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Assessment of the Winter Skate Fishery
In Division 4VsW

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Abstract

The experimental skate fishery on the Scotian Shelf began in 1994 with a developmental period of 5 years. This was extended for one year to allow further analysis of the stock and better define the ability of skate to sustain a limited commercial fishery. In 1994, landings in the fishery were 2152t. Since then landings have been progressively lower reflecting reductions in the TAC. In 1999 the TAC was 600t and landings amounted to 623t.

The traffic light approach was used to summarize the several indicators of stock status that were available for this stock in a consistent and unified manner.

Abundance of the fishable component of the winter skate population has been below average for the last three years. Spawning stock biomass (RV Biomass 75+) has been consistently low, whereas the immature fishable biomass (RV Biomas 60-74) has been above average in four out of the last five years. Area occupied has been declining steadily since 1992 and is currently at an historical low (Areaoccupied). The March RV No. indicator has also been low in recent years. Indicators based on the directed fishery and industry/science surveys (CPUE, Industry Spring Biomass, Industry Fall Biomass) have been either stable or increasing but are only available since 1995.

Several indicators suggest that productivity has been low since 1995. Condition factor was high throughout the 1970s and has been in the low part of the range since the mid-1990's (RV Condition @70). Recent recruitment has also tended to be in the low part of the range (RV Biomass 36-59). Total mortality, estimated from the directed fishery, doubled from 1995 to 1997 and has remained at a stable high level (Commercial Z).

There are three indicators associated with mortality based on catch of skate in 4VsW versus RV biomass and biomass estimates from the spring and fall industry surveys. The fishing mortality indicator based on RV survey biomass estimates (RV Relative F) has been in the high part of the range during the past several years. Fishing mortality should not be allowed to increase. The indicators based on biomass estimates from the industry surveys (Industry Spring Relative F, Industry Fall Relative F) available since 1995 suggest a recent reduction in exploitation that is consistent with falling TAC’s in that period.

The initial developmental period of the experimental skate fishery has ended, but it is uncertain whether or not the fishery is having a negative impact. Due to the uncertainty in the winter skate stock dynamics it will be important to find ways, such as extending the developmental period, to continue to monitor the status of the stock.

Résumé

La pêche expérimentale de la raie sur le plateau néo-écossais a été ouverte en 1994 pour une période d'essai de cinq ans, qui a été prolongée d'un an afin de permettre une analyse approfondie du stock et une meilleure détermination de la capacité de la raie à assurer le maintien d'une pêche commerciale restreinte. En 1994, les débarquements de la pêche étaient de 2152 t. Depuis, ils ont progressivement diminué en raison de réductions concomitantes du TAC. En 1999, le TAC était de 600 t, et les débarquements totalisaient 623 t.

On a utilisé la méthode des feux de circulation pour résumer de manière constante et uniforme les quelques indicateurs de l'état des stocks disponibles pour ce stock.

L'abondance des composantes pêchables de la population de raie tachetée a été inférieure à la moyenne au cours des trois dernières années. La biomasse du stock reproducteur (« biomasse de raies de 75+ cm de NR ») est demeurée constamment faible, tandis que la biomasse de juvéniles pêchable (« biomasse de raies de 60 à 74 cm de NR ») a été supérieure à la moyenne durant quatre des cinq dernières années. La superficie du secteur occupé décroît régulièrement depuis 1992, se situant actuellement à un creux historique (« région fréquentée »). L'indicateur du « nombre de NR en mars » a aussi été bas au cours des dernières années. Les indicateurs qui s'appuient sur la pêche dirigée et sur les relevés industrie/Sciences (CPUE, « biomasse de printemps établie par l'industrie », « biomasse d'automne établie par l'industrie ») ont été stables ou à la hausse, mais sont seulement disponibles depuis 1995.

Plusieurs indicateurs laissent croire que la productivité est faible depuis 1995. Le facteur de condition était élevé pendant les années 1970 et se situe au bas de la fourchette depuis le milieu des années 1990 (« facteur de condition @ 70 cm de NR »). Le recrutement des dernières années montre aussi une tendance à se situer au bas de la plage (« biomasse de raies de 36 à 59 cm de NR »). La mortalité totale, estimée à partir de la pêche dirigée, a doublé de 1995 à 1997, et se maintient à un niveau élevé stable (« Z commercial »).

Trois indicateurs sont associés à la mortalité; ils sont fondés sur les prises de raie dans 4VsW, par rapport à la biomasse de navire de recherche et aux estimations de la biomasse provenant des relevés printanier et automnal de l'industrie. L'indicateur de la mortalité par pêche, qui s'inspire des estimations de la biomasse issues des relevés de navire de recherche (« F relatif de NR »), se situe au haut de la fourchette depuis plusieurs années.
On ne peut se permettre d'augmenter la mortalité par pêche. Les indicateurs tirés des estimations de la biomasse provenant des relevés de l'industrie (« F relatif du relevé de printemps de l'industrie », « F relatif du relevé d'automne de l'industrie ») disponibles depuis 1995 suggèrent une récente baisse de l'exploitation qui concorde avec la réduction du TAC au cours de cette période.

La période d'essai initiale de la pêche expérimentale de la raie s'est achevée, mais on ne peut dire avec certitude si la pêche a des répercussions négatives ou non. En raison de l'incertitude concernant la dynamique du stock de raie tachetée, il sera important de trouver des moyens permettant de continuer à surveiller l'état du stock, tels que le prolongement de la période d'essai.

Introduction

This document contains information and analyses relevant to the experimental skate fishery on the eastern Scotian Shelf. Here we provide a comprehensive assessment of winter skate (*Raja ocellata*) based upon a recent fishery, a co-operative industry/science skate survey, and research vessel survey data. Although five species of skate (winter skate, thorny *Raja radiata*, smooth *Raja senta*, little *Raja erinacea* and barndoor *Raja laevis*) occur on the Scotian Shelf, the commercial fishery directs for winter skate with a small bycatch of thorny skate within the Div. 4VsW management unit (Figure 1).

Previous assessments of this stock were conducted in 1994, 1995, 1996 and 1998 and have provided information on the detailed history of the fishery and the industry surveys, bycatch information, age and growth and maturity of winter skate. We have not attempted to summarize this body of information in the document.

Fishery

Past

A regulated fishery for skates on the Scotian Shelf began in 1994. Landings data exist since 1961, however the data may only represent a fraction of the actual catches since there was no requirement to report incidental catches. There was no distinction made among species and the landings represented an aggregate of the skate complex. Canadian landings have generally been low. The only exception occurred in Divs. 4VW, during the mid-1970s, when landings ranged between 100 - 800t (Table 1).

Foreign fleets have reported much greater landings than Canadian fleets. Prior to 1977 and the extension of jurisdiction, foreign landings were reported as high as 6,100t in Div. 4Vs and 16,000t in Div. 4W (Table 1) though the validity of these high catches has been questioned. After 1977, reported skate landings never exceeded 2,600t and were generally restricted to Div. 4W (Figure 2).

Present

The history of the current directed skate fishery on the eastern Scotian Shelf and the rationale for the harvesting plan have been reviewed in Simon and Frank (1995, 1996, 1998). In 1998, the TAC of 1200t was not met due to market conditions and problems reallocating quota when one of the vessels in the developing fishery was sold. Reported landings were only 526t. In 1999, the TAC was reduced to 600 t due to concerns about the health of the stock. Market conditions strengthened and Canadian skate landings including bycatch was 623 t. In 2000, the TAC remained at 600t and landings have been 340t to September 1.

In previous research documents the data from the International Observer Program (IOP) was examined from 1989 onward to determine the by-catches of all species of skates from other fisheries operating on the Scotian Shelf. In 1998 (Simon and Frank 1998), an attempt was made to determine the by-catch of winter skate alone. Only the species identification from 1994-1997 was considered valid. The average bycatch of winter skate from those years was calculated from each of these fisheries and applied to the entire time series (1989-1998). Using the same criteria in this document the series has been extended to 1999 (Table 2, Figure 3). Winter skate removals from the foreign fisheries in Div. 4W were calculated to be as high as 1182t in 1990 and have been generally less than 100t since 1994 (Table 2). Estimated winter skate discards in the non-directed Canadian fisheries peaked in 1989 at 1043t (Table 2). Estimates of the total removals by fisheries other than the directed fishery peaked in 1990 at 2193t and have been less than 200t since 1994. In 1999, the combination of catches from the directed fishery, by-catch and estimated discards totaled 684t (Table 2).

The discarding of undersized skate was a problem when the directed fishery began (Simon and Frank, 1995). Industry has annually adjusted gear mesh sizes in an attempt to address this problem. A reexamination of observer reports indicate that the discard levels have fallen from 24.5% in 1995 to 14.7% in 1996 and were less than 1% in 1999.

Commercial Catch Rates

Estimates of commercial catch rates (t/hr) from March 1st to June 30th were calculated for the four vessels directing for winter skate from 1994-2000 (Figure 4). No trends were evident from this spring fishery. Catch rates in 1999 and 2000 have been the highest observed (>2t/hr).

Distribution

Distribution information from the 1986-1993 (pre-directed fishery) and the 1994-2000 (directed fishery) periods are presented from the Canadian ZIF landings (Figure 5). Unfortunately, skates were not identified to species in Canadian landings and so are presented as a complex. The pre-directed period was characterized by much lower reported catches of skate concentrated on the eastern shoal area and slopes of Banquereau Bank. Scattered occurrences of skate were reported in the area of the Gully. The directed period shows that the skate fishery was concentrated in the eastern shoal area of Banquereau with secondary concentrations west of Sable Island and along the southern edges of Sable Island Bank.

Commercial Catch at Length

Commercial sampling of winter skates by DFO port technicians began in 1995 (Table 3). Sampling of the fishery was adequate from 1995-97 with 11, 16 and 17 length frequency samples, respectively. However, in 1998 and 1999 only 4 samples were collected in each year. In 2000, 9 samples of winter skate were collected with 2729 fish measured. Sample length frequencies were used to adjust the landings data to the total number of removals at length (Figure 6). Catches peaked at about 76cm in 1995 and declined monotonically towards fish greater than 100cm. The smallest sizes landed were about 60cm. The skewness of the length frequency distribution is probably a result of both discarding and the large mesh gear (255-320mm cod end) used in the fishery. From 1996 to 2000 catches in the fishery have peaked between 71-73 cm. The percentage of fish greater than 90 cm has declined from 25% in 1995, to 6% in 1996 and has been less than 3% since 1997 (Figure 7). The percentage of fish greater than 76 cm has remained steady.

There have been sporadic reports of thorny skate occurrences in the 1995-1999 commercial samples (15 out of 52). These reports indicate that roughly 2.4 to 7% of the total catch in the spring fishery was composed of thorny skate. In the fall of the year, the quantities ranged 3.6 to 24.2%. In 2000, an attempt was made to better quantify the amount of thorny skate in the commercial samples. Thorny skate were reported in 8 out of 9 commercial samples and ranged from 1.7 to 8.6% of the catch in those samples. Thorny skate are a plumper species than winter skate and so the total length necessary to meet the minimum length for a commercial product is less. Thorny skate ranged from 45 to 75 cm with a peak of 62cm (Figure 8).

Research Vessel (RV) Surveys

Distribution

Spring

Spring research vessel surveys of the eastern Scotian Shelf groundfish community have been conducted from 1979 to 2000. The 1996 spring survey was not considered comparable to previous spring surveys because coverage was incomplete. There was no spring survey in 1998. A progressive shift was noted in the distribution of winter skate in Div. 4VsW towards the edge of the shelf, particularly along the edges of Western and Sable Island Banks in the 1995-97 period (Simon and Frank 1998). In 1999 and 2000, although very few winter skate were caught, a similar pattern of distribution was observed (Figure 9).

Summer

Summer research vessel surveys of the Scotian Shelf groundfish community have been conducted since 1970. The distribution of winter skate from the summer survey prior to the onset of the directed fishery in 1994 revealed that winter skate were concentrated on the eastern banks and adjoining slope waters of the Scotian Shelf (Figure 10). Winter skate were also concentrated on Browns Bank and in the upper Bay of Fundy. The distribution of winter skate after commencement of the directed fishery revealed an overall reduction in abundance on the eastern shelf. In Div. 4X, winter skate appear to have increased in the Browns Bank region and the Bay of Fundy (Figure 10). Note however, that there is no directed skate fishery in Div. 4X.

Area Occupied

Two different measures of distribution were evaluated from the summer RV survey in Div. 4VsW. The area occupied or proportion of nonzero sets displayed an increasing trend from the late 1970s to the early 1990s. Since then the area occupied has decreased (Figure 11). Resource concentration or the proportion of the area with 75% of the log(1+numbers) was also examined. In general, the area of concentration followed a pattern similar to the area occupied (Figure 11).

The recent reduction noted in both indices reflects possibly a decrease in abundance as well as a shift in distribution towards the shelf edge. Uncertainty exists at this time in separating the two factors, but it is felt that the extremely low 2000 values make the stock vulnerable to overfishing.

Abundance

Spring

Winter skate catch rates have generally been below 5 fish per tow with the exception of 1994 when an extremely large set occurred in Div. 4Vs and inflated the abundance estimate to greater than 20 fish per tow. The most recent estimates in 1999 and 2000 of 0.3 fish per tow respectively are well below the long-term mean (based on the entire time series excluding the anomalous 1994 value, Figure 12).

Summer

Winter skate catch rates have exhibited a variable pattern of abundance, though the mean number per tow has been well below the long-term mean of 0.76 fish per tow for the past six years(Figure 12). The mean weight per tow has exhibited a progressive reduction since the beginning of the survey series with the 1998 estimate being the lowest in the series (Figure 12). While the 1999 and 2000 estimates have increased they remain well below the long term average.

Condition Factor

The predicted weight of an individual winter skate was estimated for juvenile (40 cm) and adult (70 cm) sizes from the summer research vessel survey (Figure 13). Note that no individual weights were collected from 1986-1994 and the anomalous 1970 values are excluded. The predicted weights for 40 cm winter skate from 1971-85 were quite variable ranging from ~360 to 510 grams. Since 1994, predicted weights were near the long-term average of 436gm. The predicted weight of a 70cm fish generally declined from 1971 to 1984 from ~2800gm to < 2500gm. Since 1994, the mean weight has averaged about 2500gm, which is slightly below the long-term average of 2613gm.

A decline in the mean weight of an individual fish from the summer RV survey in Div. 4VsW from 5-6 kg in the early 1970's to a low (<1 kg) in 1994 was noted (Figure 14). There has been some recovery with the 2000 values being much closer to the long term mean in both the summer and spring RV surveys. No long-term decline was evident in the spring RV in Div. 4VsW or winter skate in the summer survey in Div. 4X.

Size composition

Summer

The annual catch at length is portrayed in both tabular and graphical form (Table 4; Figure 15). Due to high interannual variablility in the length frequencies, the percent length compositions were combined into 5 year time blocks with exception of the 1970-75 period which was six years. Each time block was compared to the 1970-2000 mean. The size composition of winter skate during the 1970-1975 period was bi-modal with peaks occurring near 52 and 97cm with large numbers of fish occurring at sizes greater than 100cm (Figure 16). This larger peak did not appear in any significant numbers at any other time. The 1991-95 period showed a peak at 37 cm with fewer fish >52 cm compared to the long-term mean. The 1996-2000 period indicated the peak in the size composition increased to 70 cm. Winter skate in the 58-85cm range appear to be near the long term average, but there appears to be a further reduction in the number of fish greater than 85 cm.

Slope and Non-slope Strata

Due to the apparent redistribution of winter skate within the management unit, stratified mean numbers and weights were calculated separately for the slope (RV strata 46,49-54) and non-slope areas (RV strata 47,48,55-58) (Figure 17). The mean number and weight per tow show that skate have been redistributed within the management unit. Slope strata indices increased dramatically since the mid-1980's. The 2000 weight per tow was the third highest in the series. The non-slope strata have decreased and in 2000 the lowest number and weight per tow was observed (Figure 17).

Resource concentration and area occupied indices were also generated for the two areas. These areas show opposing trends. The slope strata indices begin to increase in1978 and peak in 1991 (Figure 18). Recent values have decrease but remain above the long-term mean. The non-slope strata values are variable until 1992 with no apparent trend. Since, 1992 both indices have fallen sharply with the 2000 values being the lowest in the time series (Figure 18).

