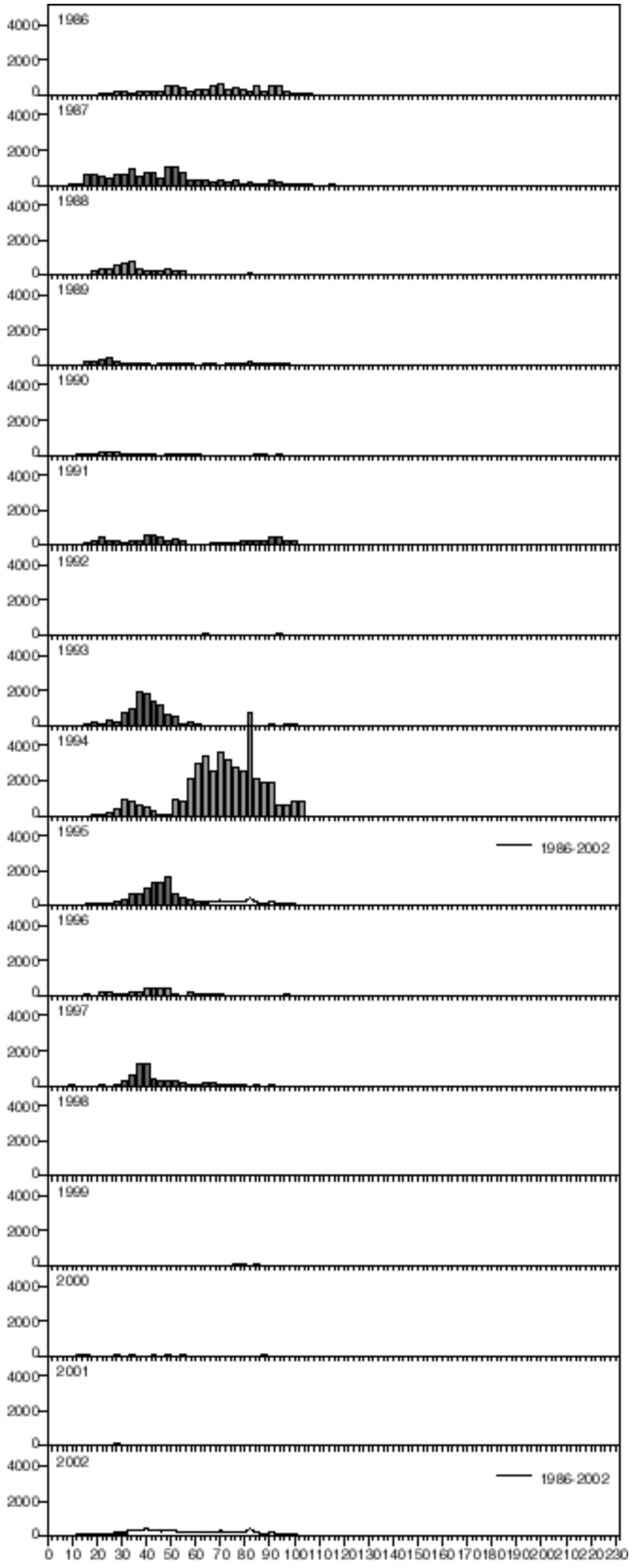

Figure 24. Annual catch numbers at length of winter skate from the 4VWCOD RV survey in Div. 4VsW.

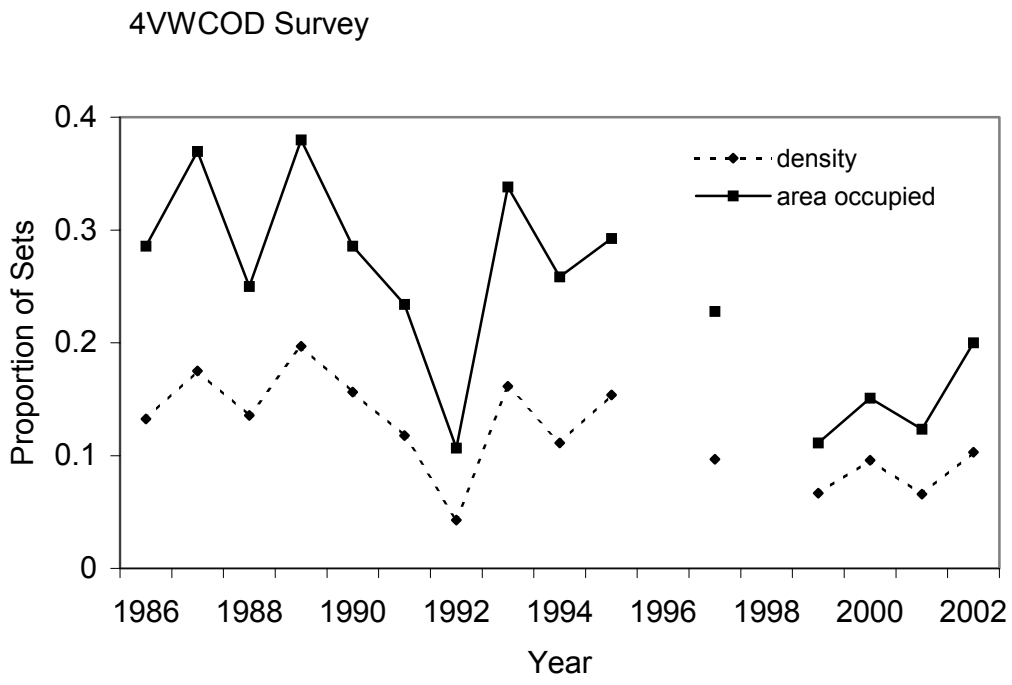

Figure 25. Distribution indices (area occupied and resource concentration) of winter skate from the 4VWCOD RV surveys on the Scotian Shelf.

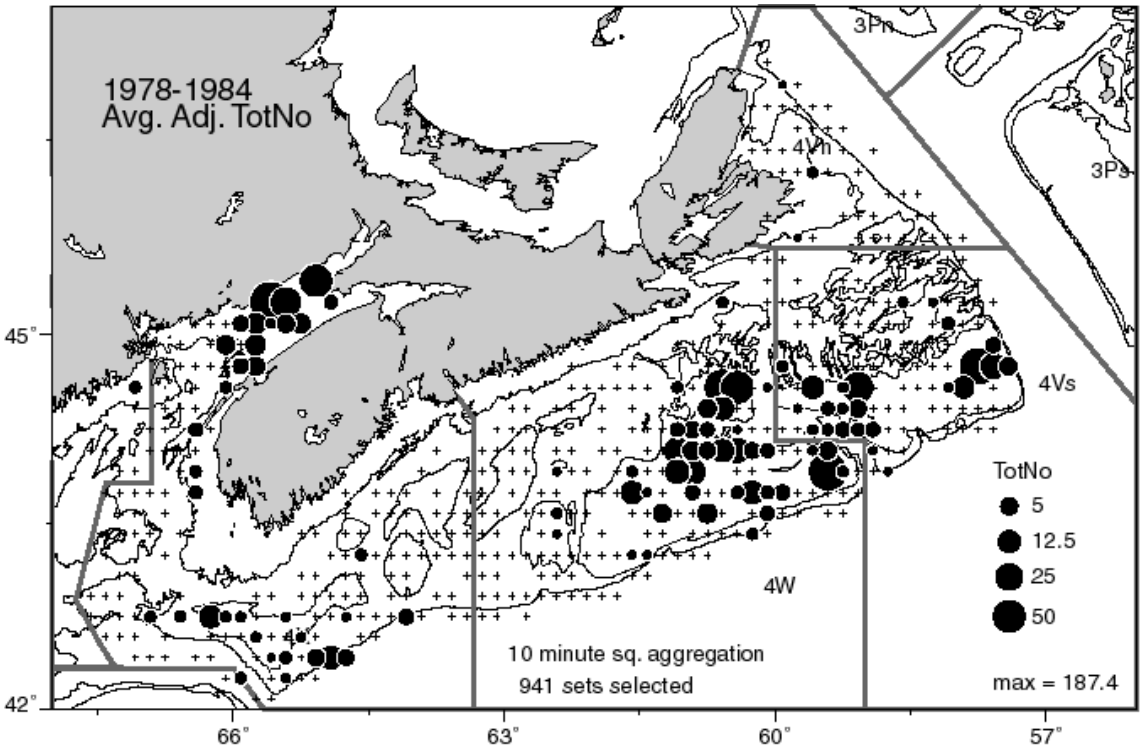

Figure 26. Distribution of winter skate (#/tow) from the Fall Research survey (1978 – 1984), average catch aggregated for all years.

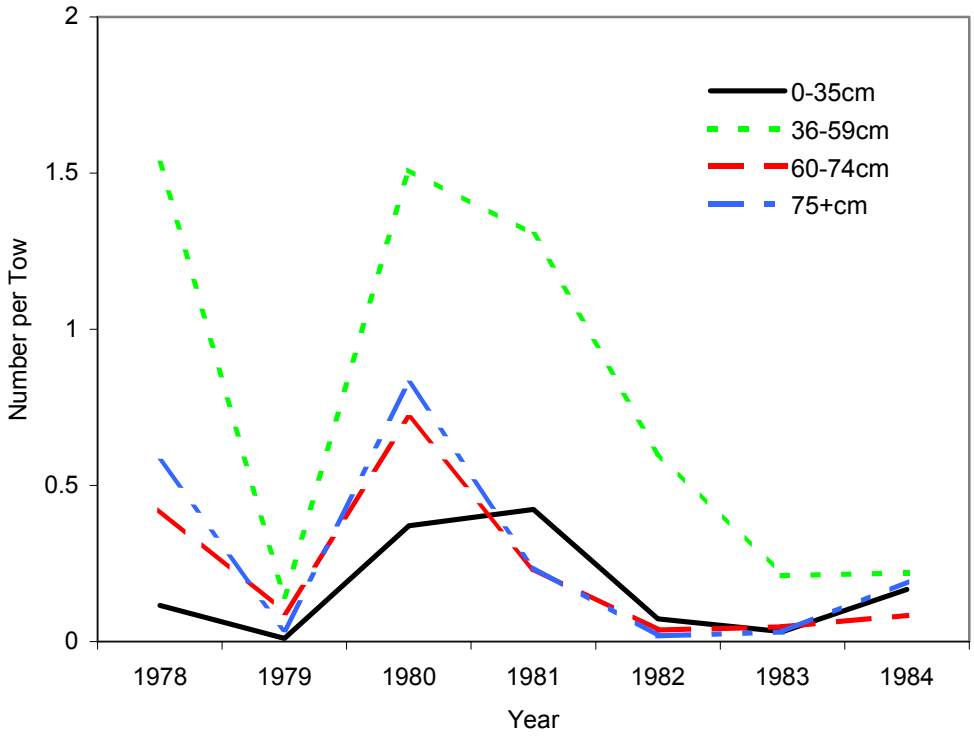

Figure 27. Stratified mean number per tow by length groupings of winter skate from the Fall RV survey in Div. 4VWX.