Biomass

Recruitment into the fishery was approximated by the biomass of 36-59 cm fish from the summer RV. This index appears to be variable, with some indication of increased recruitment from 1991-1994, although the 2000 value is very low (Figure 19).

Annual estimates of biomass were made from the summer RV survey for 60-74 and 75+cm fish (Figure 19). Since size at 50% maturity of females is 75 cm, the RV survey was broken into immature (60-74 cm) and mature (75+ cm) fishable biomass. The fishery generally exploits fish greater than 60 cm. The immature fishable biomass was lowest in the early 1970's and peaked in 1979 with no trend evident since then. The mature fishable biomass declined progressively from the beginning of the series. The 1998 estimate was the lowest ever observed and a slight increase was noted in 2000 (Figure 19).

The minimum trawable biomass for all length groupings of winter skate was calculated for Div. 4VsW, the slope strata, non-slope strata and the industry survey area (strata 46-58) for the summer RV surveys. Estimates from Div 4VsW have been generally less than 3000t since 1992 (Figure 20). Recent slope and non-slope strata biomass estimates are about 2800t and 300t respectively. Biomass estimates from those strata that encompass the industry survey area are close to 3000t. Recent spring RV estimates were extremely variable and low (Figure 20)

Industry/Science Skate Directed Survey

Distribution

As part of the domestic harvesting plan established in 1994, industry agreed to conduct two skate surveys per year. Sampling of the catch was to be undertaken by observers from IOP with costs borne by industry. The survey objectives were to map the extent of the resource in Div. 4VsW, estimate by-catch levels of traditional species and to begin to collect detailed biological information on individual skate. Science designated the fishing locations and requested the use of 155mm mesh gear in 1994. Results of these surveys were reviewed in Simon and Frank (1995). In 1995, a stratified random survey design was implemented (Figure 21) with surveys conducted during April and October. Mesh sizes used ranged from 255 to 315mm. Since 1996, the stratified random survey design has been maintained for both surveys with the use of 155mm mesh in the codend. It should be noted that since 1995, in addition to the 12 to 16 sets per vessel allocated to the survey, three directed fishing sets were permitted to each boat (designated as Captain's sets).

Results from the 1994 and 1995 surveys were summarized in Simon and Frank (1996). Here we present the results of the spring 1996 to 2000 and fall 1996 to 1999 surveys (Figure 22 and 23). The captain’s sets are also presented for each survey (Figure 24 and 25). Both industry surveys revealed a tendency for high catch rates to occur along the edge of the shelf in the areas south of Sable Island Bank and Banquereau Bank. This pattern is similar to what was observed in the recent summer RV surveys. Captain sets were predominately near the slope areas.

Area Occupied

The percentage of nonzero sets of winter skate was calculated for the spring and fall surveys. (Figure 26) The spring survey was slightly below 40% in 1996-98, rose to 76 % in 1999 and fell to 55 % in 2000. The fall survey has been less variable and near 50% each year.

Abundance

The strata by strata estimates from the spring and fall industry surveys are presented in Table 5. Survey coverage was excellent with, except for 1995, a minimum of 2 sets per strata fished. Highest catch rates were commonly found in strata 53, 47 and 49 in the spring survey while the catches in the fall survey were highest in strata 46, 53 and 54. Stratified catch rates were calculated for the industry surveys and compared to the spring and summer RV surveys for Div. 4VsW, the slope strata alone and the non-slope strata (Table 6, 7 and 8). Catch rates for Div. 4VsW in both the spring and fall industry surveys appear on the whole to be increasing. Mean catch rates tend to be ten times greater than the summer RV estimates (Figure 27). In Simon and Frank (1998) there appeared to be a similar pattern between the spring industry and the summer RV slope estimates for 1995-1997. This pattern does not appear to have held in recent years. Catches in the slope waters were approximately four times those seen in the non-slope waters in both the spring and fall surveys.

Mean catch rates were calculated separately for the captain’s sets in the spring and fall industry surveys (Table 9; Figure 28). Catch rates in both the spring and fall were similar and averaged about 250 kg per hour.

Biology

Industry has previously noted females extruding complete purses (a leathery case containing the skate embryo) only in the late summer/early autumn west of Sable Island and suggestions were made that this may be a spawning area. In the spring RV survey, winter skate purses were noted by the author in Div. 4Vs. This indicates that spawning may occur in areas and times not previously recorded.

Total mortality

Estimates of total mortality (Z) of winter skate in Div. 4VsW were derived from an analysis of commercial catches using a growth model. A preliminary aging study of winter skate on the Scotian Shelf was used to convert lengths to ages. Analysis of the commercial catch at length data using the winter skate growth model produced a catch at age ranging from ages 3 to 20. The slope of the descending limb of the catch at age, fitted by linear regression, was considered an estimate of total mortality. Total mortality was lowest in 1995 (Z=0.35), increased to 0.76 in 1997, and has leveled off since, though the 2000 estimate of 0.84 was the highest seen in the series (Figure 29).

Relative Fishing Mortality

Estimates of relative fishing mortality (F), the ratio of catch divided by the summer RV biomass of winter skate were calculated from 1977 to 1999. Prior to the extension of jurisdiction in 1977 reported landings were not felt to be as accurate. During the period preceding the directed fishery relative F's were highest from 1986 to1989. Relative F's were high at the beginning of the directed fishery but have fallen as TAC's have been reduced (Figure 30).

Relative F's were calculated in the same manner as the summer RV for the spring and fall industry surveys (Figure 31). These estimates were highest in 1995 and 1997 in the spring and have been below average in the last two years, while the fall estimates were high in 1995 and 1996 and have been much lower the last three years (Figure 31).

Traffic Lights

The traffic light approach summarizes all the indicators of stock status in a consistent and unified manner. The annual values of each indicator are depicted as one of three lights depending on whether they are among the highest values observed for that indicator, among the lowest or somewhere in between. For indicators such as stock biomass and recruitment, high values are good and have a green light + and low values are bad and have a red light −. Intermediate values are yellow. However, for indicators such as mortality, high values are bad and are assigned a red light whereas low values are good and receive a green light. The method allows the division between red/yellow and yellow/green to be arbitrarily set by the investigator. This can be based on different mathematical methods depending on the type of data. For winter skate simple averaging, geometric means or percentiles (condition) were used. The boundary values chosen for indices using simple averaging were the average value for yellow/green and 0.6 of the average for the red/yellow boundary. For indicators using percentiles (condition), 66.6 percentile (yellow/green) and 33.3 percentile (red/yellow) were used. For indicators with an inverse relationship with the traffic lights, like mortality, simple averaging was used with the mean value for the yellow/green boundary but 1.4 times the mean was used to define the red/yellow boundary.

Other stocks that are using the traffic light approach have included a summary line that combines all of the indicators. These indicators are combined by assigning weights for each indicator, 1 for all of the longer time series and 0.1 for the shorter time series.
Given the very different signals that the long and short time series exhibit in this assessment and the uncertainty what weighting that should be given for each, no summary line has been included for this assessment.

Stock Indicators

The Traffic Light figure (Figure 32) summarizes some of the indicators of stock status discussed above. The following 13 indicators were selected for inclusion in the table:

- Summer RV biomass 75+ cm
- Summer RV biomass 60-74 cm
- Area occupied (proportion of sets in which winter skate were caught) from the summer RV survey
- March RV number per tow
- Catch per unit of effort (CPUE) from the directed fishery
- Spring Industry survey catch(kg) per tow
- Fall Industry survey catch(kg) per tow
- Condition factor (predicted weight at 70 cm) from summer RV survey
- Summer RV biomass 36-59 cm
- Total mortality (Z) as estimated from commercial landings length frequencies
- Relative fishing mortality (F) (commercial landings/RV survey biomass) from summer RV survey

- Relative fishing mortality (commercial landings/spring industry survey biomass)
- Relative fishing mortality (commercial landings/fall industry survey biomass)

Although many indicators may be used, the above were chosen as the most appropriate as well as the most independent indices.

Abundance of the fishable component of the winter skate population has been below average for the last three years. Spawning stock biomass (RV Biomass 75+) has been consistently low, whereas the immature fishable biomass (RV Biomas 60-74) has been above average in four out of the last five years. Area occupied has been declining steadily since 1992 and is currently at an historical low (Areaoccupied). The March RV No. indicator has also been low in recent years. Indicators based on the directed fishery and industry/science surveys (CPUE, Industry Spring Biomass, Industry Fall Biomass) have been either stable or increasing but are only available since 1995.

Several indicators suggest that productivity has been low since 1995. Condition factor was high throughout the 1970's and has been in the low part of the range since the mid-1990's (RV Condition @70). Recent recruitment has also tended to be in the low part of the range (RV Biomass 36-59). Total mortality, estimated from the directed fishery, doubled from 1995 to 1997 and has remained at a stable high level (Commercial Z).

There are three indicators associated with mortality based on catch of skate in 4VsW versus RV biomass and biomass estimates from the spring and fall industry surveys. The fishing mortality indicator based on RV survey biomass estimates (RV Relative F) has been in the high part of the range during the past several years.. The indicators based on biomass estimates from the industry surveys (Industry Spring Relative F, Industry Fall Relative F) available since 1995 suggest a recent reduction in exploitation that is consistent with falling TAC’s in that period

Summary

Our assessment of this stock in 1998 indicated that harvest levels were too high to sustain a directed skate fishery. Restrictive market conditions in late 1998 and a reduced TAC in 1999 and 2000 resulted in a reduction in landings. Commercial catch rates have remained stable and no further contraction in the length range has been observed. Total mortality rates from the commercial fishery doubled from 1995 to 1997, and thereafter have remained stable. However, these mortality rates are extremely high for such a slow growing species. Fishing mortality should not be allowed to increase.

Current levels of abundance and productivity based on the research vessel surveys are at the low end of historical observations. However, industry data, available since 1995, indicated that the winter skate resource is at a stable or possibly increasing level.

The initial developmental period of the experimental skate fishery has ended, but it is uncertain whether or not the fishery is having a negative impact on winter skate. Due to the uncertainty in the winter skate stock dynamics it will be important to find ways, such as extending the developmental period, to continue to monitor the status of the stock.

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Table 1. Reported nominal landings of skates (all species combined) in Divisions 4Vs, 4W.

Year	4Vs				4W				4VsW				TAC
	Canada	USSR	Others	**Total**	Canada	USSR	Others	**Total**	Canada	USSR	Others	**Total**	
1961	-	-	-	0	1	-	-	1	1	-	-	1	-
1962	-	-	-	0	4	-	-	4	4	-	-	4	-
1963	-	-	-	0	-	-	-	0	-	-	-	0	-
1964	-	-	-	0	-	-	1	1	-	-	1	1	-
1965	17	-	4	21	51	-	-	51	68	-	4	72	-
1966	-	-	1	1	14	-	-	14	14	-	1	15	-
1967	-	-	-	0	16	-	-	16	16	-	-	16	-
1968	3	780	4	787	56	5397	-	5453	59	6177	4	6240	-
1969	4	269	8	281	10	4122	-	4132	14	4391	8	4413	-
1970	2	60	6	68	24	3802	-	3826	26	3862	6	3894	-
1971	12	1519	3	1534	1	15970	-	15971	13	17489	3	17505	-
1972	1	894	10	905	-	4325	5	4330	1	5219	15	5235	-
1973	3	364	38	405	2	6287	1	6290	5	6651	39	6695	-
1974	-	-	89	89	61	8323	18	8402	61	8323	107	8491	-
1975	2	633	81	716	-	15451	5	15456	2	16084	86	16172	-
1976	705	6026	108	6839	57	1738	-	1795	762	7764	108	8634	-
1977	382	-	-	382	52	489	-	541	434	489	-	923	-
1978	109	-	20	129	26	755	29	810	135	755	49	939	-
1979	52	-	-	52	36	287	5	328	88	287	5	380	-
1980	59	-	-	59	12	756	6	774	71	756	6	833	-
1981	7	5	-	12	2	297	-	299	9	302	-	311	-
1982	-	-	-	0	-	-	-	0	-	-	-	0	-
1983	-	-	-	0	9	130	18	157	9	130	18	157	-
1984	7	-	-	7	9	141	-	150	16	141	-	157	-
1985	7	-	-	7	-	421	5	426	7	421	5	433	-
1986	6	-	-	6	6	1467	-	1473	12	1467	-	1479	-
1987	17	-	-	17	28	1632	*107	1767	45	1632	*107	1784	-
1988	3	-	-	3	4	2580	*29	2613	7	2580	*29	2616	-
1989	3	-	-	3	7	1364	*167	1538	10	1364	*167	1541	-
1990	0	-	-	0	2	1655	*315	1972	2	1655	*315	1972	-
1991	5	-	-	5	8	1112	*721	1841	13	1112	*721	1846	-
1992	0	-	-	0	2	279	*158	439	2	279	*158	439	-
1993	66	-	-	66	101	*117	*658	876	167	*117	*658	942	-
1994	1971	-	-	1971	181	*0	*20	201	2152	*0	*20	2172	2000
1995	1502	-	-	1502	21	*0	*117	138	1523	*0	*117	1640	1600
1996	1372	-	*1	1373	283	*15	*192	490	1655	15	*193	1863	1600
1997	911	-	-	911	137	-	*76	213	1048	-	*76	1124	1200
1998	394	-	*1	395	132	*4	*59	195	526	4	*60	590	1200
1999	466	-	-	466	157	-	*38	195	623	-	*38	661	600
2000	339	-	-	339	1	-	-	1	340	-	-	344	600

1961-1988 NAFO data
1989-present ZIF data (Canadian)
* - IOP data
2000, partial year data, to Sept. 1/2000

Table 2. Winter skate removals in Canadian and foreign fisheries in Divs. 4VsW as estimated by the International Observer Program and statistics.

	Foreign [1] 4W			Canadian [2] Groundfish(4VsW)			Canadian [3] Flatfish(4Vs)			Summaries				
	USSR	Others	Total	Landings,t	Bycatch estimate %	Est. skate discards	Landings,t	Bycatch estimate %	Est. skate discards	Canadian Discards	Foreign Bycatch	Total Non-directed	Canadian Directed	Estimated Total Removals
1989	818	100	918	60127	0.015	872	3424	0.05	171	1043	918	1961	10	1971
1990	993	189	1182	57117	0.014	799	4246	0.05	212	1011	1182	2193	2	2195
1991	667	433	1100	56591	0.013	735	2506	0.05	125	860	1100	1960	13	1973
1992	167	95	262	47698	0.011	500	3149	0.05	158	658	262	920	2	922
1993	70	395	465	8972	0.016	144	2916	0.05	145	289	465	754	167	921
1994	0	12	12	8211	0.003	25	2226	0.05	111	136	12	148	2152	2300
1995	0	70	70	6328	0.007	45	1614	0.05	81	126	70	196	1523	1719
1996	7	96	103	4789	0.005	24	1137	0.05	57	81	103	184	1655	1839
1997	0	45	45	4398	0.004	16	1036	0.05	52	68	45	113	1048	1161
1998	2	35	37	2832	0.004	10	827	0.05	41	51	37	88	526	614
1999	0	23	23	1964	0.004	7	614	0.05	31	38	23	61	623	684

Note:
1. Foreign IOP coverage 100% in 1989 -2000.(winter skate estimated to be 60 % of all skate caught)
2. Estimated catch of winter skate caught in the cod, haddock, pollock, and redfish fisheries.(50 % of all skate,estimated)
3. Estimated catch of winter skate caught in the flatfish fishery.(25 % of all skate ,estimated)

Table 3. Canadian commercial sampling of winter skate in Div. 4VsW. The number measured is the top value, while the bottom value is the number of samples taken.

Quarter	1995	1996	1997	1998	1999	2000
1	-	1640 3	308 1	-	227 1	-
2	335 1	765 2	1349 4	485 2	655 2	2729 9
3	176 1	1658 4	259 1	411 2	-	-
4	4038 9	2504 7	3544 11	-	257 1	-
Sum	4549 11	6567 16	5460 17	896 4	1139 4	2729 9

Note: In 2000, 8 samples of thorny skate were collected during the second quarter. Number measured was 876.

Table 4. Number of winter skate caught at length during the summer research vessel groundfish survey in Div. 4VsW.