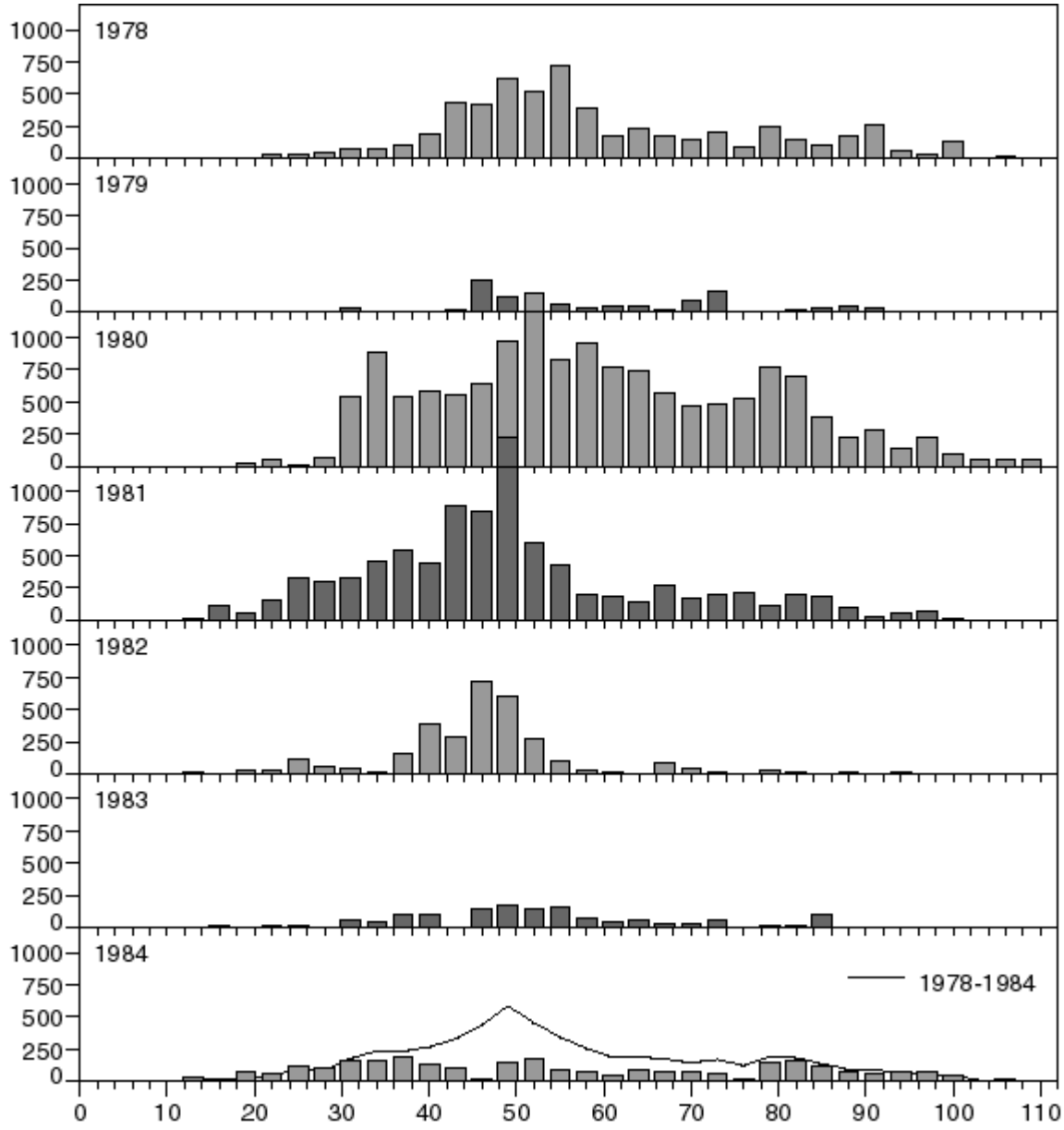

Figure 28. Annual catch numbers at length of winter skate from the Fall RV survey in Div. 4VWX. The line represents the 1978-1984 average value.

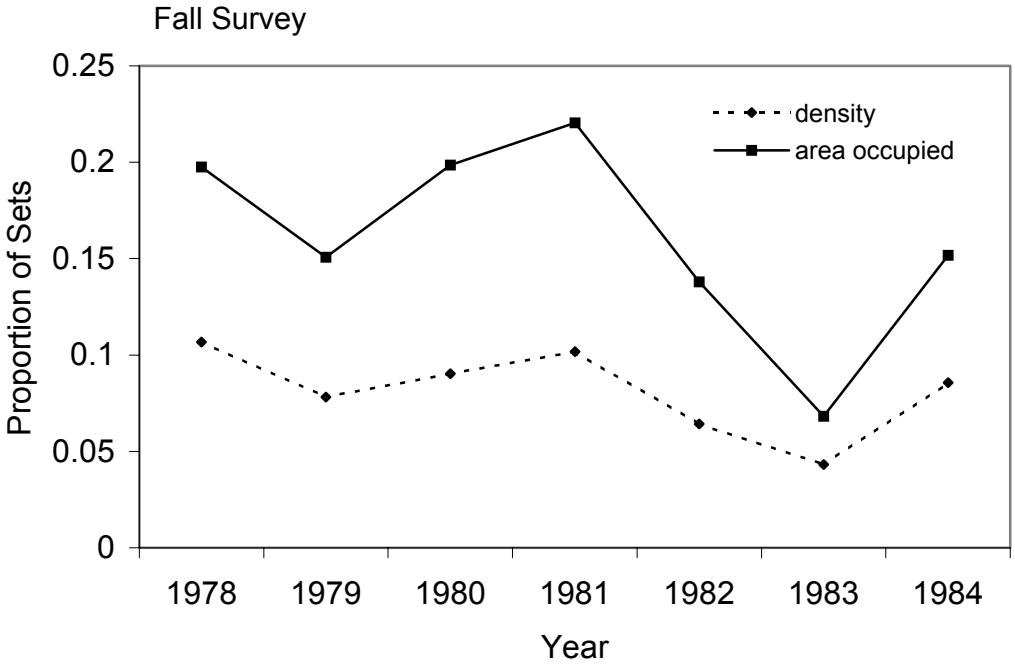

Figure 29. Distribution indices (area occupied and resource concentration) of winter skate from the Fall RV survey in Div. 4VWX.

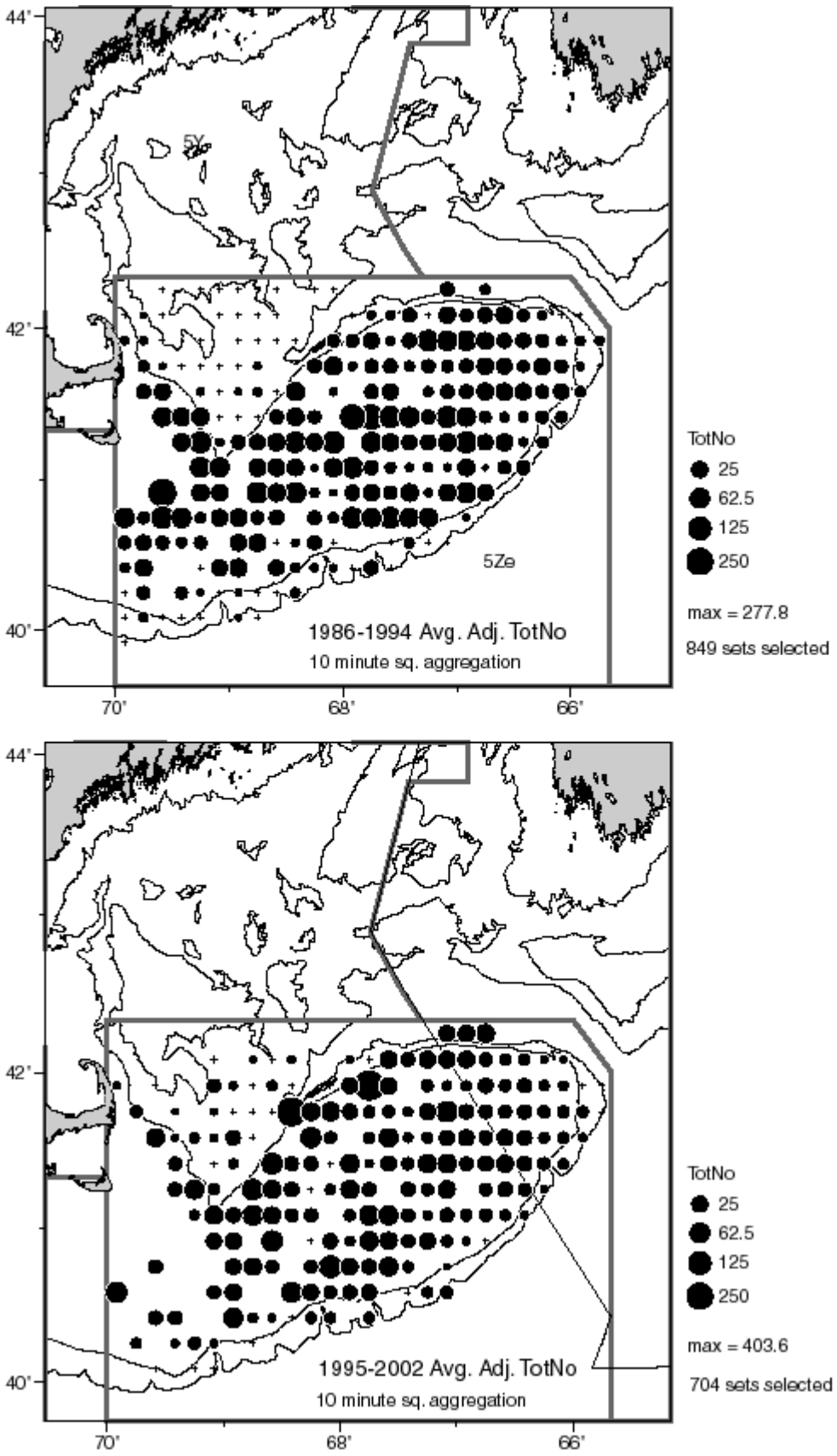

Figure 30. Distribution of winter skate (#/tow) from the Georges Bank survey (1986 – 2002), average catch aggregated into eight year time blocks.

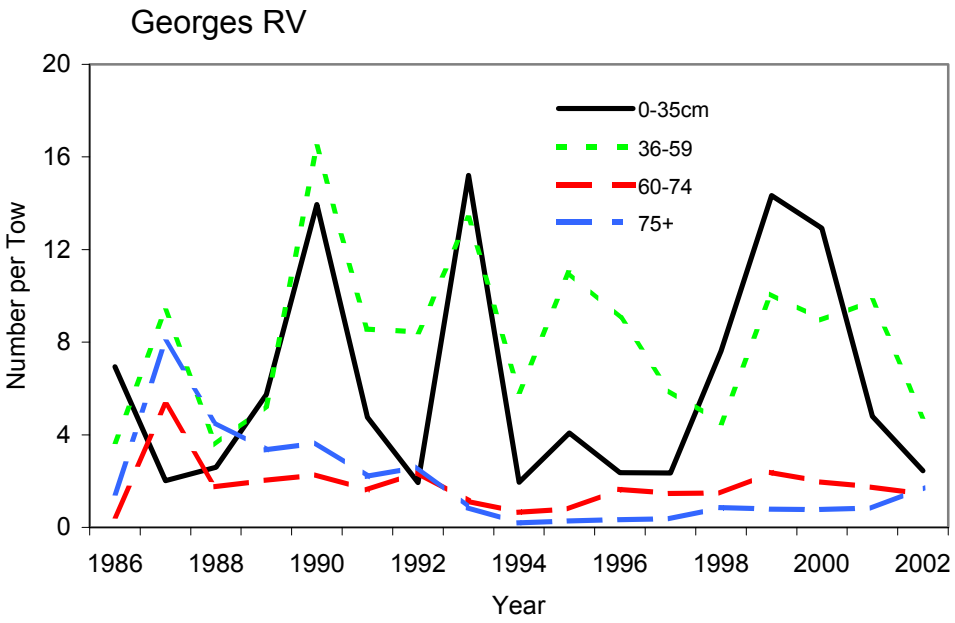

Figure 31. Stratified mean number per tow by length groups from the Georges Bank RV survey in Div. 5Z.