Length(cm)	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
1	0	0	0	0	0	0	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
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0.06	0	0	0	0	0
25	0	0	0	0	0	0	0.01	0	0	0.17	0	0	0	0.01	0
28	0	0	0	0.01	0	0	0	0	0	0.20	0	0	0	0	0.01
31	0	0	0	0	0	0.01	0	0.01	0	0.21	0	0	0	0.01	0.03
34	0	0	0	0.01	0.01	0	0	0.02	0	0.15	0.02	0	0	0.02	0.02
37	0	0	0	0	0	0	0	0.12	0	0.14	0	0.01	0	0.01	0.01
40	0	0	0	0.02	0	0	0.01	0.03	0	0.03	0.01	0.04	0.02	0	0
43	0	0	0	0.02	0.03	0	0.01	0.11	0	0.08	0.02	0.02	0.01	0.05	0.03
46	0	0	0.01	0.01	0.01	0.02	0	0.04	0.03	0.07	0.03	0.05	0.04	0.07	0.03
49	0	0.02	0.01	0.01	0.03	0.12	0.01	0.06	0.02	0.16	0.03	0.14	0.05	0.03	0.09
52	0.01	0.08	0	0.04	0.01	0.06	0.02	0.06	0.03	0.34	0.07	0.11	0.02	0.06	0.16
55	0.01	0	0.01	0.05	0.01	0.03	0.01	0.08	0.03	0.31	0.05	0.15	0.03	0.01	0.04
58	0	0	0	0.06	0.02	0.04	0.01	0.08	0.01	0.24	0.03	0.10	0.07	0.01	0.01
61	0	0	0	0.07	0.01	0.03	0.01	0.06	0.04	0.12	0	0.10	0.03	0.03	0.04
64	0	0	0	0.03	0.00	0	0	0.02	0	0.14	0.02	0.11	0.02	0	0
67	0	0	0.01	0	0.01	0.04	0.01	0.01	0.02	0.17	0.01	0.05	0.13	0	0.01
70	0	0.01	0	0	0	0.04	0	0.08	0.04	0.02	0.03	0.08	0.08	0.04	0.01
73	0	0	0.01	0	0.01	0.04	0.03	0.05	0	0.01	0.02	0.04	0	0.03	0.01
76	0	0	0	0.06	0.01	0.04	0.01	0.05	0.02	0.02	0.07	0.02	0.03	0.01	0.01
79	0	0	0.01	0	0.01	0.03	0.02	0.06	0.01	0.01	0.04	0.01	0.01	0.01	0.02
82	0.01	0	0	0.02	0.02	0.02	0.01	0.03	0.06	0.07	0.05	0.05	0.04	0	0.01
85	0.01	0.03	0.01	0.04	0.02	0	0.01	0.02	0.01	0.05	0.02	0.01	0.01	0	0
88	0.03	0.07	0.01	0.14	0.04	0.02	0	0.04	0.02	0.06	0.05	0.03	0.06	0	0.01
91	0.02	0.08	0.06	0.10	0.01	0.03	0.01	0	0.03	0.05	0.02	0.02	0.03	0	0.03
94	0.06	0.02	0.07	0.05	0.02	0.03	0	0	0	0.02	0.01	0.03	0.06	0.01	0
97	0.02	0	0.10	0.13	0.02	0.08	0.01	0.02	0.01	0	0	0.01	0.03	0.01	0.01
100	0.05	0.01	0.06	0.07	0.01	0.15	0	0.02	0	0.02	0	0	0.05	0	0
103	0.11	0	0.02	0.03	0.01	0.06	0	0	0	0.01	0	0	0.04	0.01	0
106	0.10	0.01	0.06	0.03	0.01	0.09	0	0.02	0	0	0.02	0	0.01	0	0
109	0	0	0.04	0.03	0.02	0.01	0	0	0	0	0	0	0	0	0
112	0.01	0	0	0.02	0	0.03	0	0	0	0	0	0	0	0	0
115	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0
118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
121	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0.45	0.31	0.46	1.04	0.32	1.00	0.21	1.09	0.36	2.93	0.63	1.15	0.88	0.43	0.59

Length(cm)	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	0
1	0	0	0	0	0	0	0	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	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01
13	0	0.01	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0	0
16	0	0.03	0	0.01	0	0	0	0	0	0	0	0	0	0.01	0	0
19	0	0.02	0.02	0.01	0	0	0	0	0	0.02	0	0.01	0	0	0	0
22	0	0.01	0	0.01	0	0	0	0.00	0	0.01	0.01	0	0	0	0	0
25	0.01	0	0.01	0	0	0.01	0	0.01	0.03	0.03	0.03	0.01	0	0.01	0.01	0
28	0	0.01	0.02	0.03	0	0	0.01	0.02	0.05	0.03	0	0	0.01	0	0	0.01
31	0.01	0	0.02	0	0	0.01	0.04	0.02	0.10	0.11	0.03	0.01	0	0.01	0.03	0
34	0	0	0	0.06	0	0	0.12	0.04	0.12	0.21	0.02	0	0.01	0.02	0.03	0
37	0.01	0.01	0.02	0.02	0.01	0.01	0.11	0.04	0.22	0.21	0.04	0.01	0	0.03	0.01	0
40	0.04	0	0.03	0.06	0	0.02	0.13	0.04	0.17	0.19	0	0	0.01	0.06	0.01	0
43	0.04	0.01	0	0.02	0.02	0.01	0.15	0.04	0.17	0.09	0.03	0.04	0.04	0.05	0.02	0.01
46	0.02	0.02	0.02	0.08	0.01	0.03	0.09	0.08	0.13	0.04	0.02	0.01	0.09	0.04	0.02	0
49	0.03	0.03	0.01	0.11	0.02	0	0.15	0.11	0.11	0.01	0.01	0.05	0.07	0.03	0.01	0
52	0.08	0.10	0.03	0.08	0	0.01	0.10	0.03	0.08	0.03	0	0.03	0.03	0.02	0.02	0
55	0.10	0.10	0.03	0.10	0.01	0.03	0.07	0.08	0.11	0.01	0.03	0.02	0.09	0.01	0	0.01
58	0.08	0.04	0.02	0.05	0	0.03	0.08	0.038	0.04	0.02	0	0.02	0.07	0	0.03	0.01
61	0.05	0.03	0.02	0.09	0.03	0.03	0.06	0.02	0.03	0	0.03	0.04	0.03	0	0.03	0.02
64	0.01	0	0.02	0.05	0.02	0.06	0.08	0.07	0.01	0.01	0	0.03	0.03	0.02	0.01	0.04
67	0.03	0.02	0	0.06	0.01	0.02	0.03	0.03	0.02	0.02	0.01	0.06	0.06	0	0.04	0.05
70	0.05	0.00	0.01	0.01	0	0.06	0.05	0.06	0.01	0	0.01	0.06	0.06	0	0.04	0.06
73	0.06	0	0	0.12	0	0.02	0.07	0.06	0	0.01	0.03	0.03	0.03	0	0.04	0.04
76	0.03	0.02	0.01	0.04	0.01	0.03	0.04	0.05	0	0	0	0.04	0.05	0.01	0.02	0.04
79	0.05	0	0.02	0.04	0.03	0.05	0.03	0.04	0.01	0.01	0.03	0.04	0.01	0	0.01	0.02
82	0.01	0.01	0.02	0.05	0	0.02	0.02	0.02	0.01	0.01	0	0.03	0.02	0.01	0	0.02
85	0.03	0	0.00	0.08	0.01	0.03	0.04	0.02	0.02	0.01	0	0.03	0.01	0.01	0	0.01
88	0.05	0.01	0.01	0.02	0	0.05	0.06	0.06	0	0.01	0	0.01	0.01	0	0	0.01
91	0.02	0.01	0.01	0.08	0.01	0.02	0.02	0.05	0	0	0.01	0	0.01	0	0	0.02
94	0.01	0.05	0.01	0.03	0.00	0.03	0.02	0.03	0	0.01	0.01	0	0	0	0.01	0
97	0.04	0.01	0.03	0.04	0	0.02	0.01	0.01	0	0.01	0	0	0	0	0	0
100	0	0	0	0.03	0.01	0	0.01	0.01	0	0	0	0	0	0	0	0
103	0	0	0.01	0.01	0	0	0	0.01	0	0	0.01	0	0	0	0	0
106	0	0	0.01	0.01	0	0	0	0	0	0	0	0	0	0	0	0
109	0	0	0	0.02	0	0	0	0	0	0	0	0	0	0	0	0
112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
121	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0.84	0.56	0.39	1.38	0.19	0.59	1.59	1.09	1.42	1.09	0.33	0.56	0.75	0.35	0.40	0.38

Table 5. Detailed catches of winter skate by strata during the spring and fall industry/science survey sets.

Spring

	1995		1996		1997		1998		1999		2000	
	No. sets	kg. per tow	No. sets	kg. per tow	No. sets	kg. per tow	No. sets	kg. per tow	No. sets	kg. per tow	No. sets	kg. per tow
Strata												
46	2	0.0	3	0.0	3	0.0	3	79.0	4	46.1	5	10.9
47	5	53.0	5	87.5	5	0.0	5	47.3	4	14.3	7	116.4
48	2	0.0	5	0.2	4	0.0	3	0.0	1	0.0	4	0.7
49	1	1.5	3	38.4	3	0.0	3	328.4	4	40.5	5	259.0
50	2	0.0	2	2.2	4	7.2	4	32.4	3	12.4	5	25.9
51	1	0.0	3	974.1	4	14.1	4	5.5	4	16.2	5	5.1
52			2	1.6	3	116.3	3	3.1	3	75.2	5	8.7
53	3	80.0	4	277.4	4	22.8	4	6.8	5	212.4	5	139.9
54	3	12.3	4	28.4	4	42.2	4	22.9	4	39.8	5	30.7
55	6	0.0	5	2.5	5	8.8	5	0.7	5	5.7	9	6.3
56	4	0.3	4	0.0	3	1.0	4	0.0	3	0.3	4	0.0
57	3	1.0	3	0.8	2	0.0	3	0.0	2	2.7	3	0.0
58	3	0.0	3	0.0	3	0.0	3	0.0	2	0.0	2	0.0
Sum	35		46		47		48		44		64	

Fall

	1995		1996		1997		1998		1999		2000
	No. sets	kg. per tow	No. sets	kg. per tow	No. sets	kg. per tow	No. sets	kg. per tow	No. sets	kg. per tow	No survey
Strata											
46	3	0.0	3	28.3	3	406.7	3	266.7	2	841.5	
47	5	20.6	5	23.5	5	68.1	5	50.0	2	2.8	
48	5	2.2	4	0.0	4	1.4	3	0.0	2	0.0	
49	3	8.4	3	4.2	3	8.0	4	0.0	4	6.7	
50	3	2.5	4	8.3	4	0.4	4	10.8	3	11.6	
51	3	18.0	4	70.2	3	0.0	3	286.0	3	101.0	
52	2	0.6	3	4.4	3	1.4	3	0.0	2	4.9	
53	3	11.1	4	270.6	4	105.4	4	8.0	4	476.1	
54	3	12.9	4	68.4	4	28.5	4	56.9	4	155.6	
55	5	56.5	5	4.9	5	13.1	5	39.6	7	119.4	
56	5	4.8	3	0.0	3	76.4	3	42.0	4	0	
57	3	0.0	3	0.3	3	0.0	3	1.1	2	0	
58	3	0.4	3	0.0	3	0.0	3	0.0	2	0	
Sum	46		48		47		47		41		

Table 6. Comparison of catch rates (wt/tow) in the research vessel and industry surveys based on the summer RV survey strata (446-458).

Survey	1995	1996	1997	1998	1999	2000
Spring RV	3.5	-	2.6	-	0.6	0.4
Spring industry	11.9	38.9	9.3	19.4	17.6	31.4
Summer RV	0.7	3.1	3.7	0.8	1.8	2.6
Fall industry	17.8	18.4	46.1	41.8	90.5	-

Table 7. Comparison of catch rates (wt/tow) from the slope strata(446,449-454) in the research vessel and industry surveys.

Survey	1995	1996	1997	1998	1999	2000
Spring RV	17.2	-	6.3	-	2.8	1.2
Spring industry	14.1	104.1	31.7	50.1	60.1	47.6
Summer RV	1.8	10.8	2.2	1.07	7.3	10.4
Fall industry	6.3	59	107.2	91.5	280.5	-

Table 8. Comparison of mean catch rates(wt/tow) from the non-slope strata(447,448,455-458). in the research vessel and industry surveys.

Survey	1995	1996	1997	1998	1999	2000
Spring industry	11.4	19.4	2.6	10.2	5	26.6
Summer RV	0.4	0.9	4.1	0.7	0.2	0.2
Fall industry	21.2	6.4	28	27	33.9	

Table 9. Comparison of mean catch rates (wt/tow) from the captain's sets during the spring and fall industry surveys.

Survey	1995	1996	1997	1998	1999	2000
Spring industry	346.8	54		187.6	610.1	181.6
n	12	11	0	6	12	16
Fall Industry	162.6	262.3	185.5	13.5	76.3	
n	12	10	10	10	10	

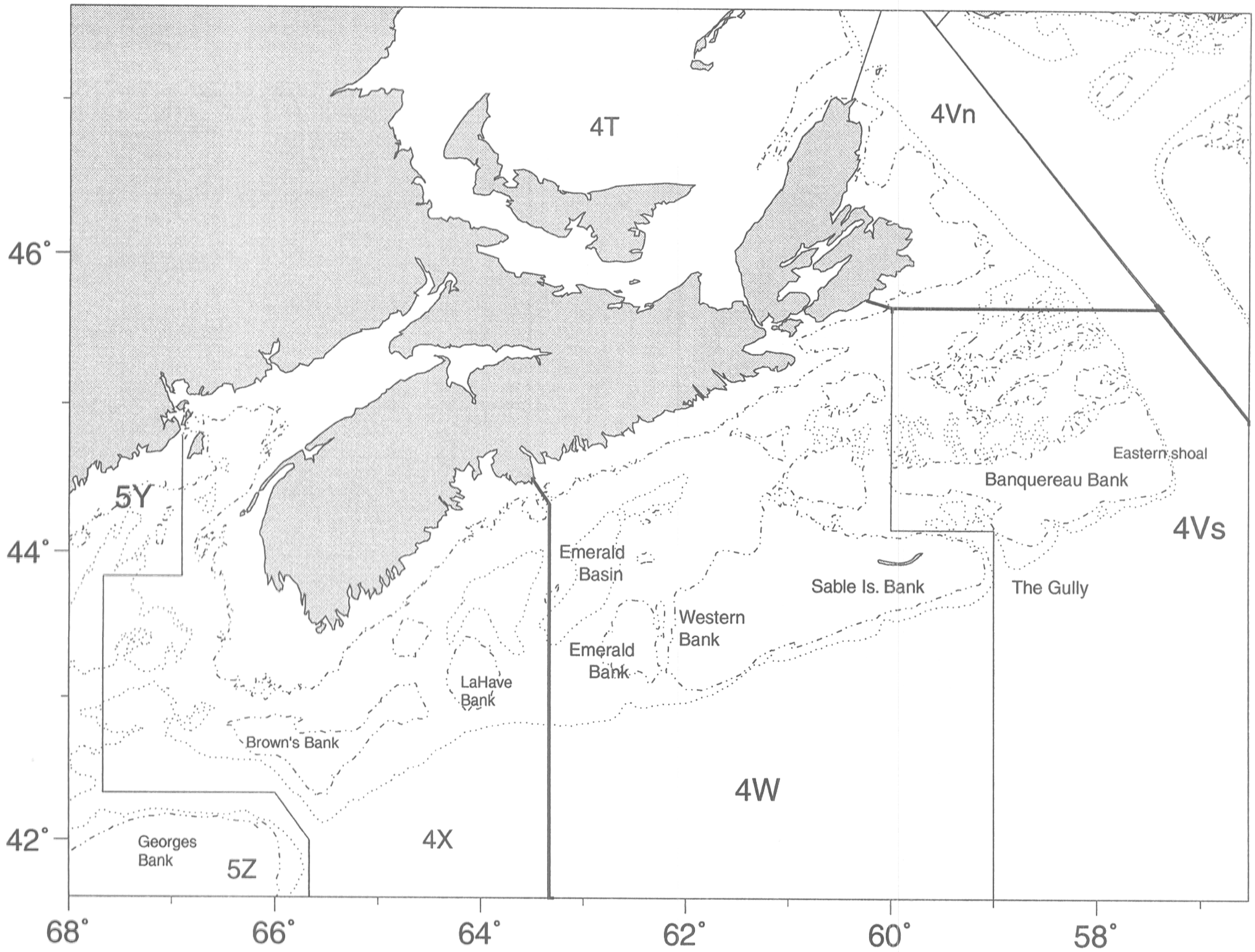


Figure 1. Geographic display of the Div. 4VsW skate management unit.

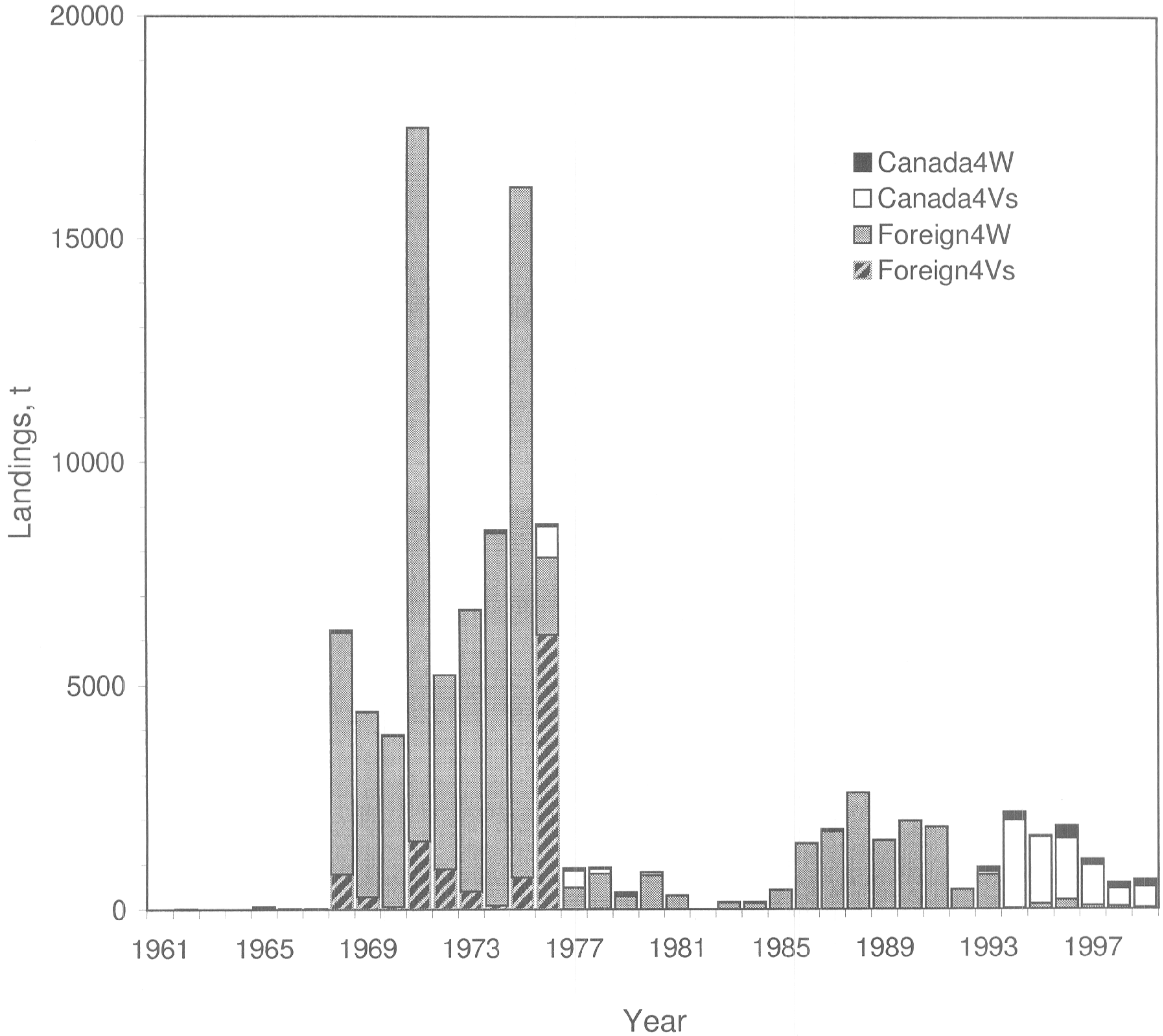


Figure 2. Reported nominal landings of skate (all species combined) in Div. 4VsW by division and country.

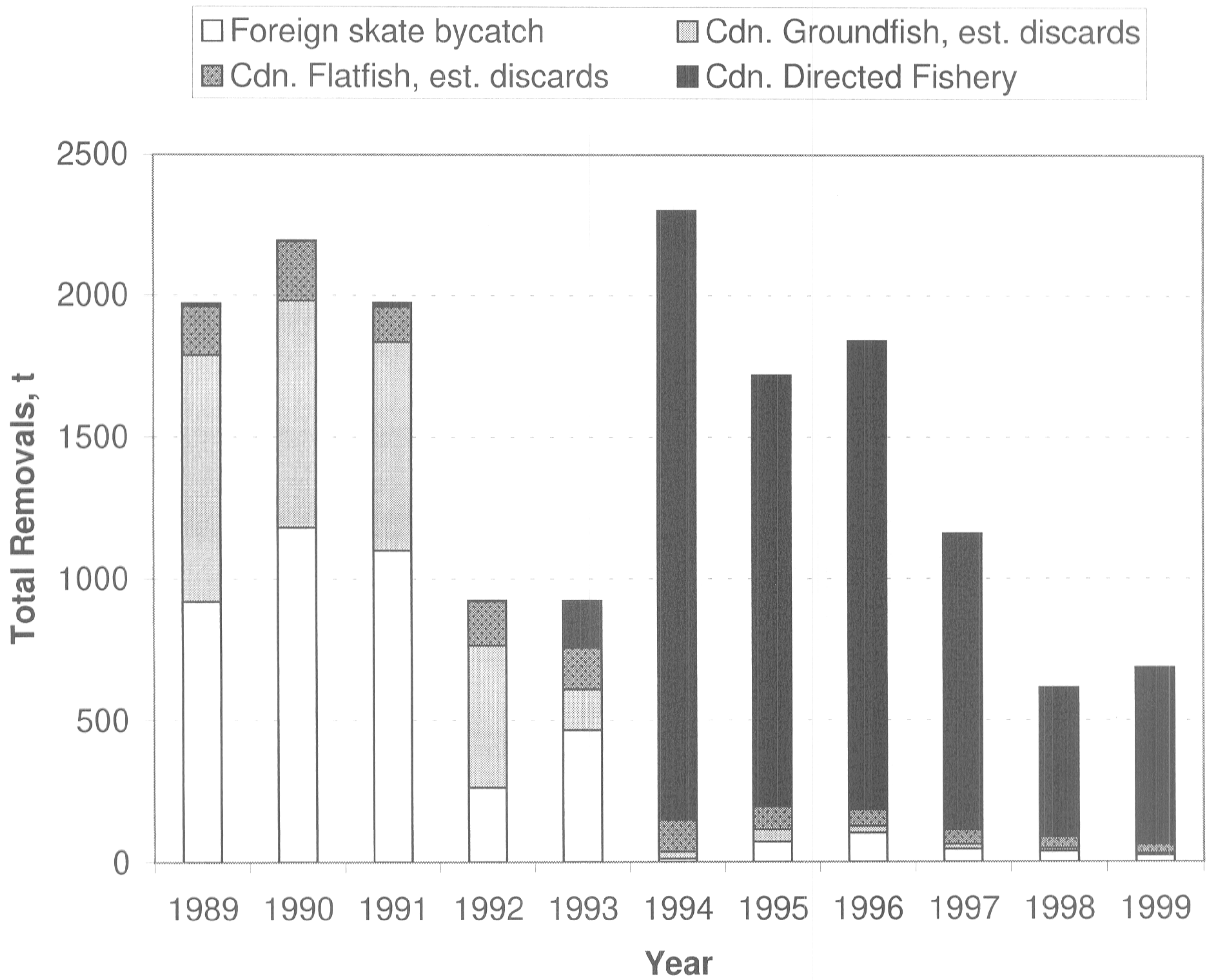


Figure 3. Total removals of winter skate in Div. 4VsW, including reported landings and discards from Canadian fisheries as estimated by DFO statistics and reports from the International Observer Program.

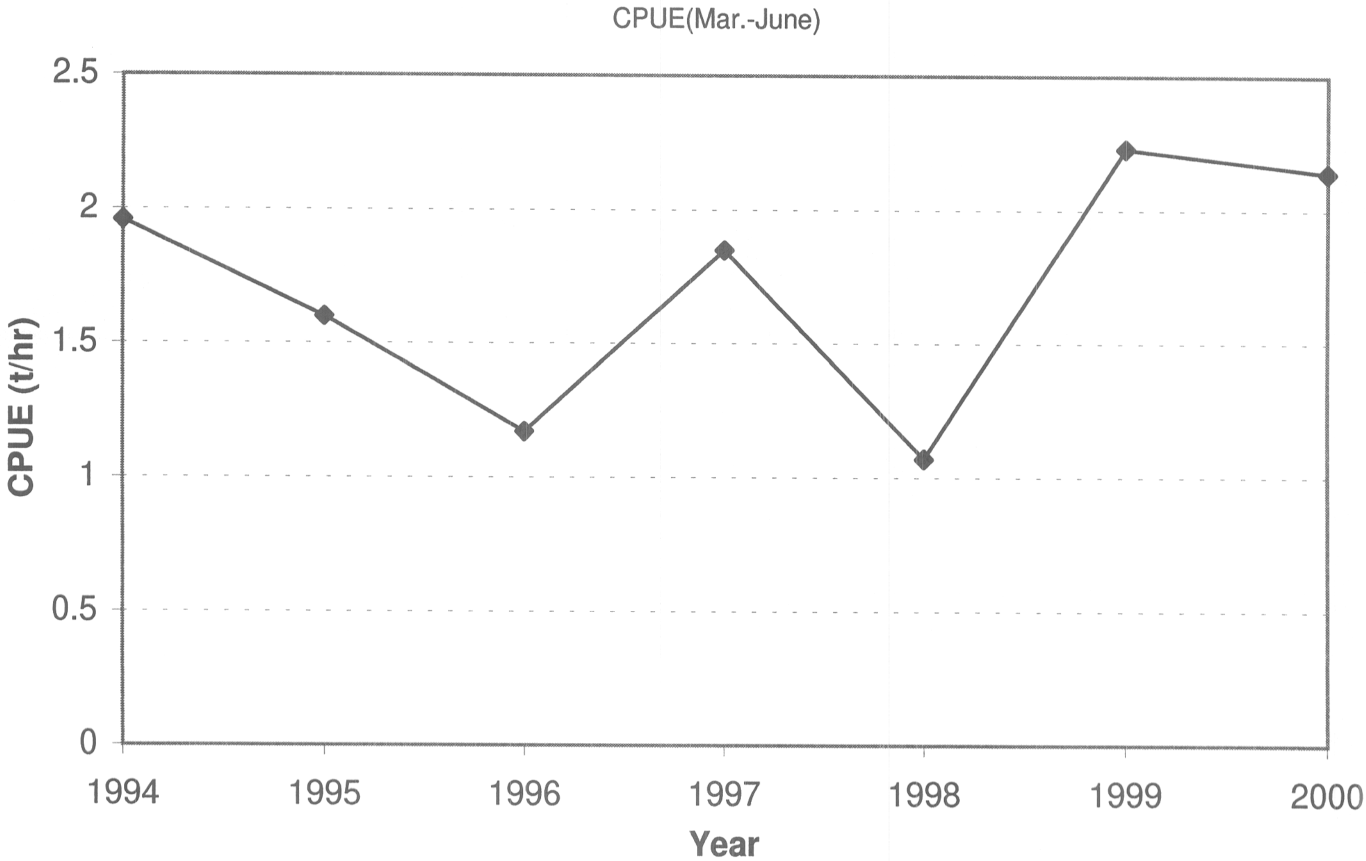
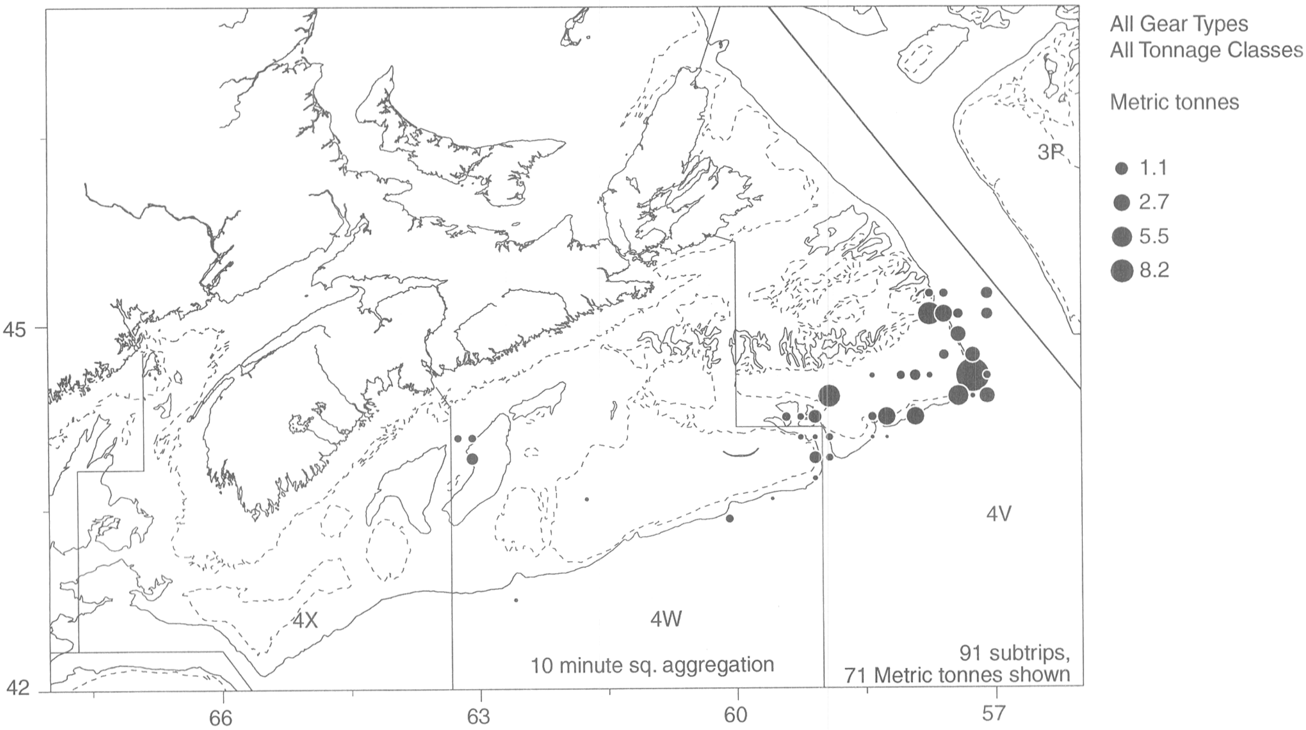


Figure 4. Directed catch per unit effort (t/hour) of winter skate from the four vessels prosecuting the spring (Mar-June) directed fishery in Div. 4Vs.