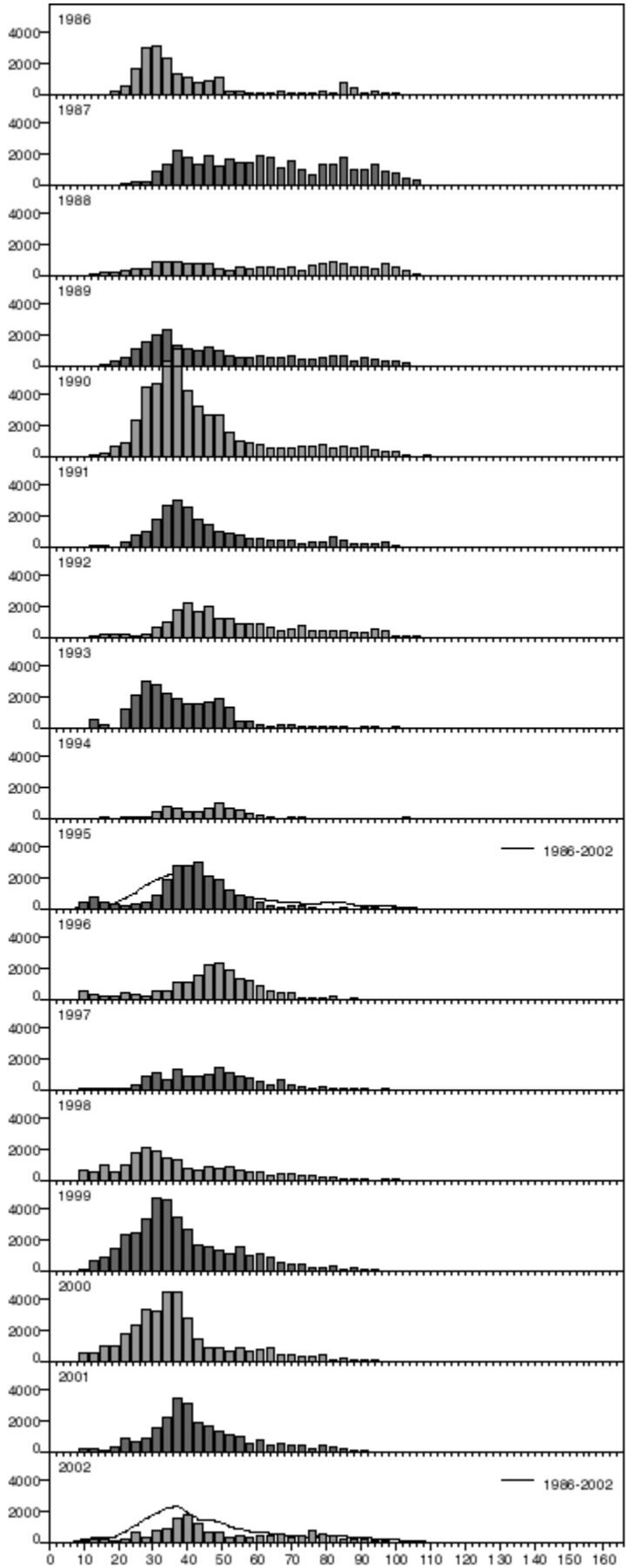

Figure 32. Annual catch numbers at length of winter skate from the Georges Bank RV survey in Div. 5Z. The line represents the 1986-2002 average value.

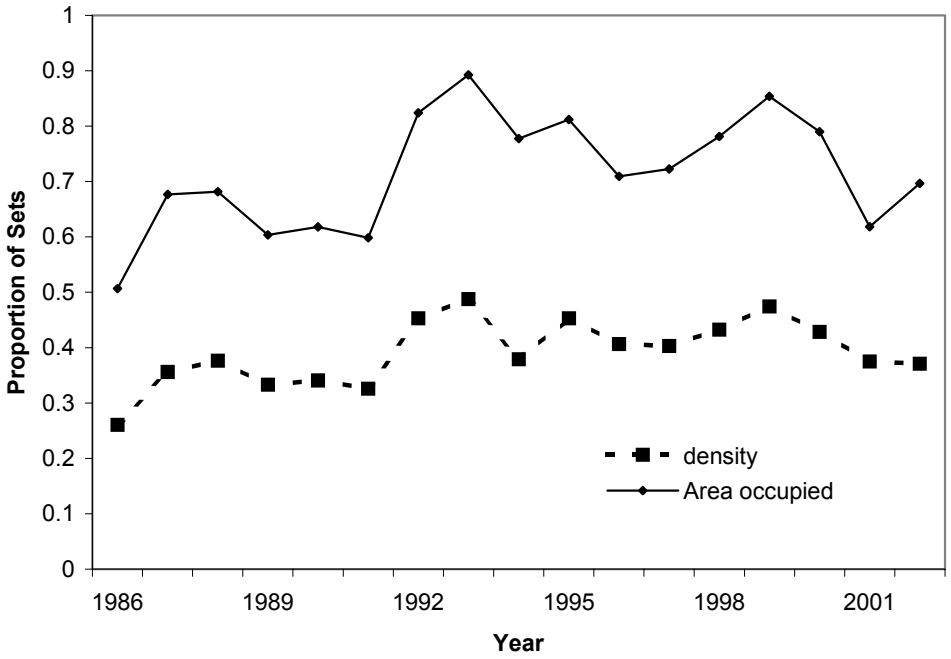

Figure 33. Distribution indices (area occupied and resource concentration) of winter skate from the RV surveys on Georges Bank, Div.5Z

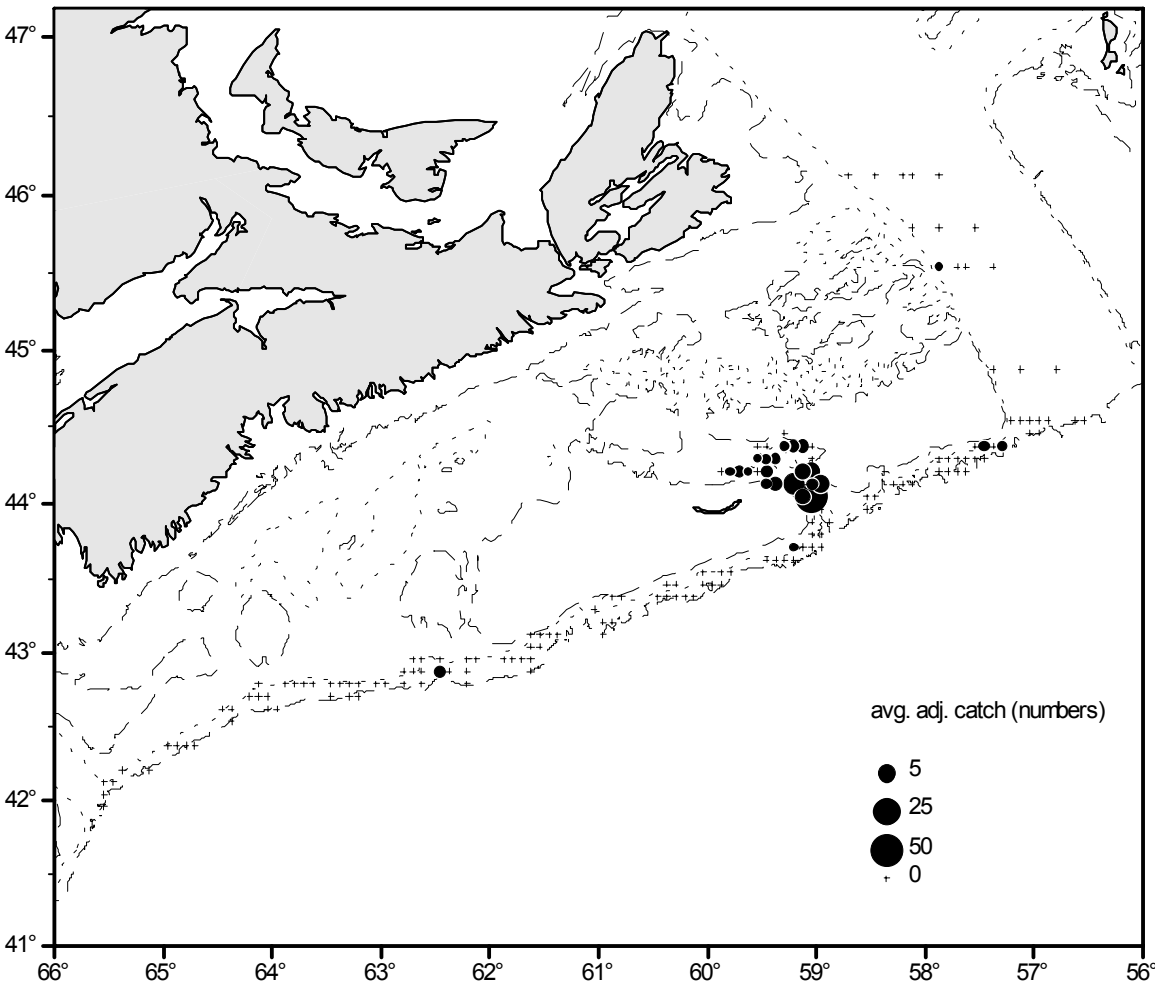

Figure 34. Distribution of winter skate catches in number per tow in the deep-sea redfish surveys averaged for all years (1982-1988) and aggregated by 5 m².

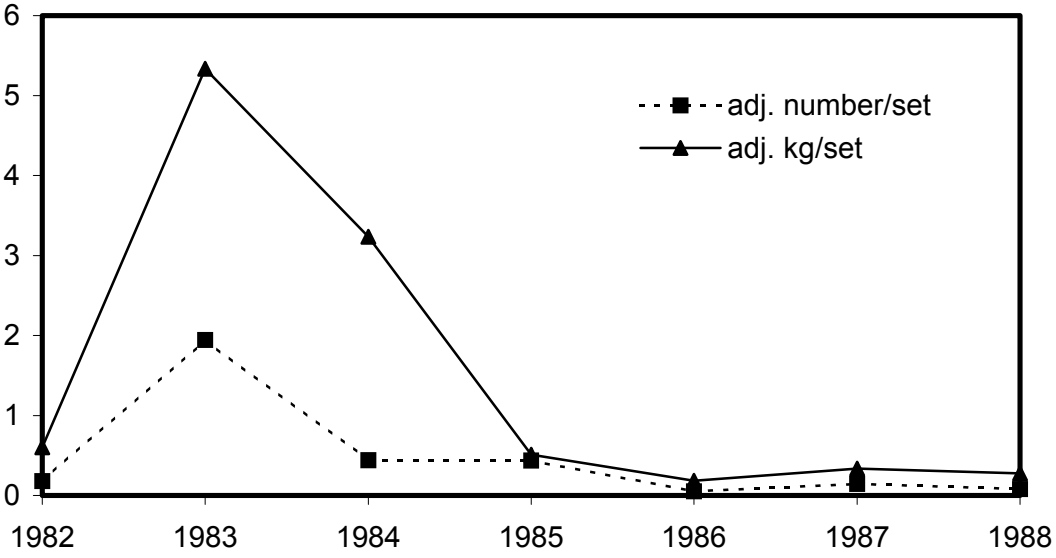

Figure 35. Average catches of winter skate (kg/tow) in the deep-sea redfish survey, 1982-1988.

Industry Surveys

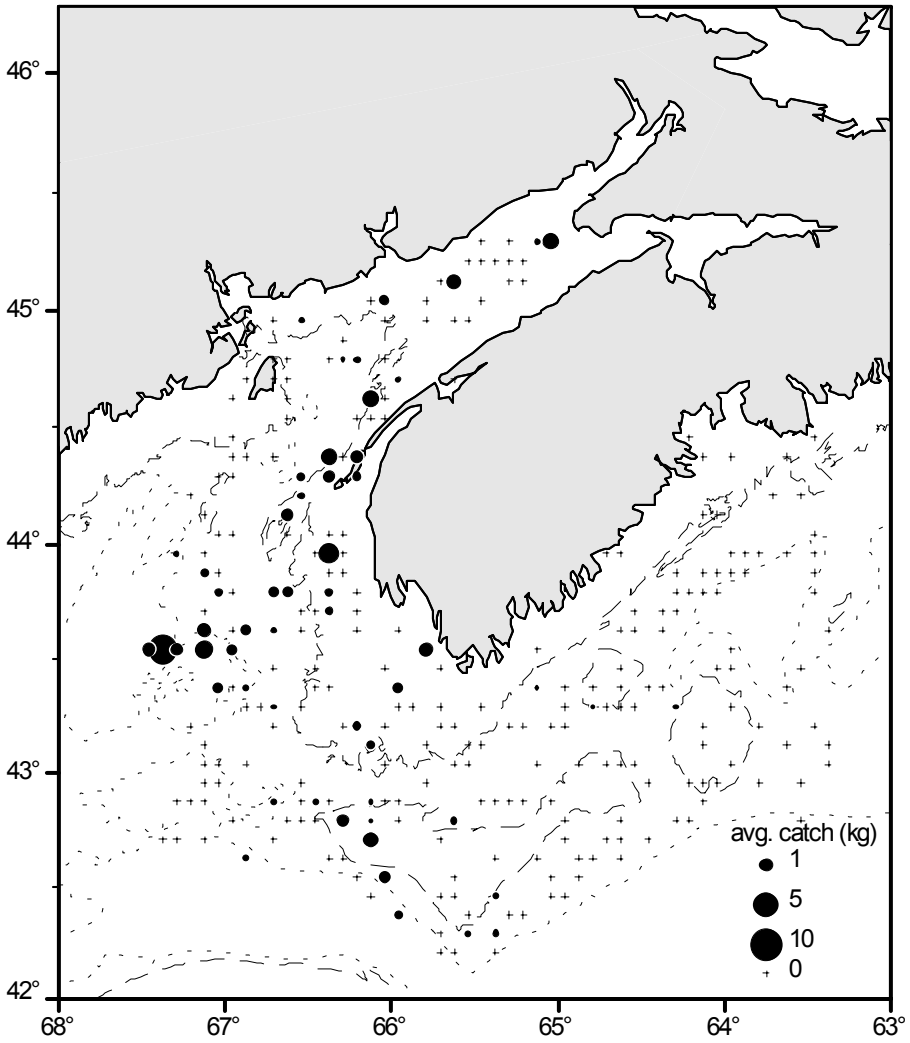

Figure 36. Distribution of winter skate catches in kilograms in the ITQ survey, averaged for all years and aggregated by 5 m².