1986-1993



1994-2000

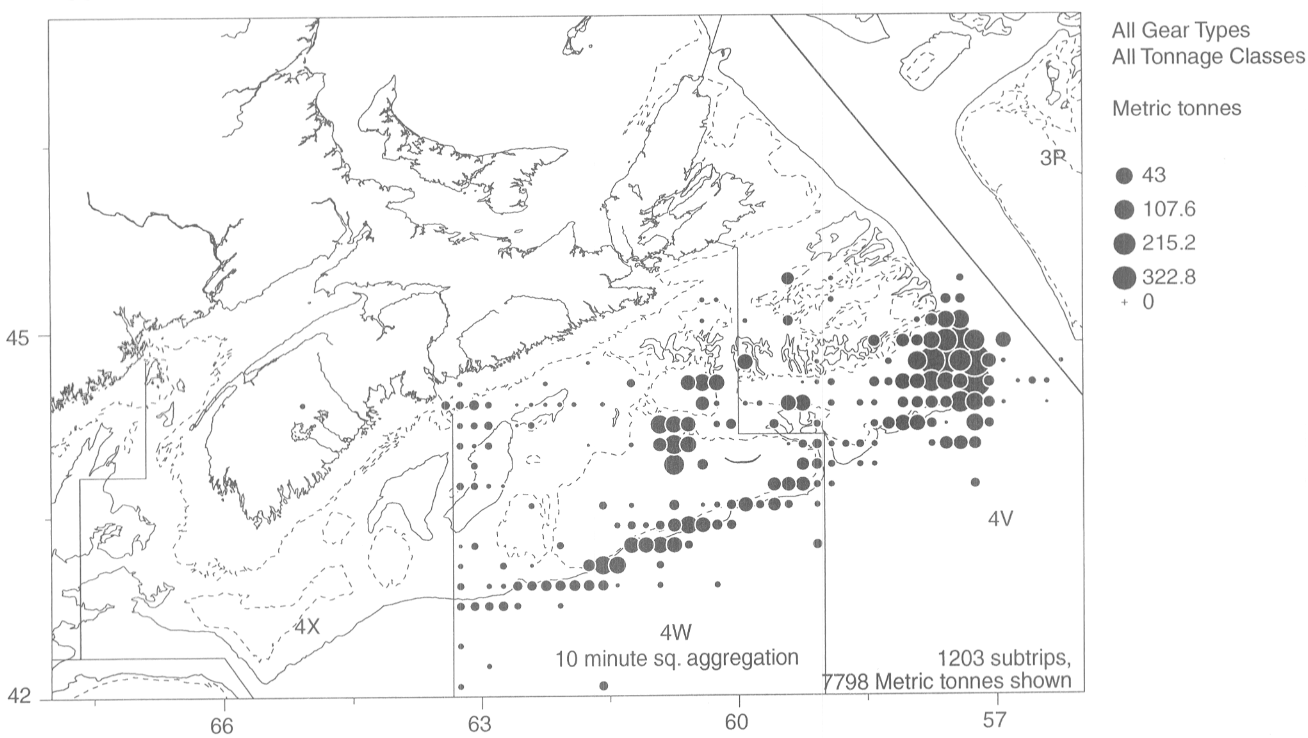


Figure 5. Reported landings of skate(all species) by Canada during the periods before and after the beginning of the directed skate fishery. Note difference in scale between the two time periods.

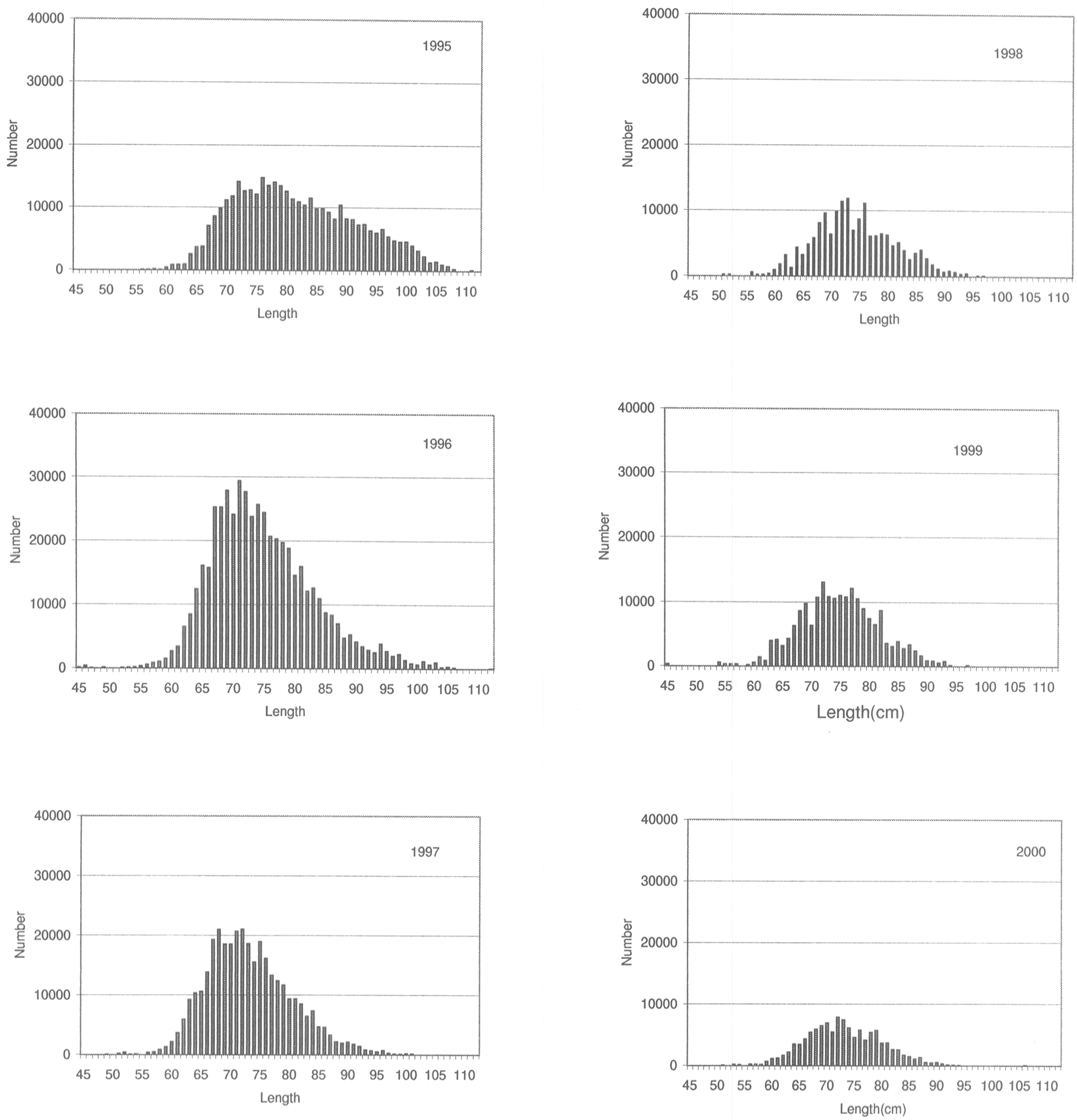


Figure 6. Total removals at length as generated from the commercial sampling of the directed winter skate fishery in Div. 4VsW.

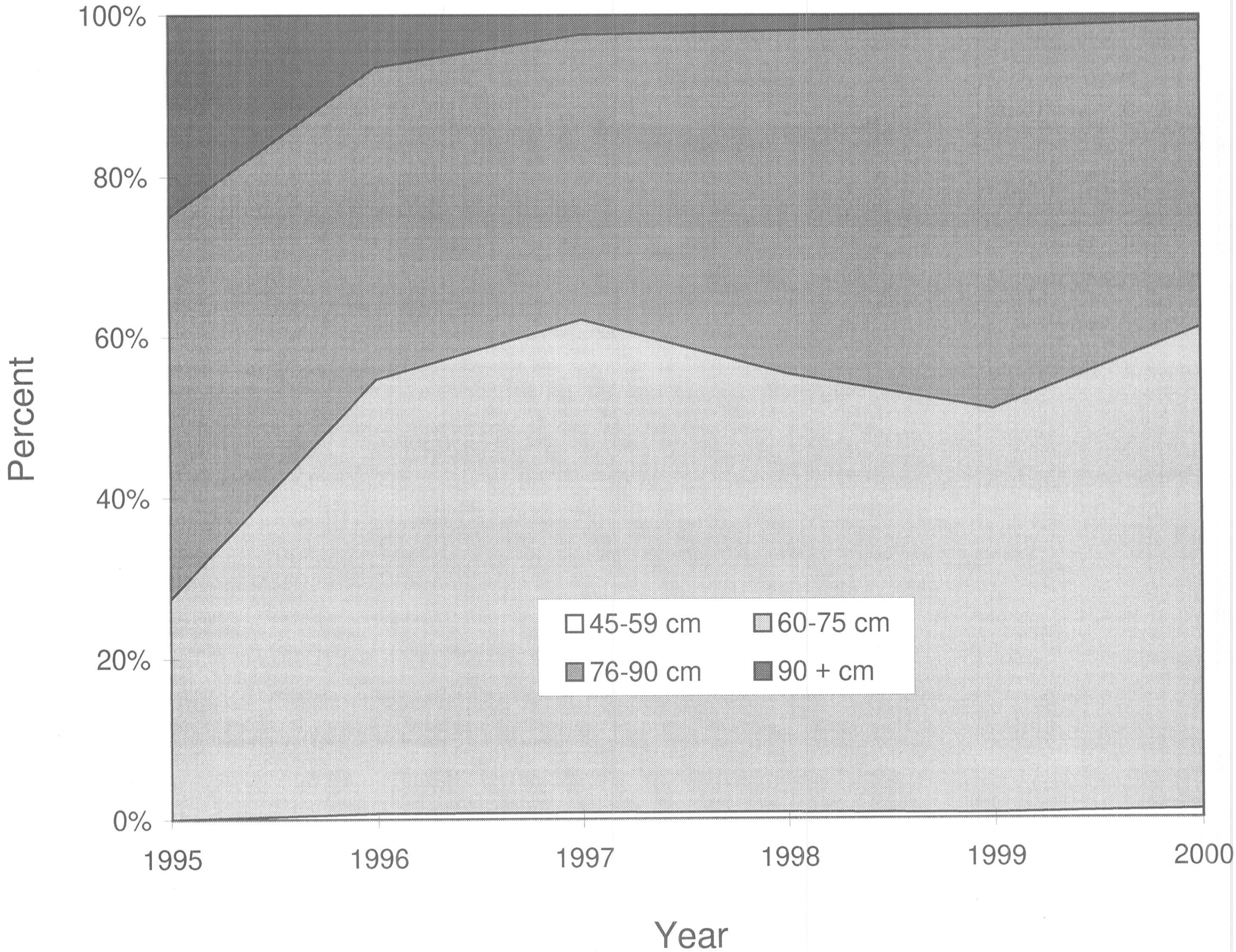


Figure 7. Percentage of winter skate by length groupings from the commercial length frequencies.

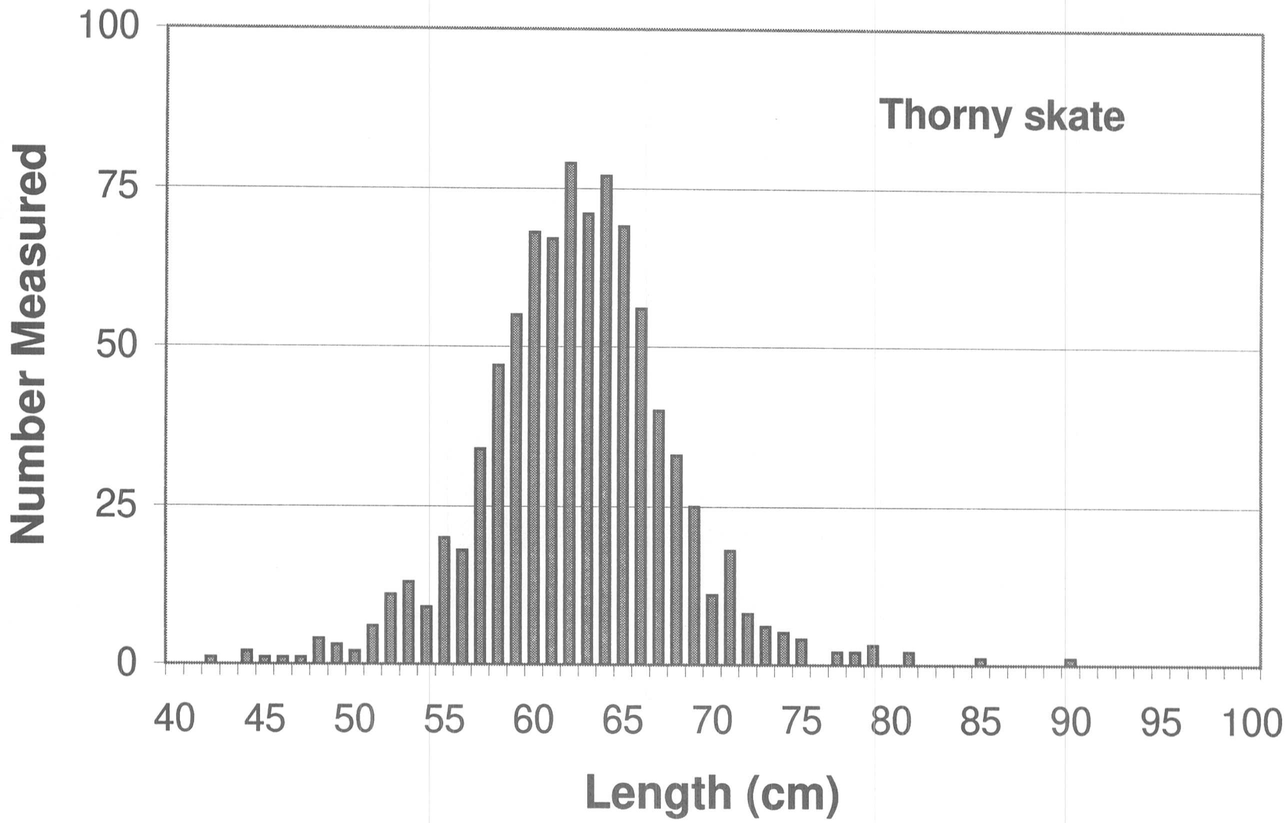


Figure 8. Combined length frequency of thorny skate from the commercial 2000 spring skate fishery in Div. 4Vs.

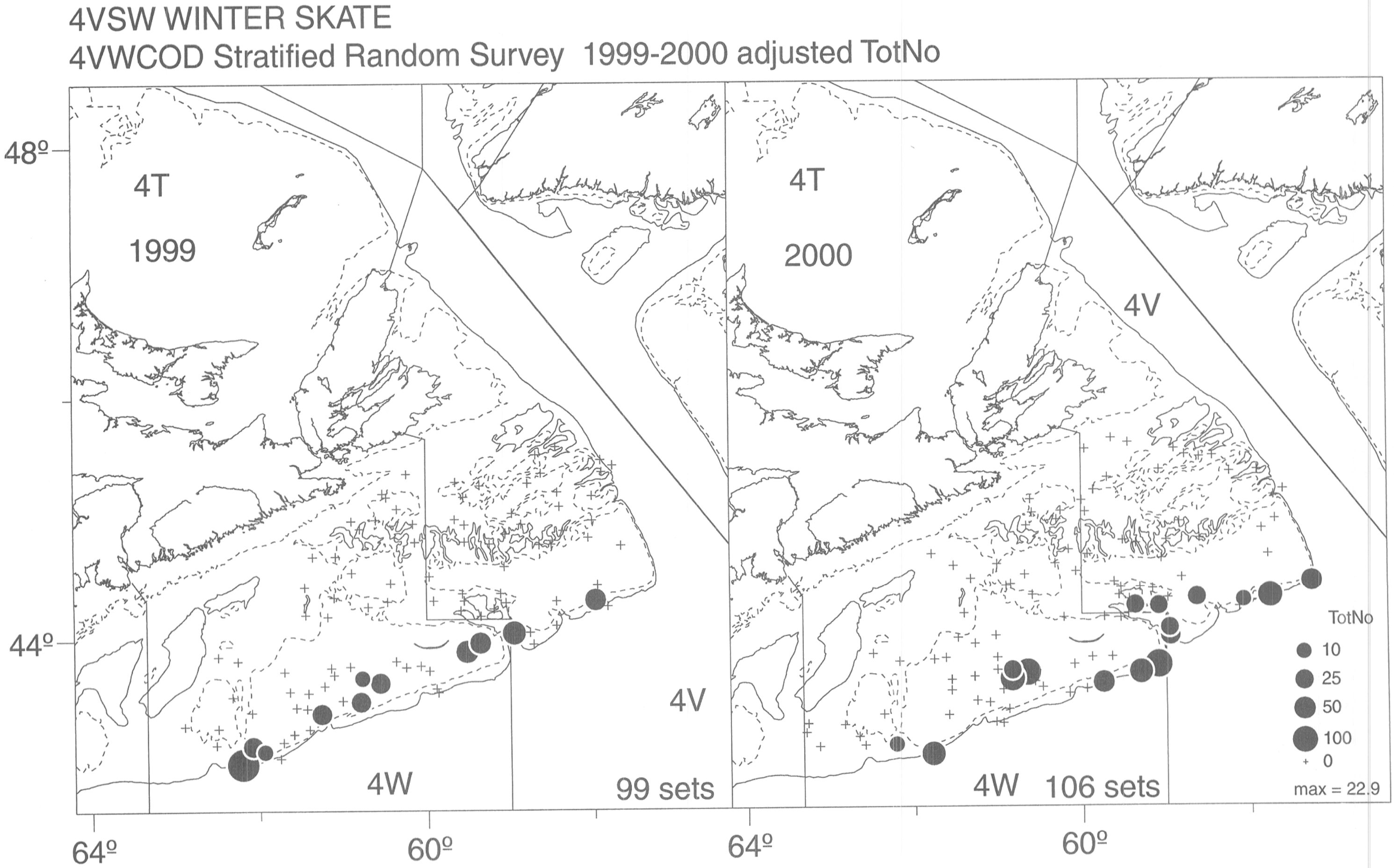


Figure 9. Distribution of winter skate (#/tow) on the eastern Scotian Shelf from the spring research survey in 1999 and 2000.