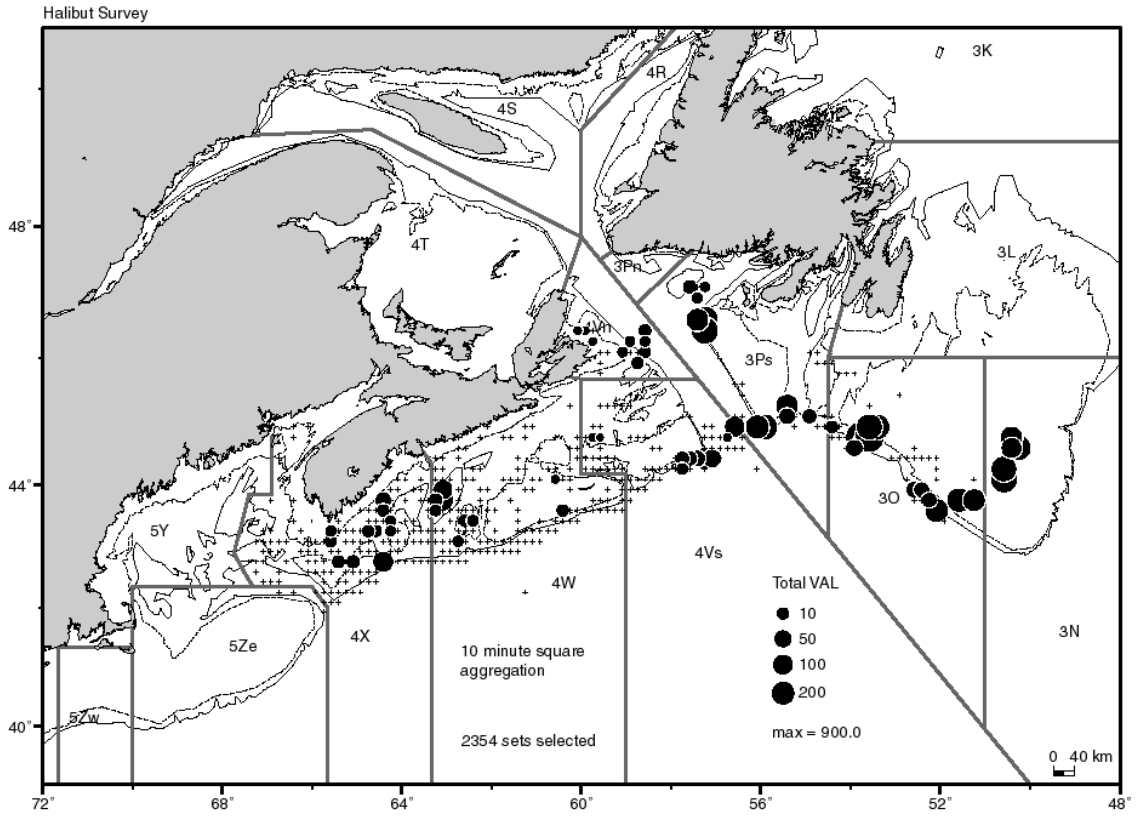

Figure 37. Distribution of winter skate from the industry halibut survey in Div. 3OP4VWX.

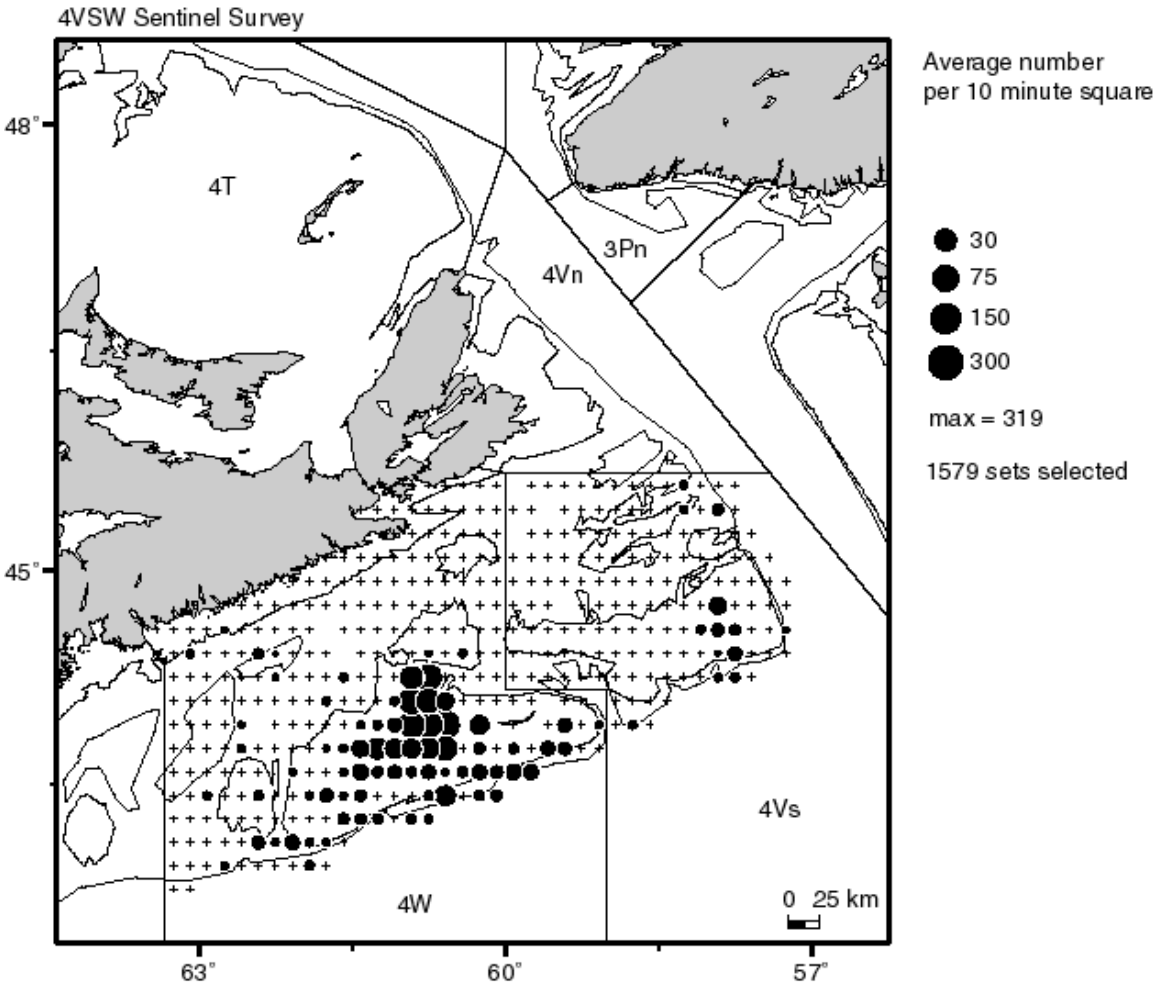

Figure 38. Distribution of winter skate from the Sentinel survey in Div. 4VsW, 1996-2001.

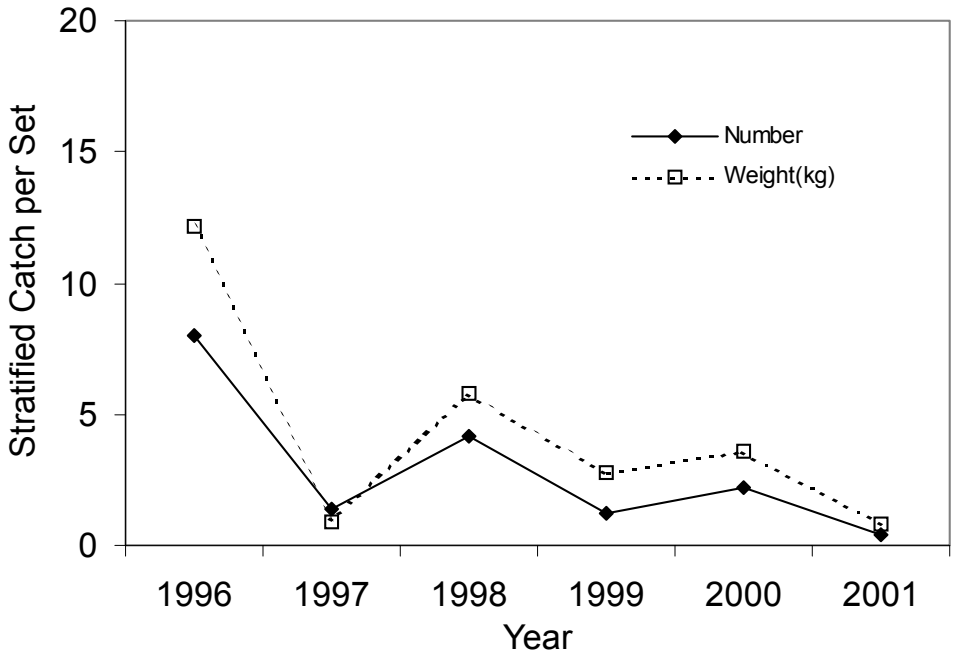

Figure 39. Stratified catch per set of winter skate from the Sentinel Survey in Div. 4VsW.

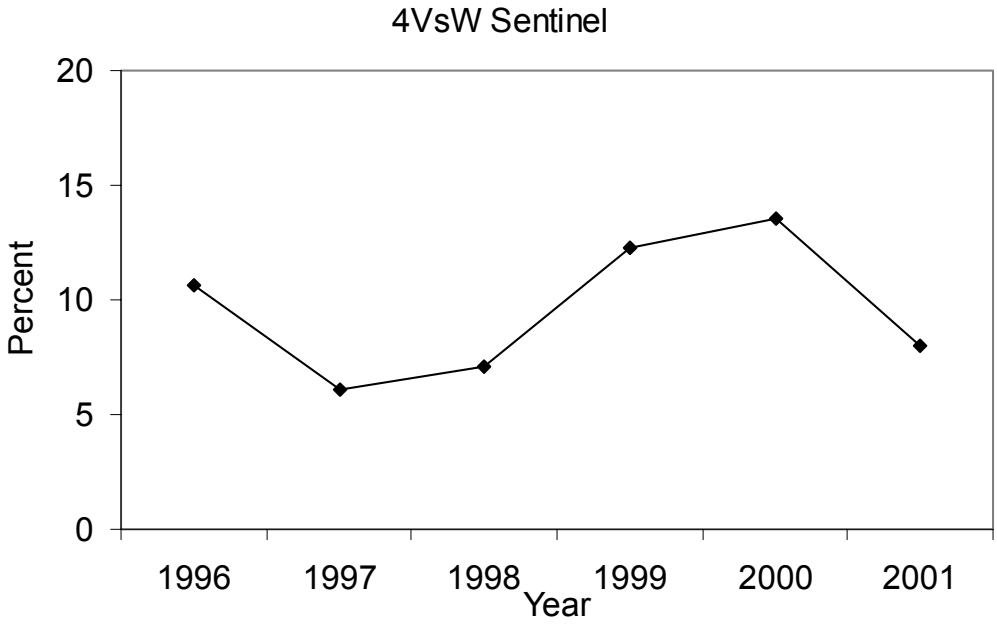

Figure 40. Percent occurrence of winter skate from the Sentinel Survey in Div. 4VsW.

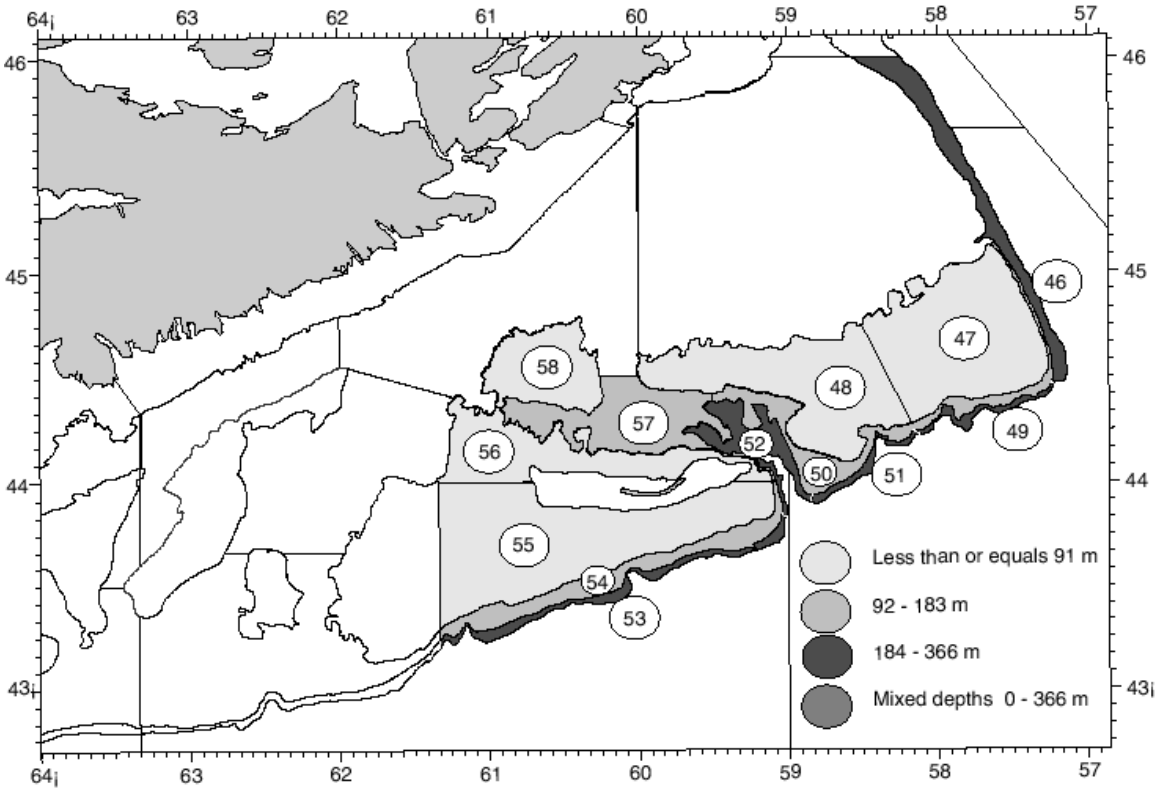

Figure 41. Summer RV groundfish strata surveyed by the joint industry/science skate surveys.

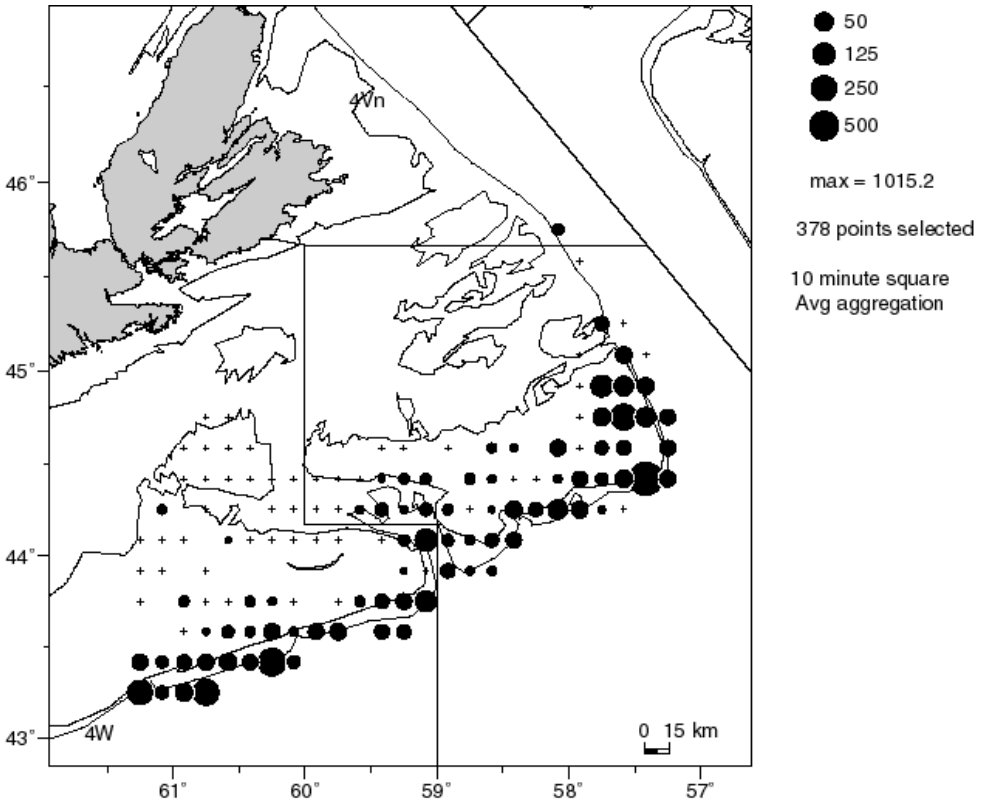

Figure 42. Distribution of winter skate from spring skate industry/science survey, 1995-2002.

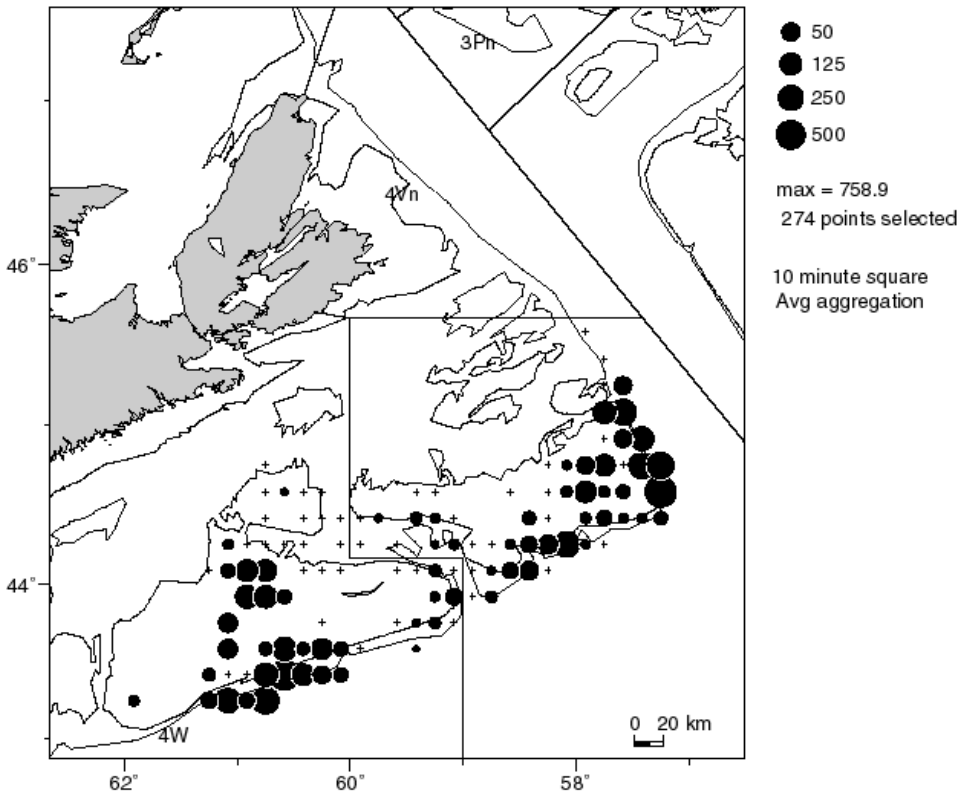

Figure 43. Distribution of winter skate from the fall skate industry/science survey, 1995-1999.

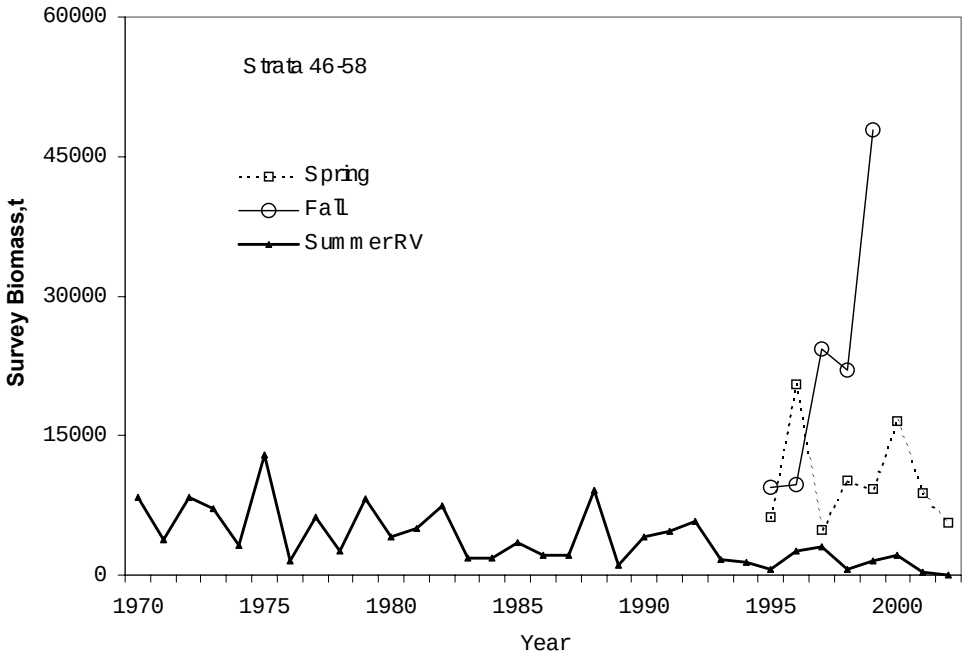

Figure 44. Total biomass as calculated for strata 46-58 of the summer RV survey and the spring and fall industry surveys.

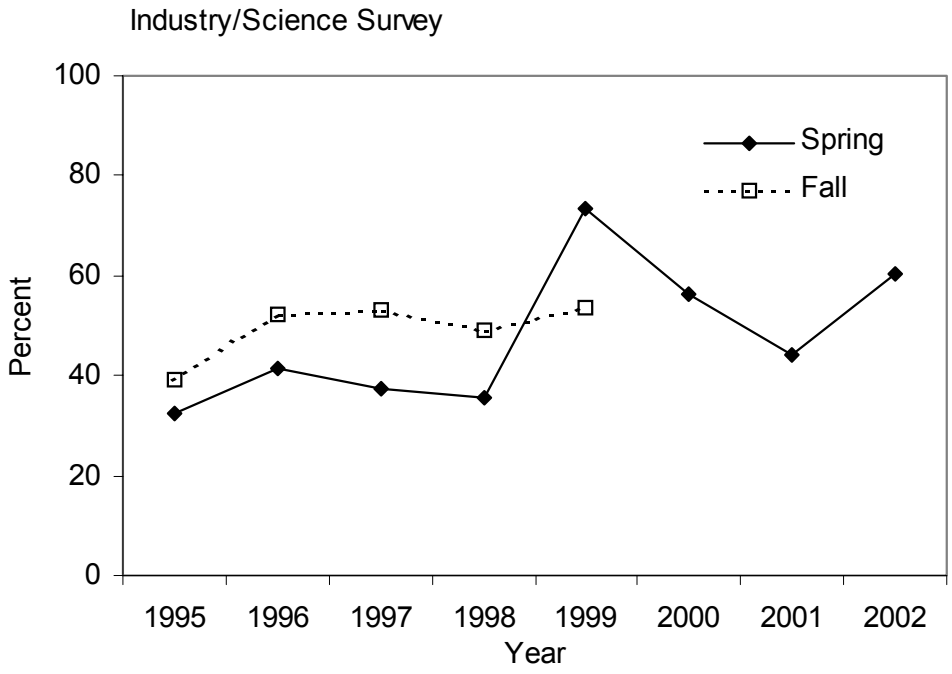

Figure 45. Percent occurrence of winter skate from the spring and fall industry/science skate surveys in Div. 4VsW.