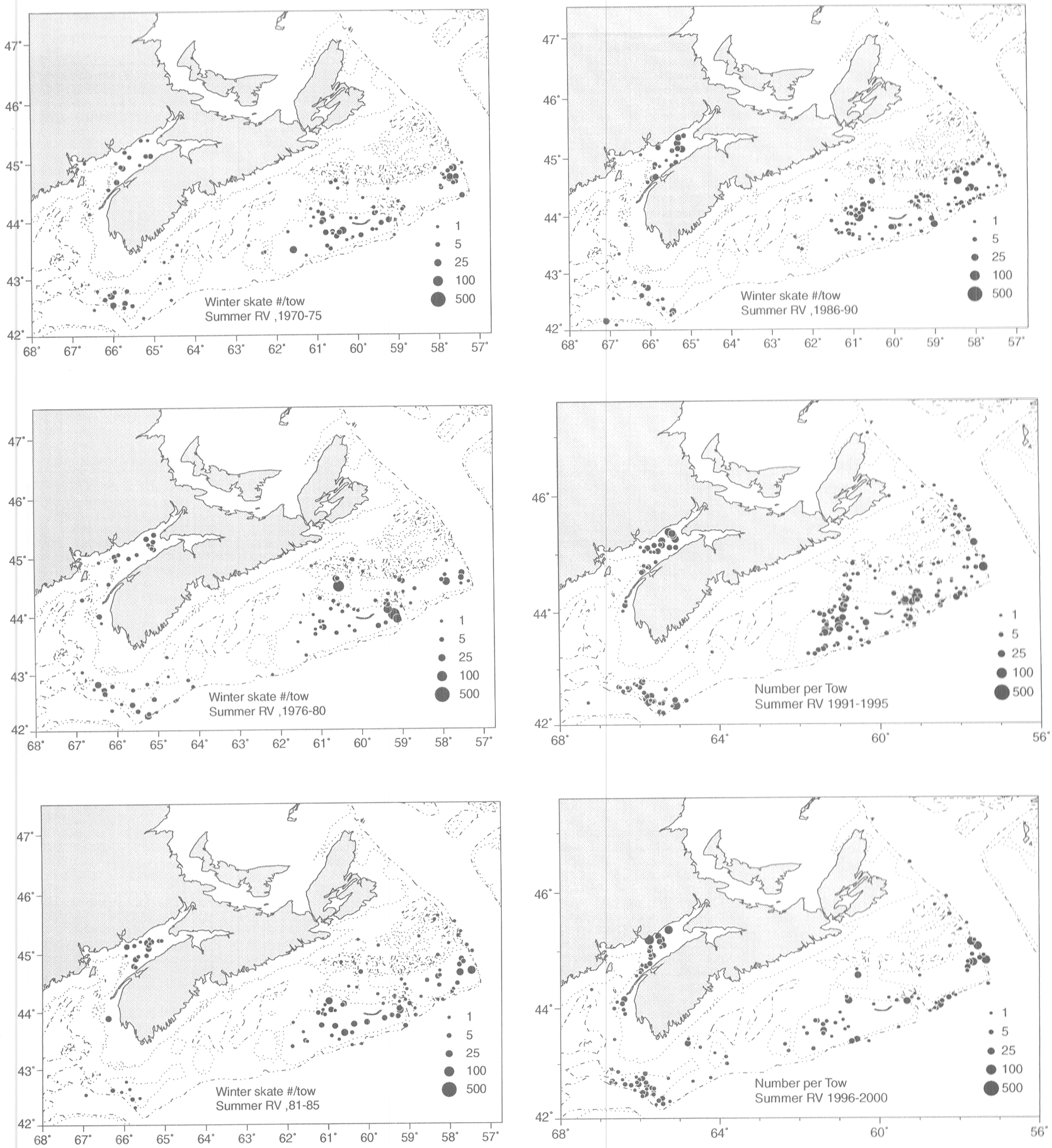


Figure 10. Distribution of winter skate (#/tow) on the Scotian Shelf from the summer groundfish research survey. Note that only positive sets are plotted.

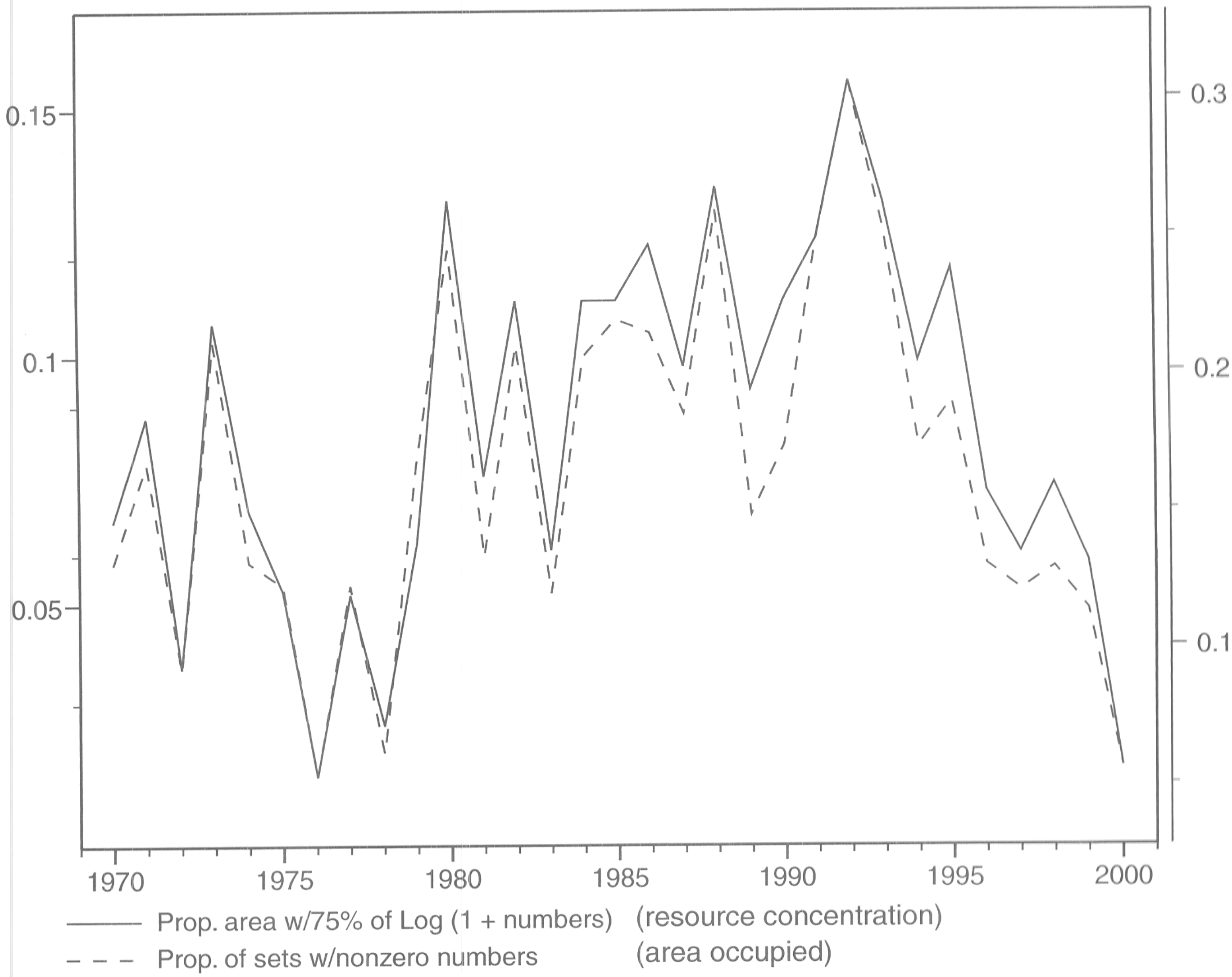
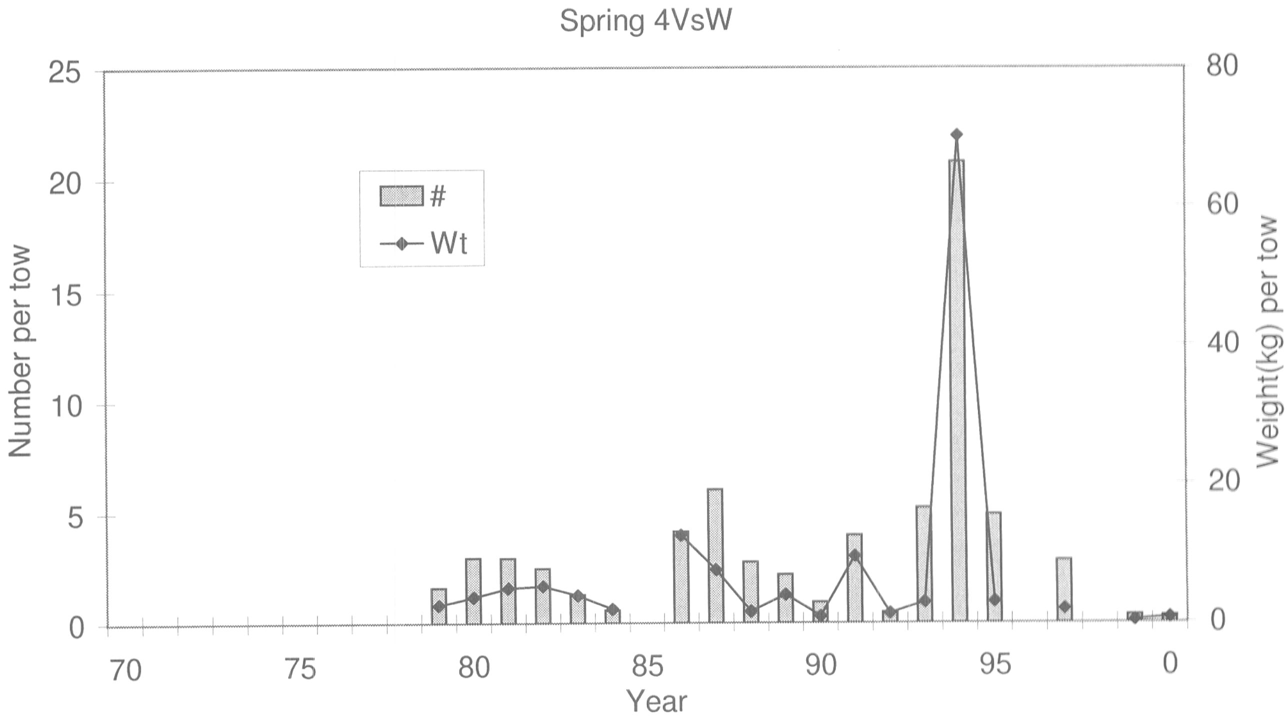


Figure 11. Distribution indices (area occupied and resource concentration) of winter skate in Div. 4VsW from the summer research vessel groundfish survey.



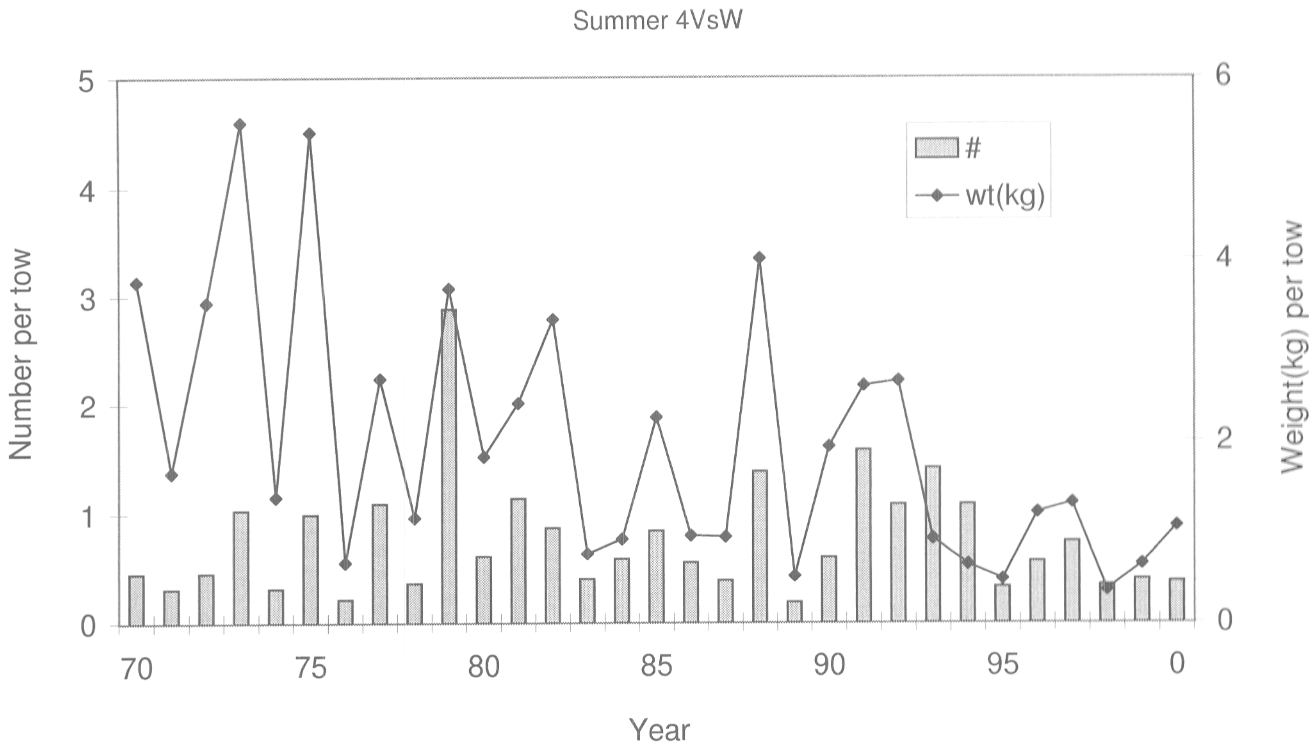
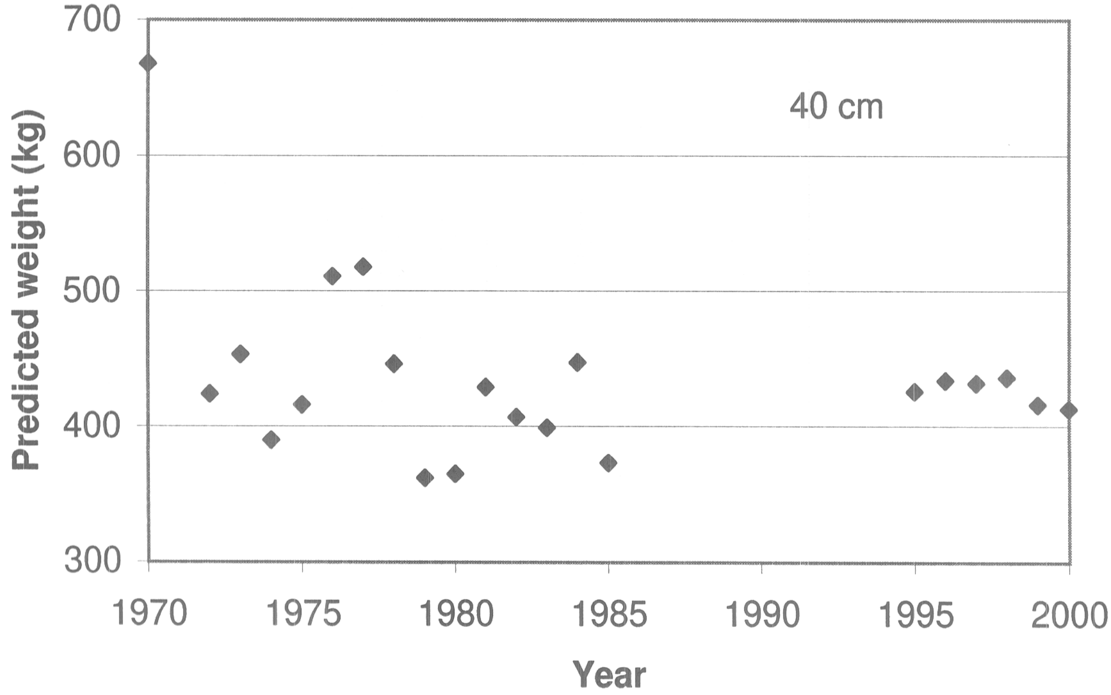


Figure 12. Mean number and weight per tow of winter skate from the spring and summer research vessel groundfish surveys surveys in Div. 4VsW.