Observer Data

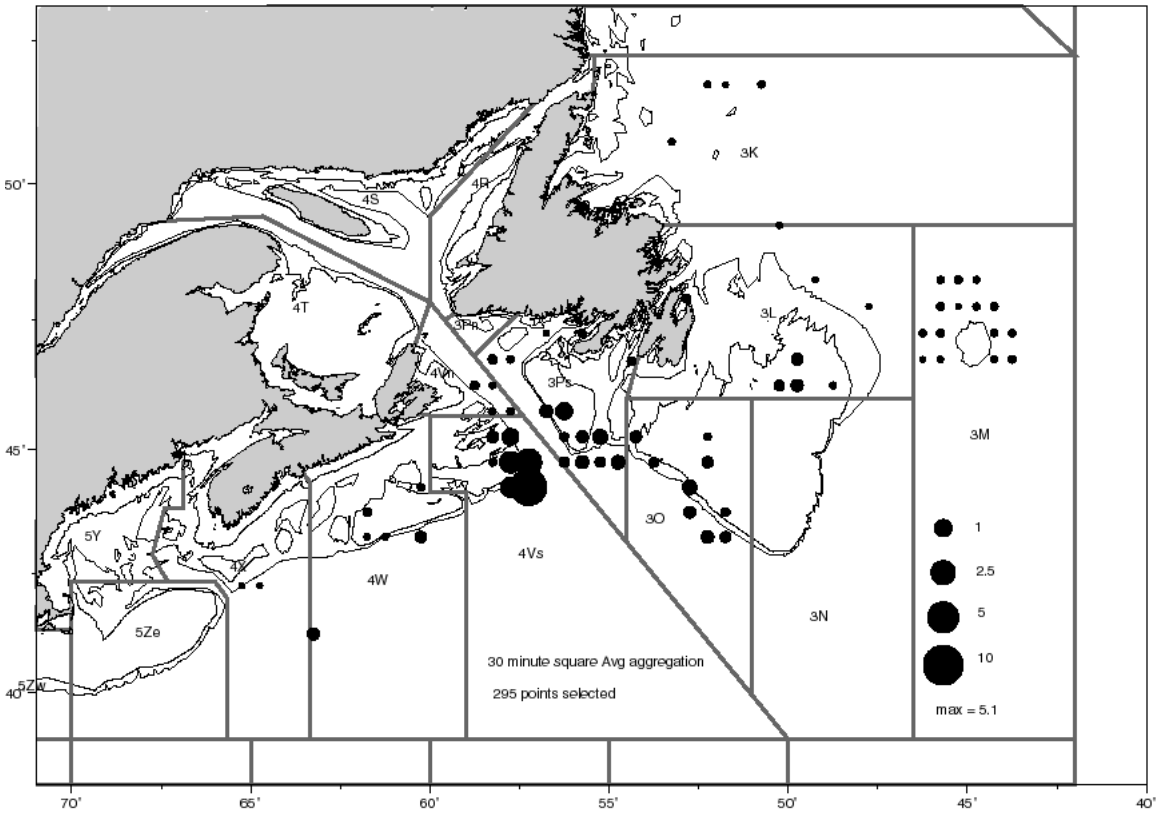

Figure 46. Distribution of winter skate as reported by Newfoundland observers, 1980-2001.

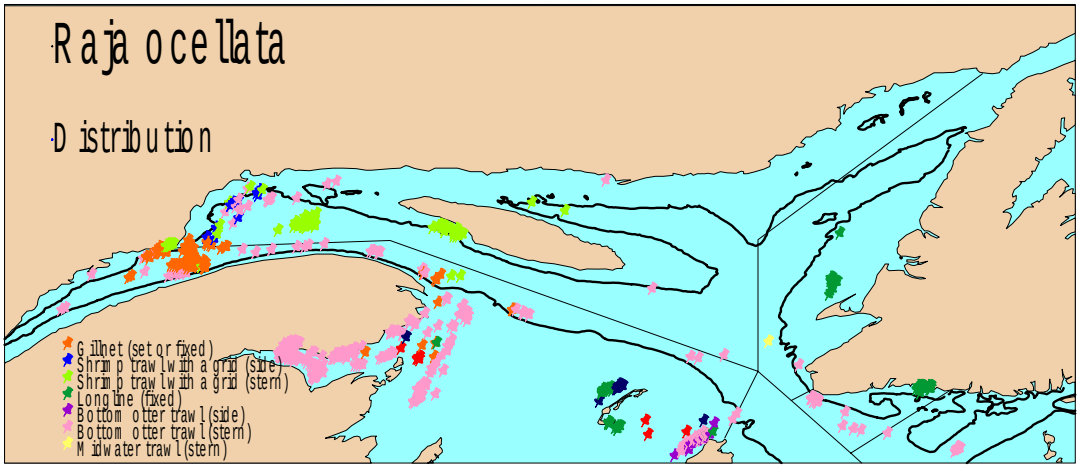

Figure 47. Catch of winter skate by gear type for the Observer program for Div. 3pn4RS and part of 4T, 1990-2001.

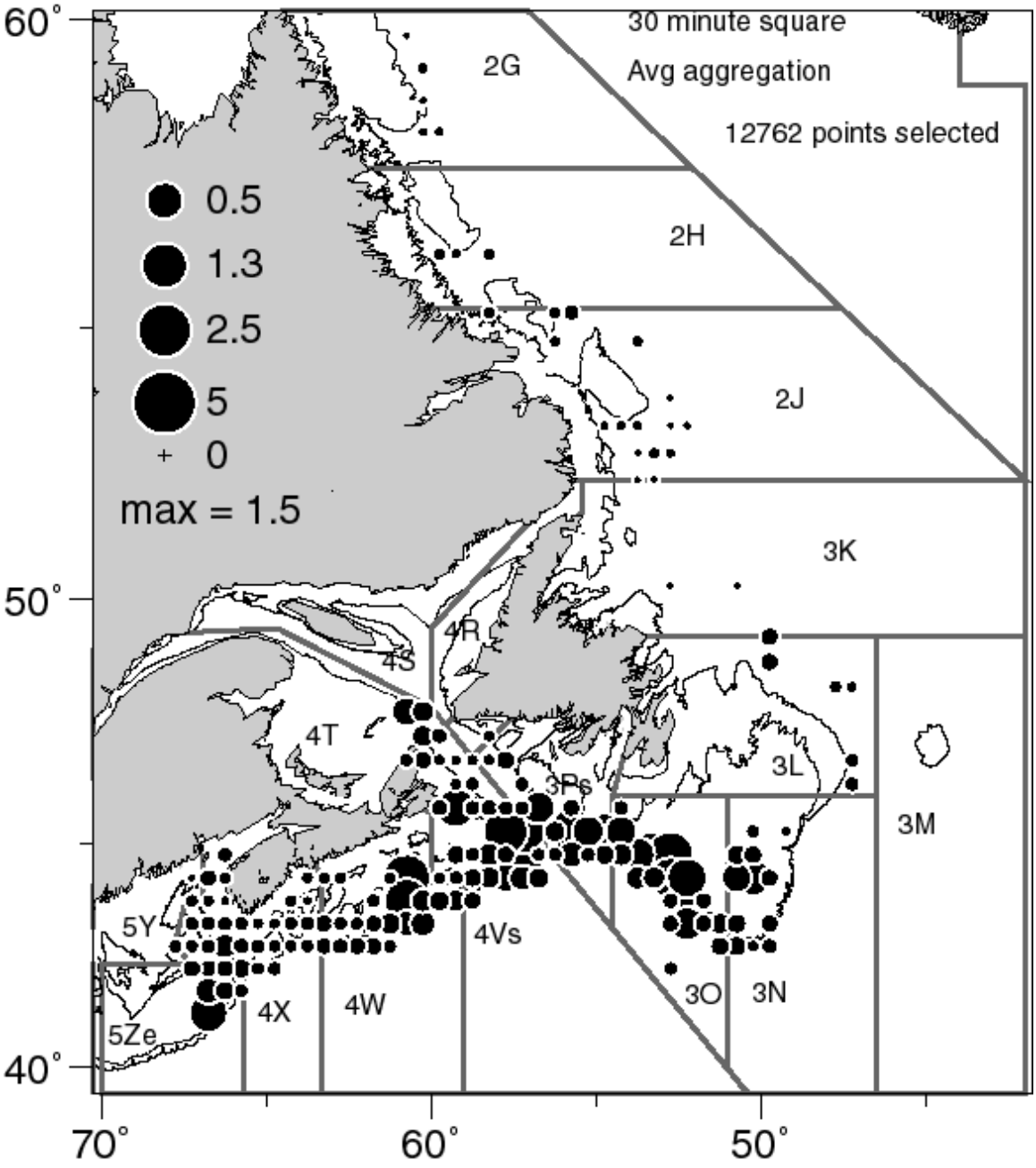

Figure 48. Distribution of winter skate observed by the Scotian shelf observers from 1995-2001.

Commercial Fishery

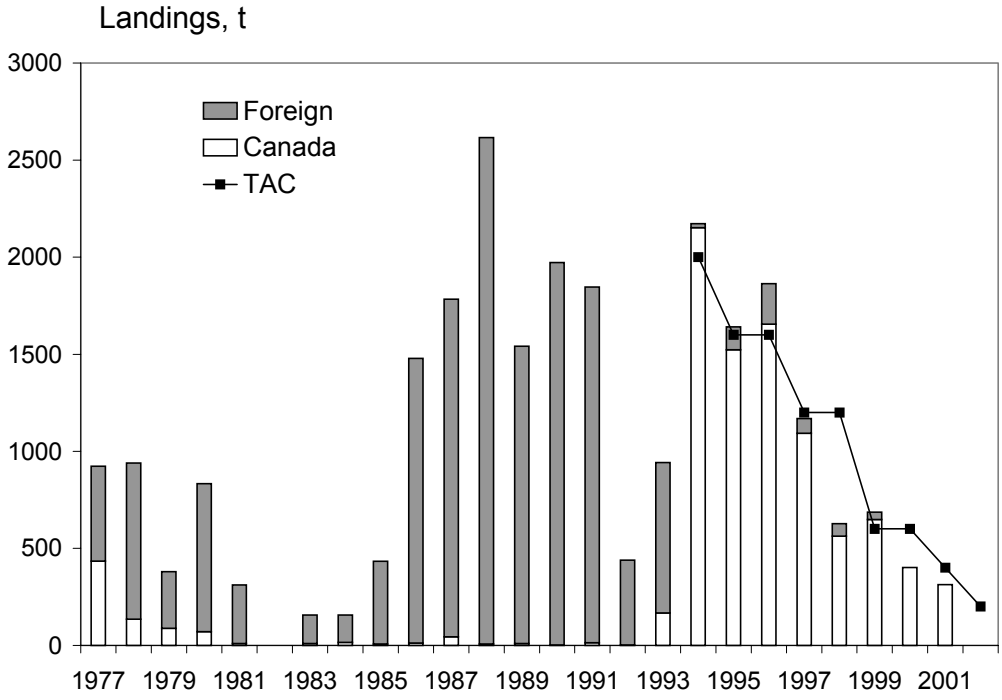

Figure 49. Reported landings, t of all skate species in Div. 4VsW. Since 1994 landings have been primarily winter skate from the directed fishery.

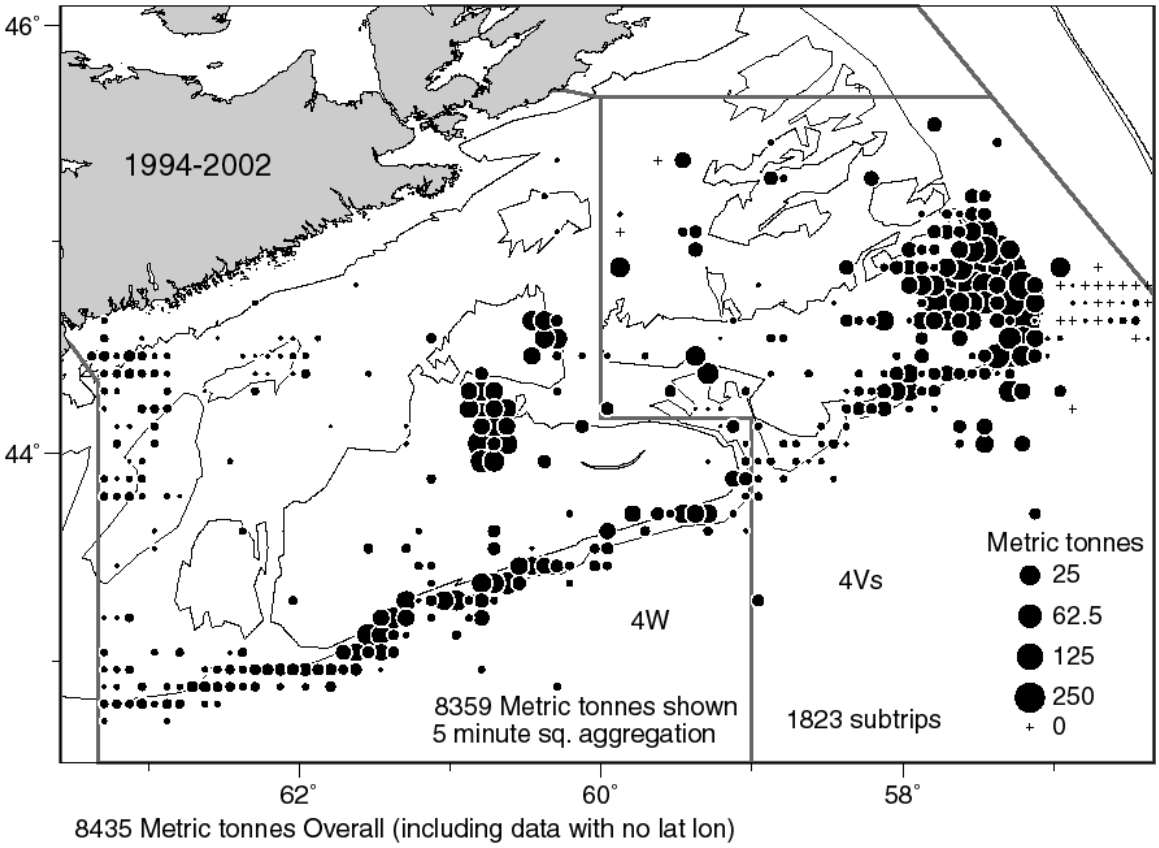

Figure 50. Distribution of reported landings of skate in Div. 4VsW.

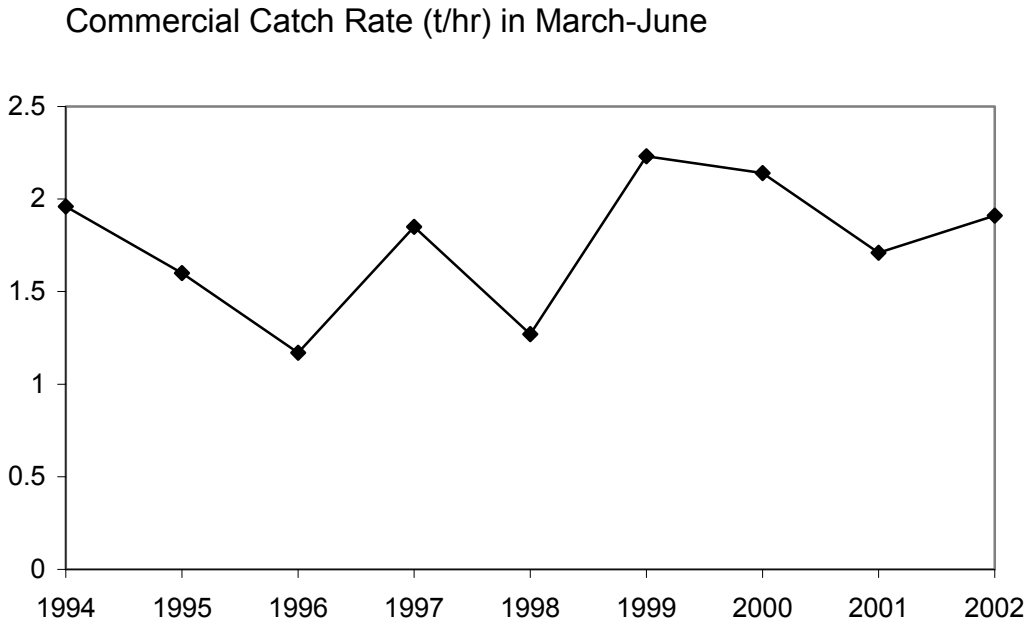

Figure 51. Commercial catch rate (t/hr) of skate (all species) from the directed fishery in Div. 4VsW.

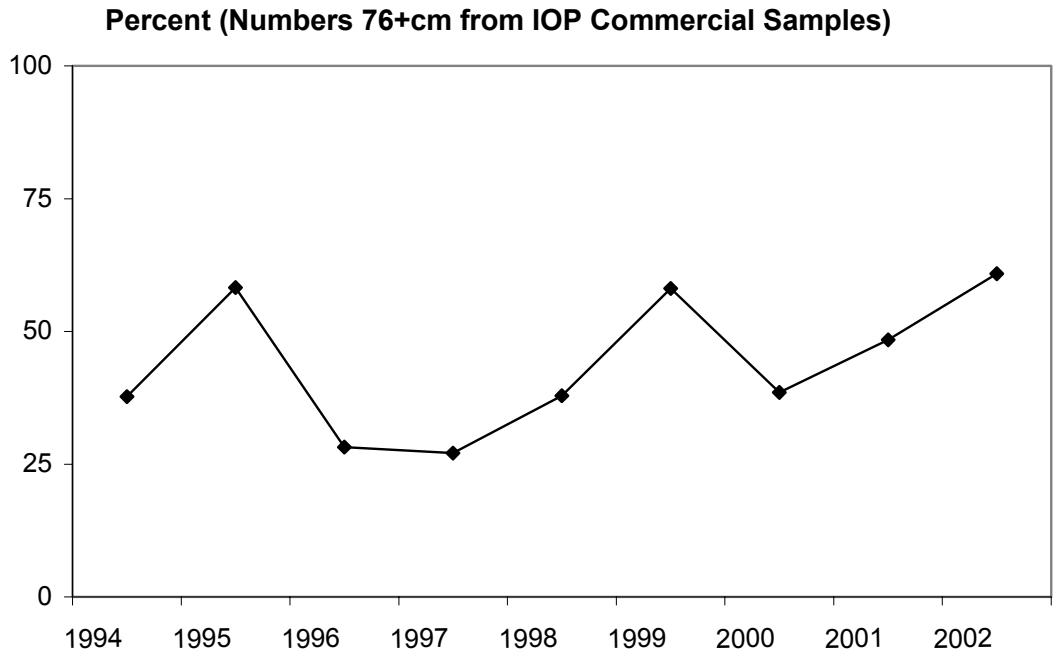

Figure 52. Length frequency observations by the International Observer Program (IOP) from the commercial phase of the directed fishery.

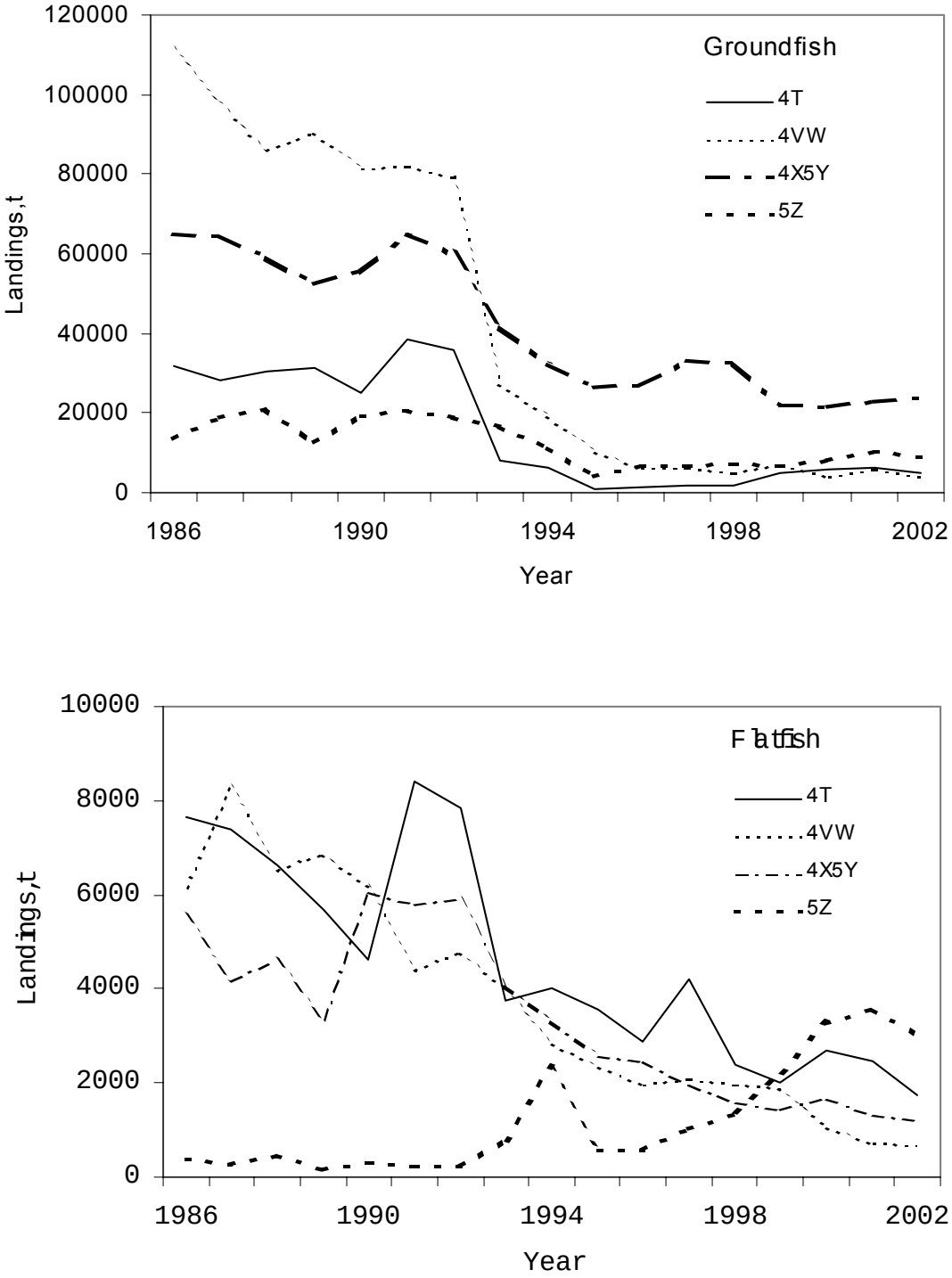

Figure 53. Landings, t of groundfish (cod, haddock, pollock and redfish) and flatfish in Divs. 4T, 4VW, 4X5Y and 5Z by all Canadian fisheries.