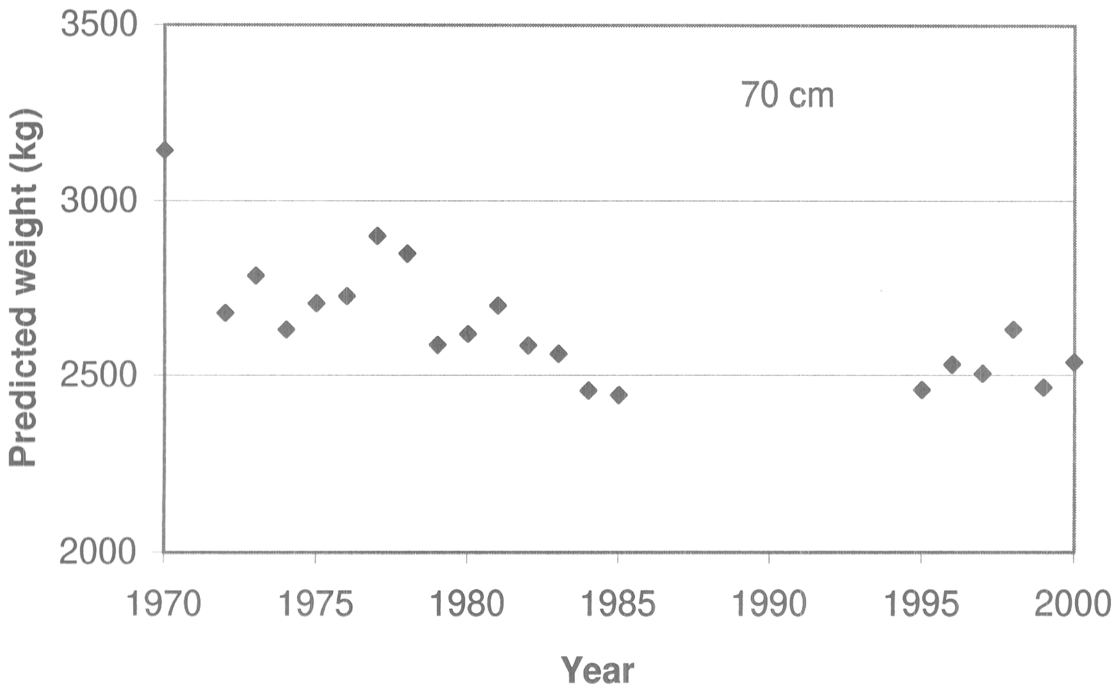


Figure 13. Predicted weight at length of winter skate from the summer research vessel survey in Div. 4VsW.

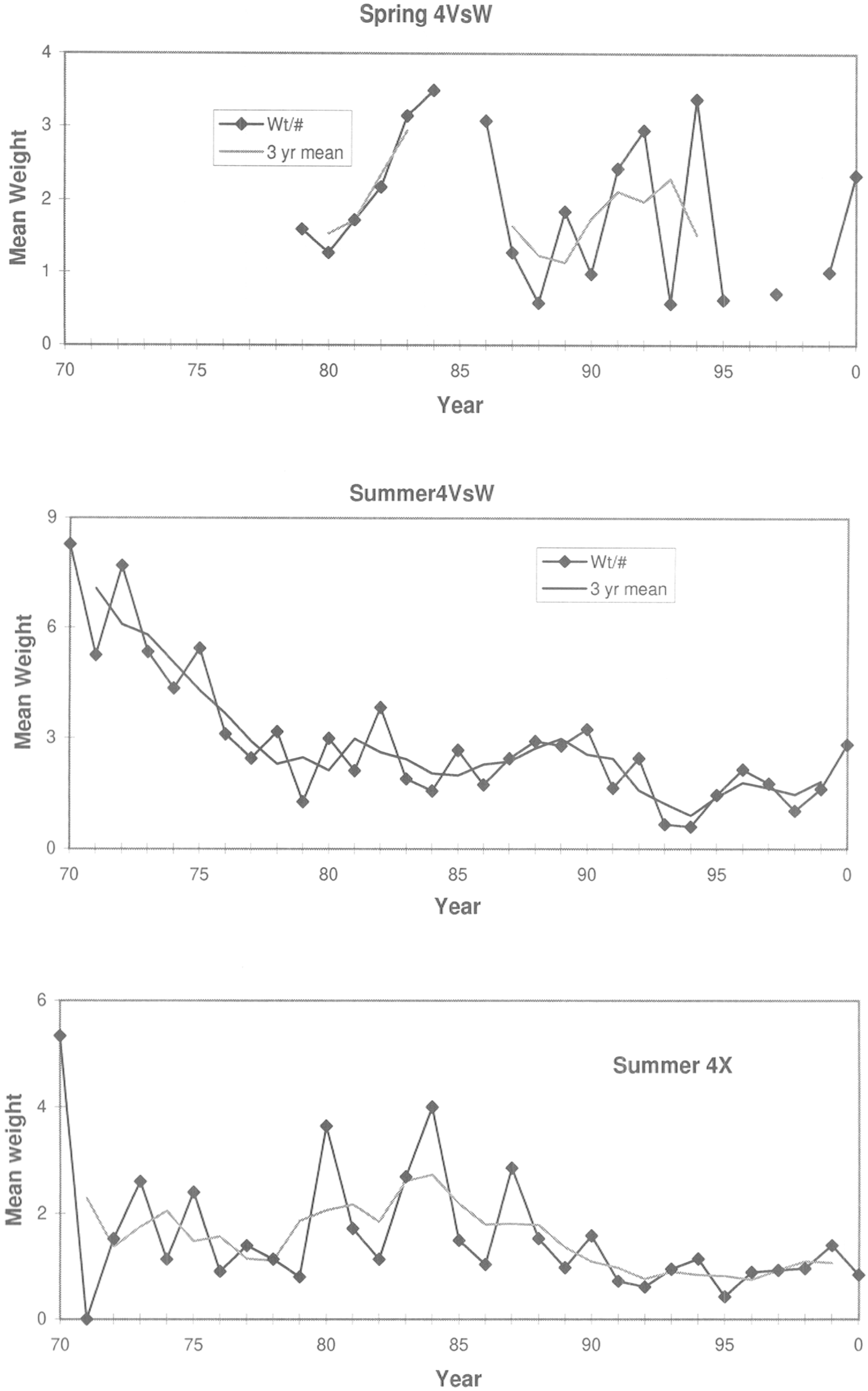


Figure 14. Comparison of the mean weight of an individual winter skate from the spring and summer RV surveys in Div. 4VsW and the summer RV survey in Div. 4X.

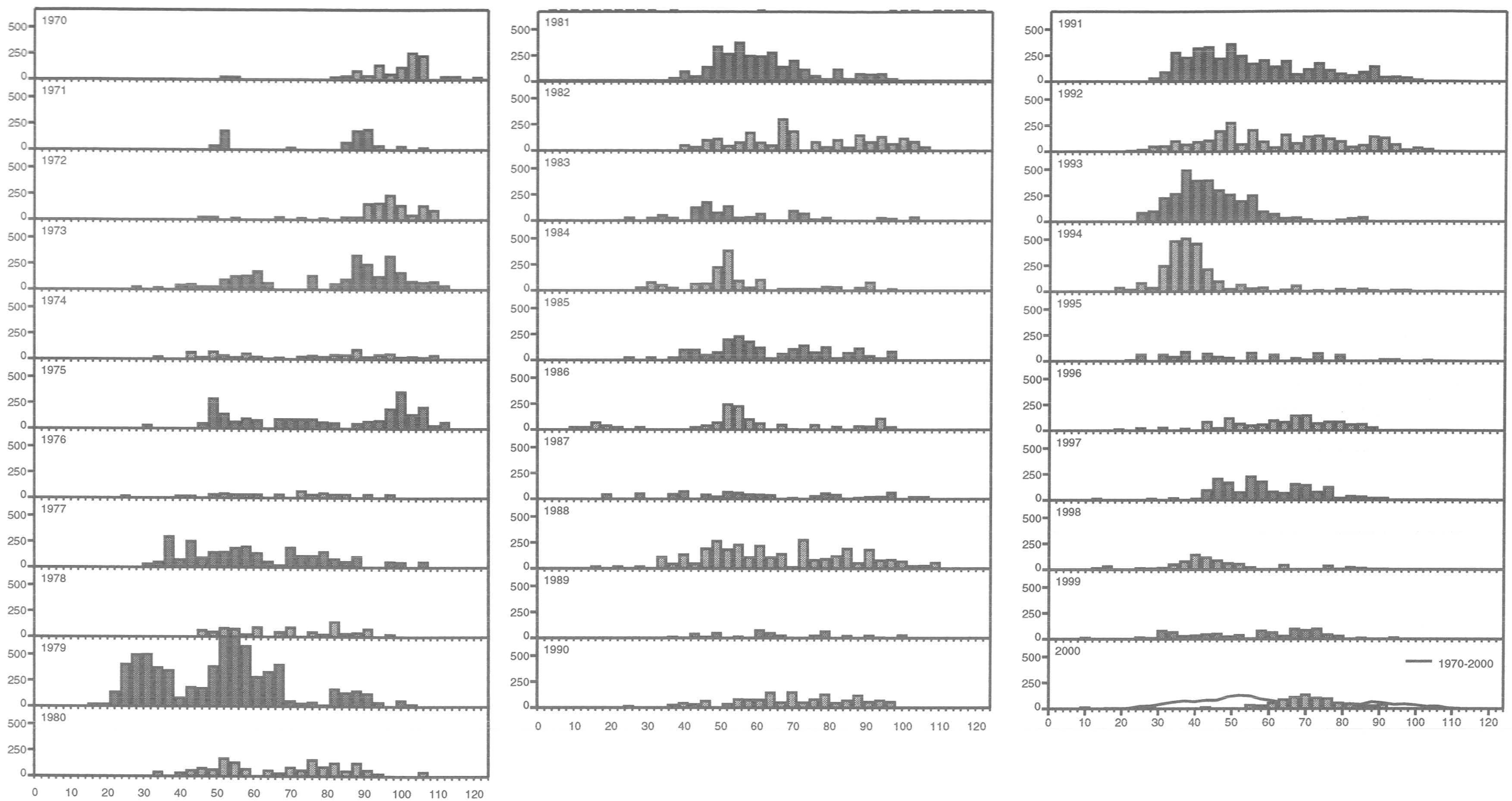


Figure 15. Annual stratified length frequencies of winter skate from the summer research vessel groundfish survey in Div. 4VsW.
The 1970-2000 mean length frequency is within the year 2000 block for comparison.

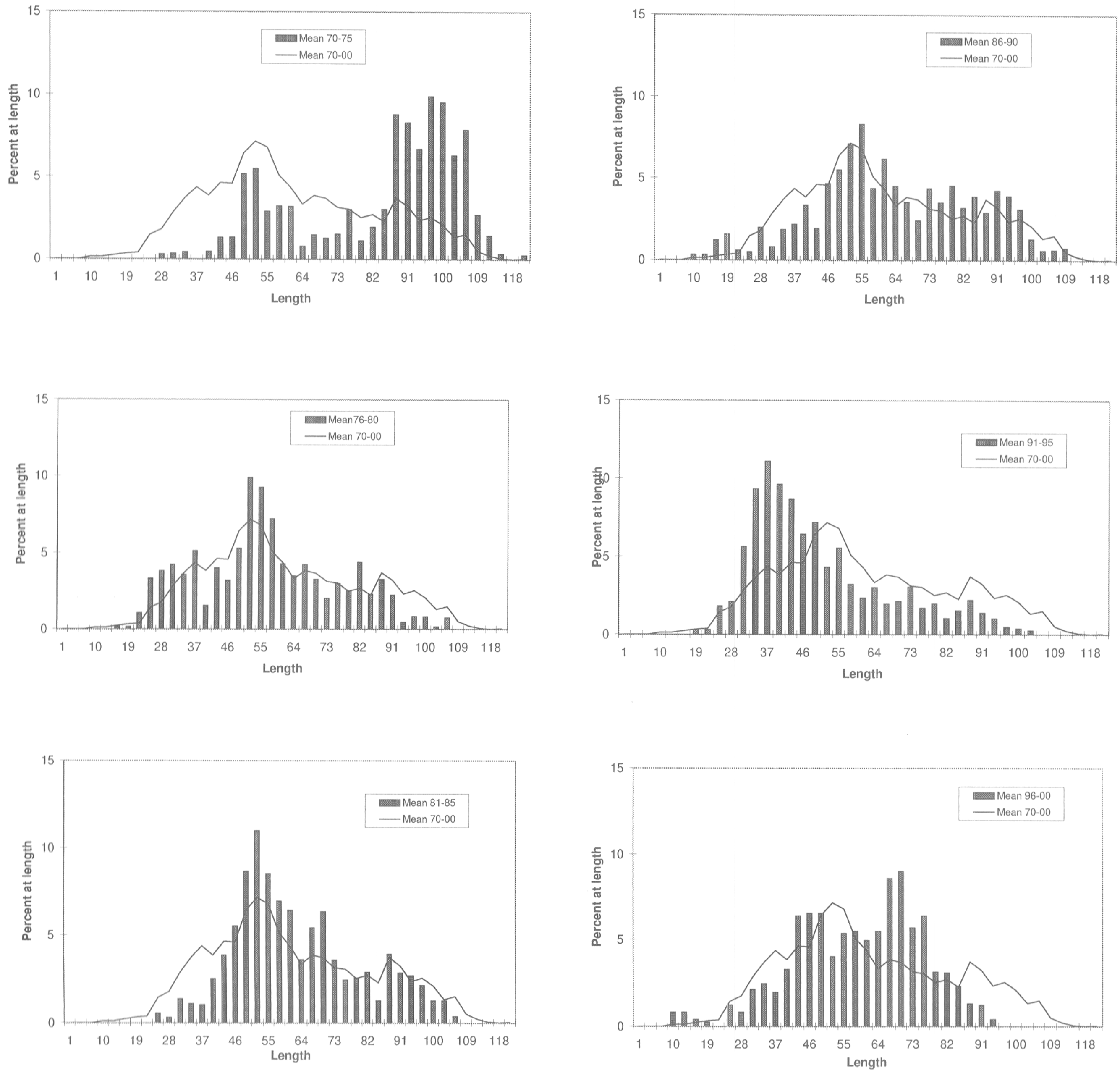
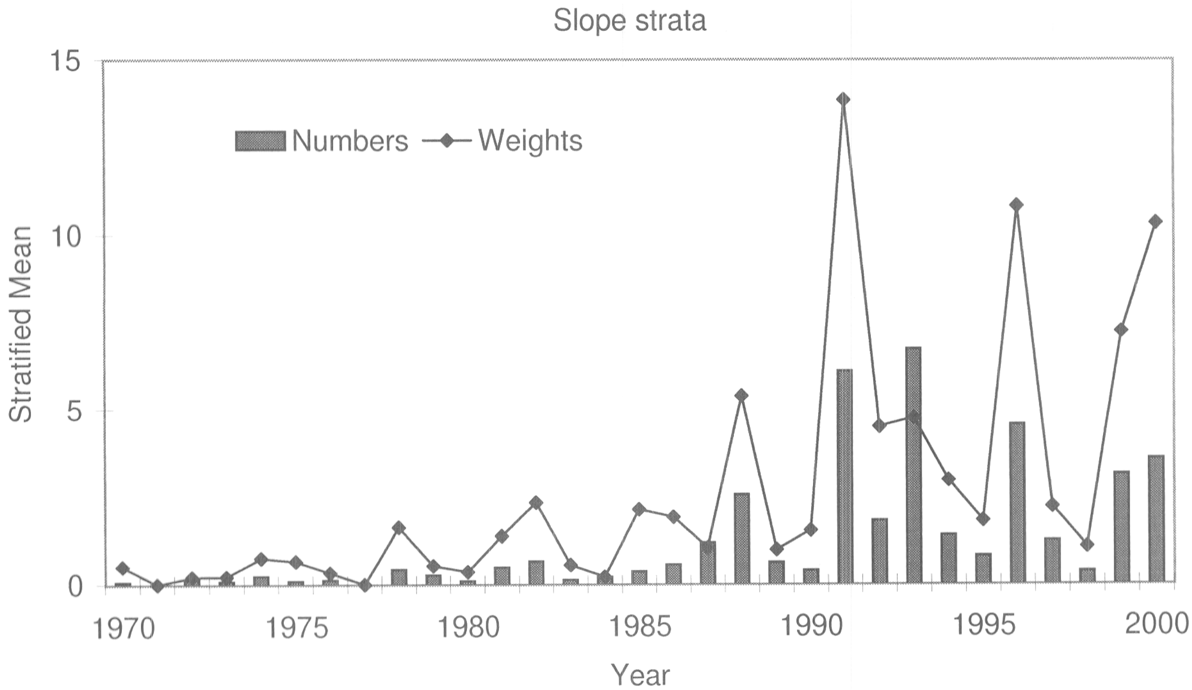


Figure 16. Percent length frequencies of winter skate from the summer research vessel groundfish surveys in Div 4VsW .