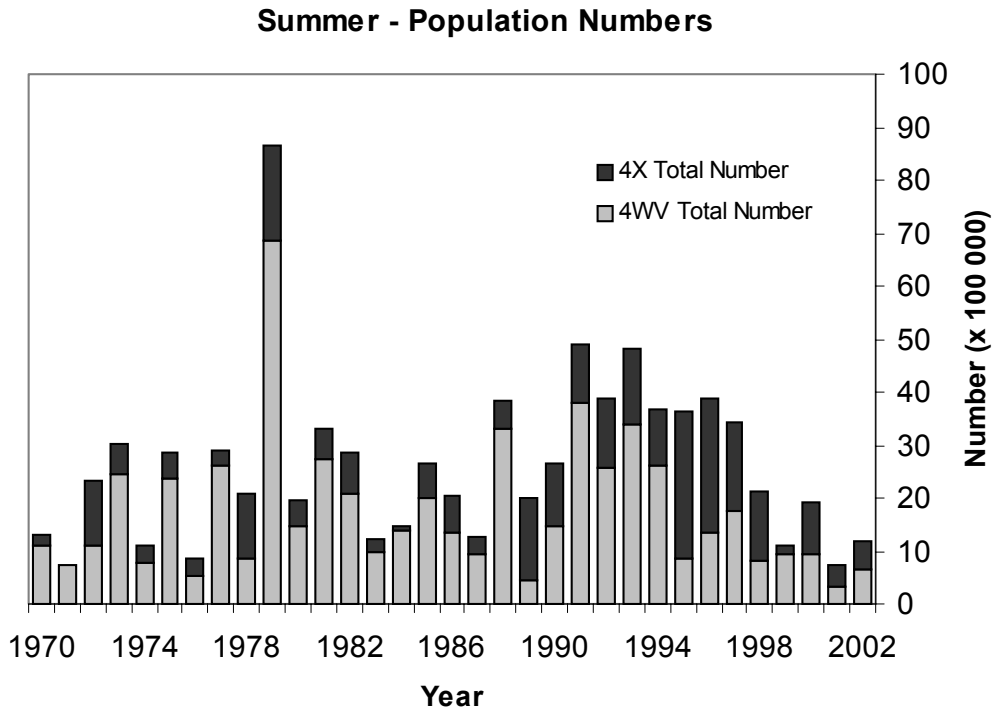

Figure 54. Total number of winter skate as estimated by the Summer RV survey, in Div. 4VW and 4X.

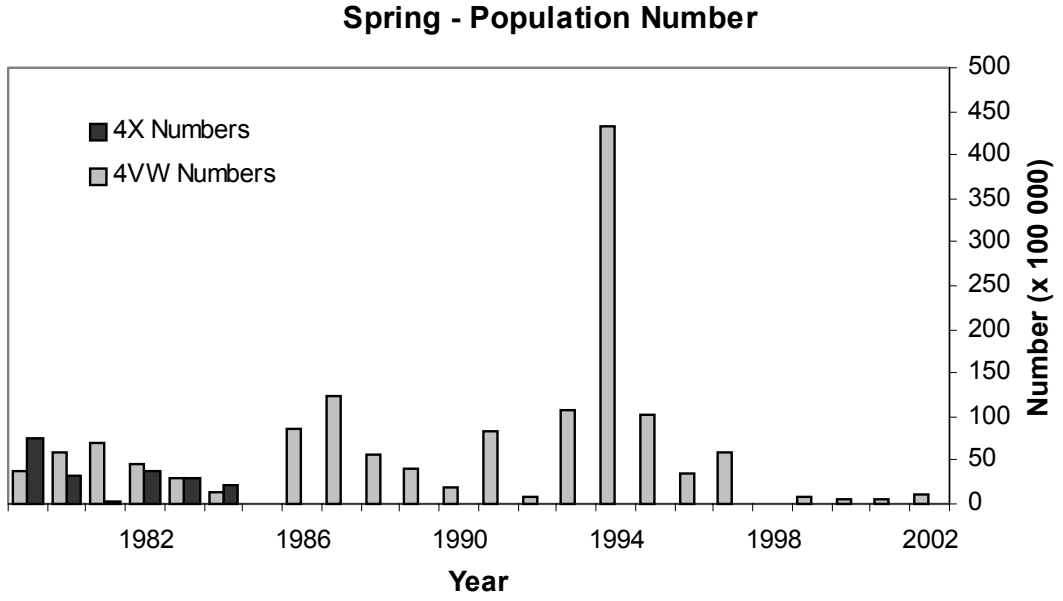

Figure 55. Total number of winter skate as estimated by the Spring and 4VWCod RV surveys, in Div. 4X and 4VW.

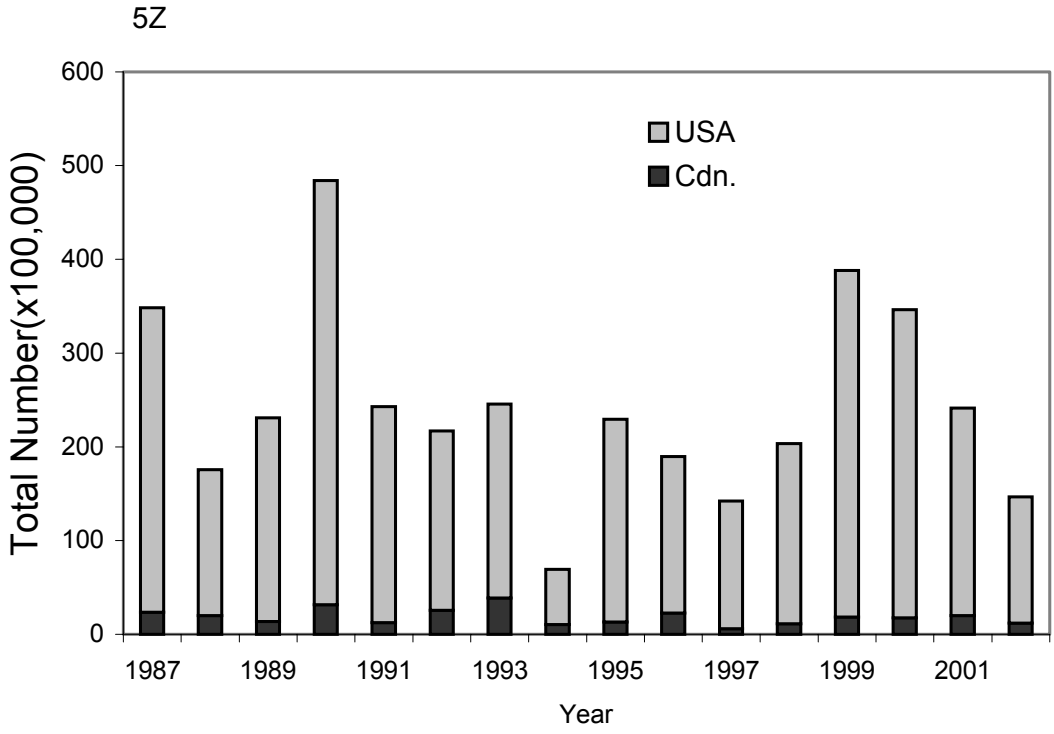

Figure 56. Total number of winter skate in Div. 5Z as estimated for the Canadian and American zones by the Georges Bank RV survey.

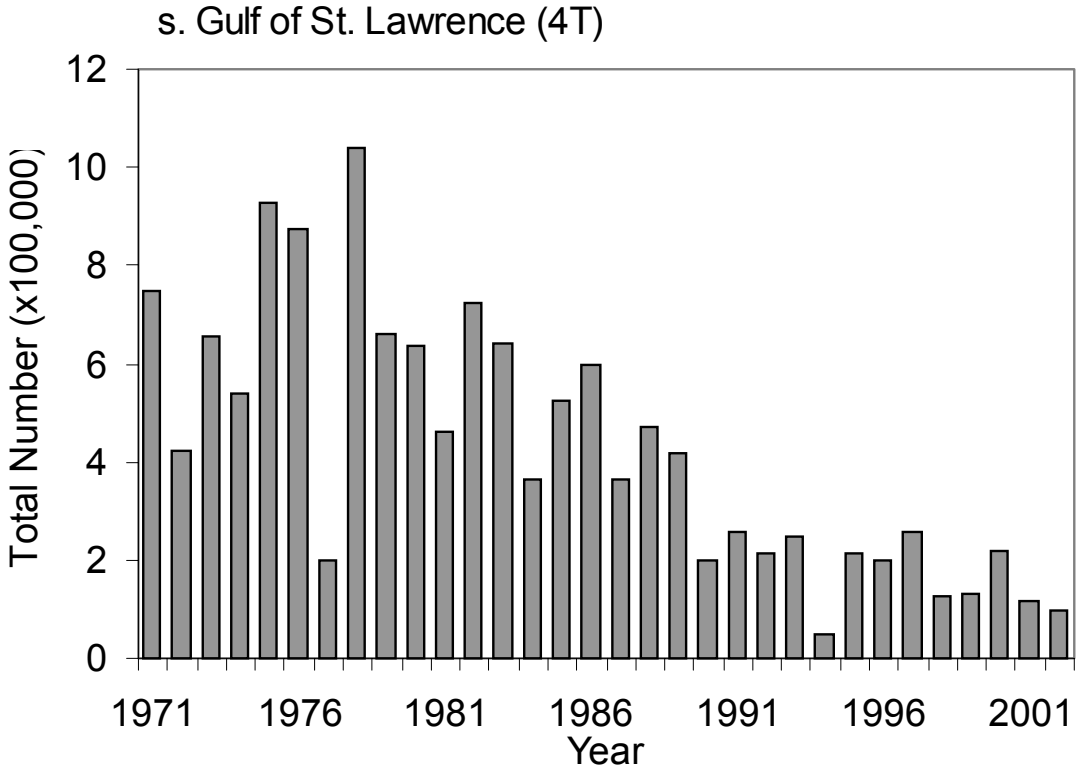

Figure 57. Total number of winter skate as estimated by the fall RV survey in Div. 4T.

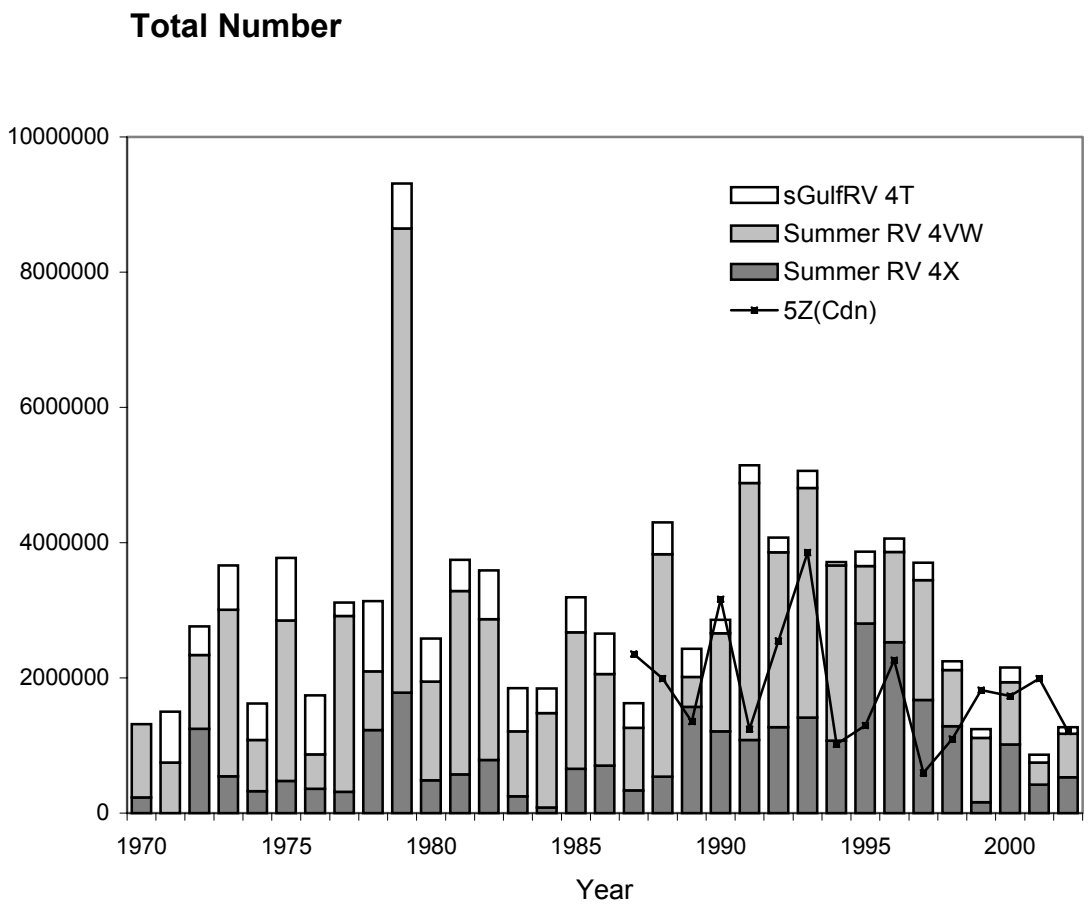

Figure 58. Total population number of winter skate as estimated by the RV surveys in Div. 4TVWX. Note there was no survey in 4T in 1970. The Div. 5Z(Cdn.) estimate is displayed separately on the graph as a line and began in 1987.