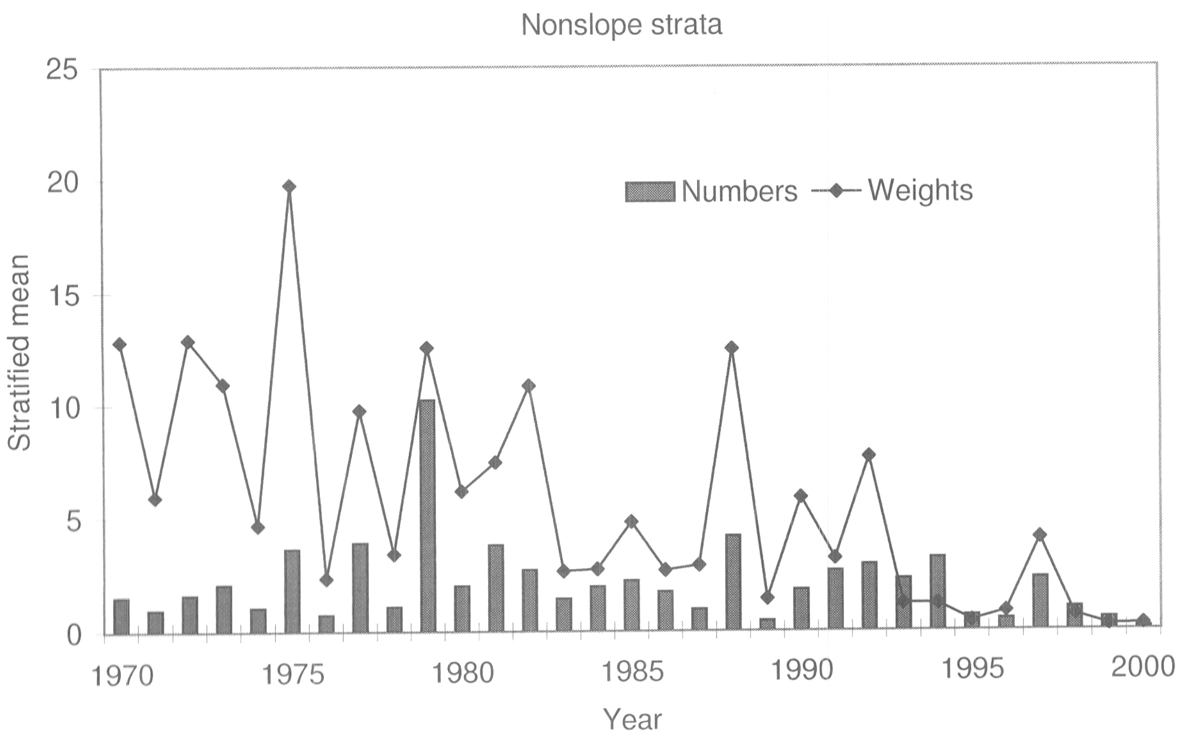
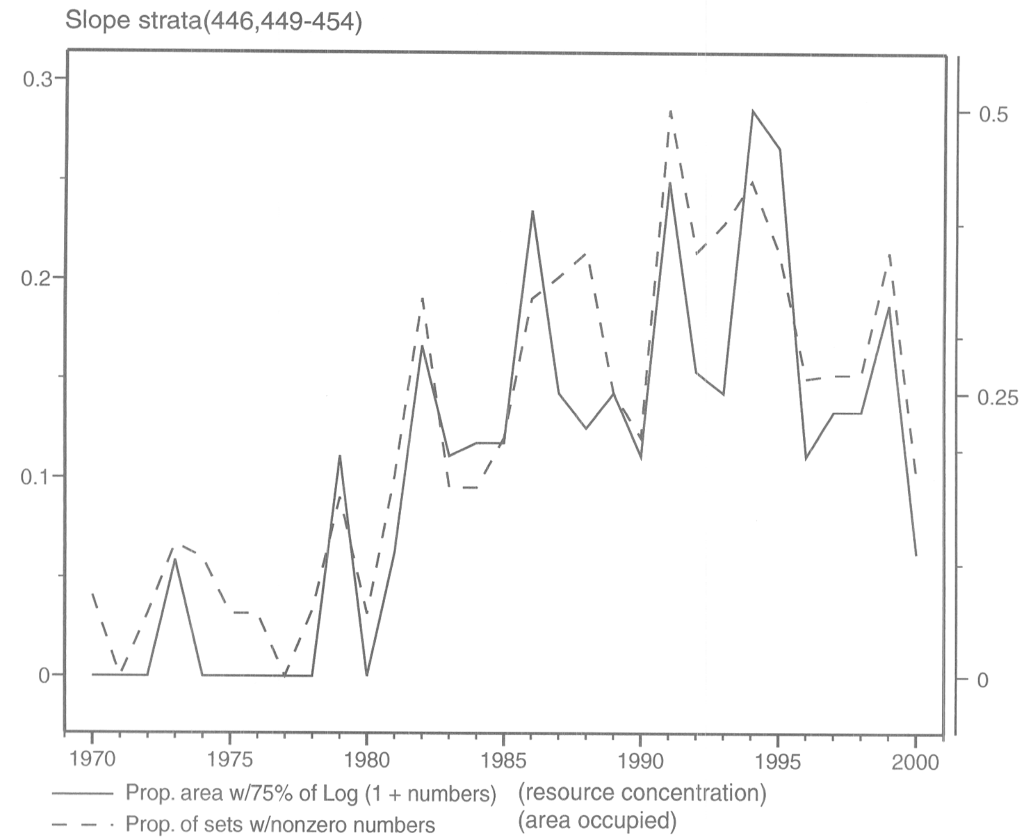


Figure 17. Number and weight(kg) per tow from the summer groundfish survey in the slope and nonslope strata of Div. 4VsW.



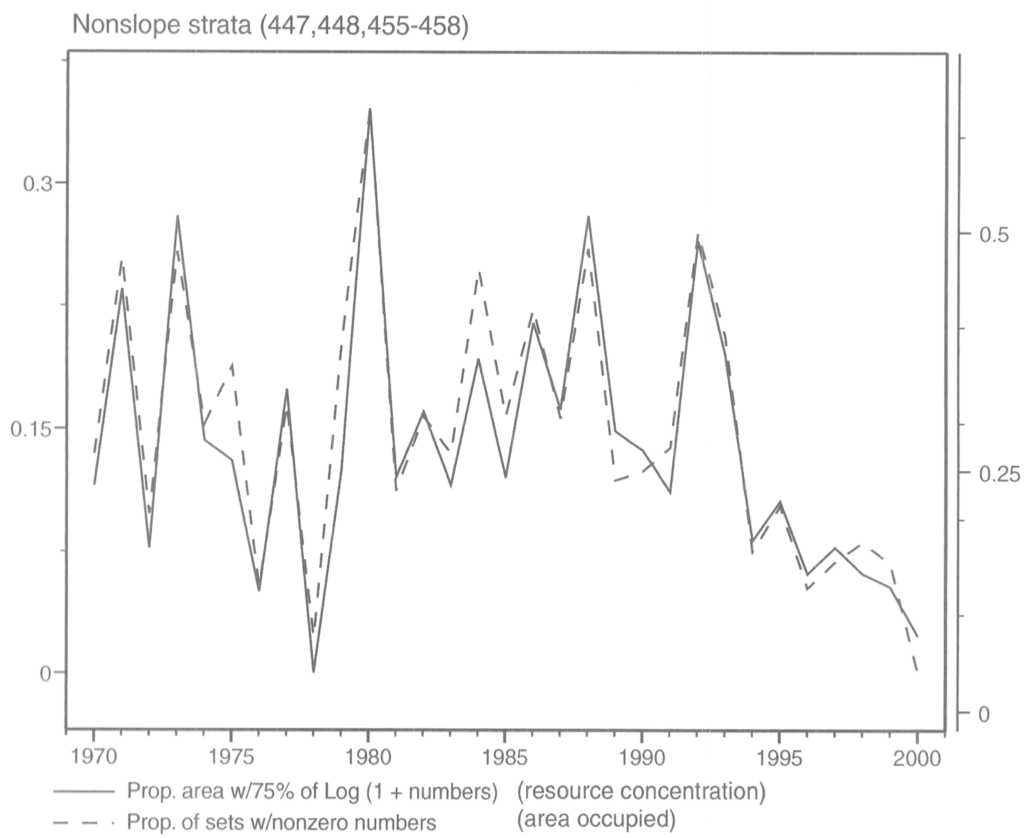
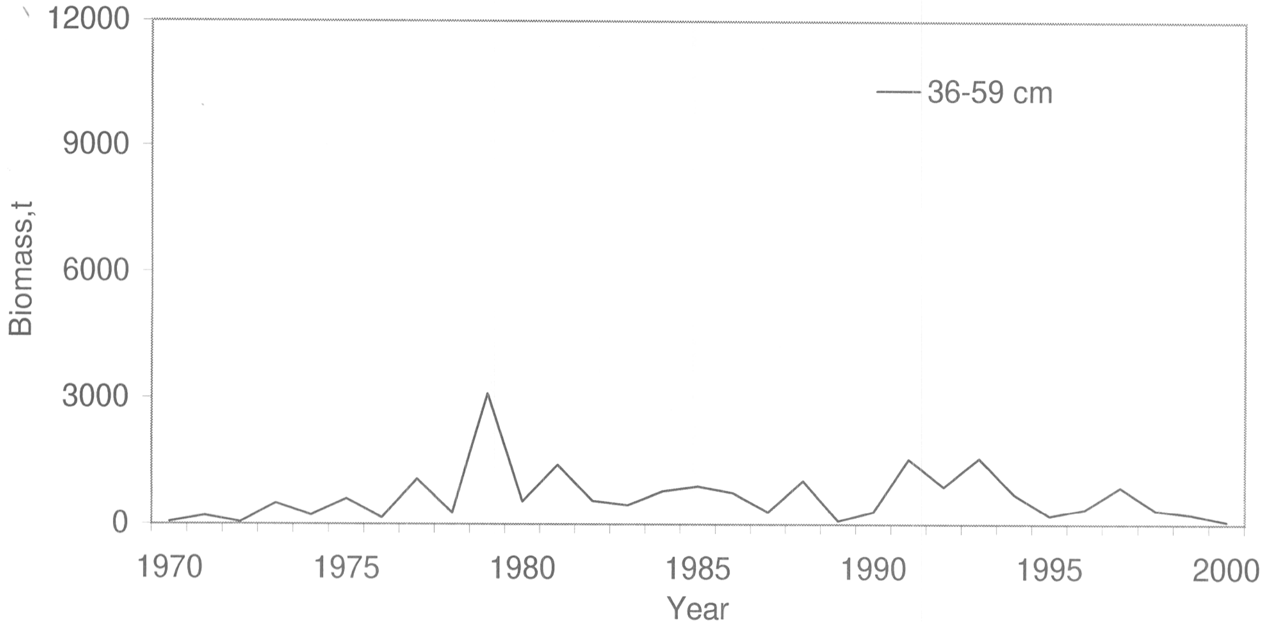


Figure 18. Distribution indices (area occupied and resource concentration) of winter skate in the slope and nonslope areas of Div. 4VsW from the summer research vessel groundfish survey.



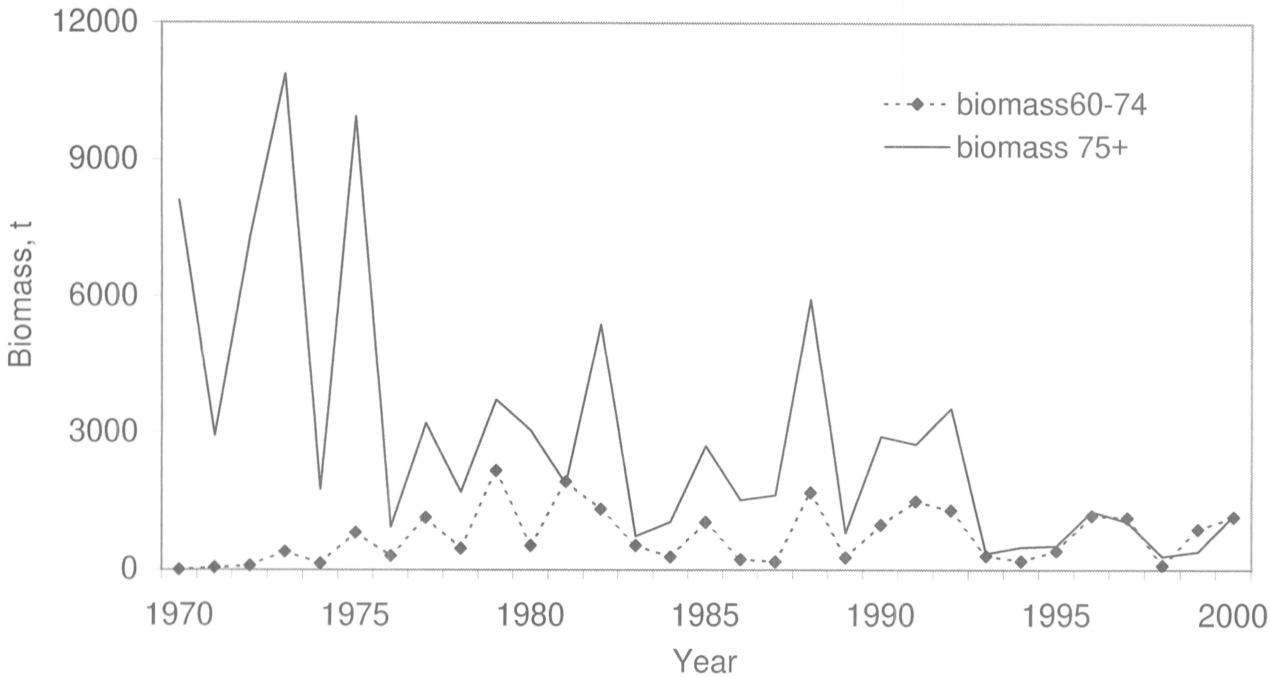


Figure 19. Biomass estimates of winter skate from the summer groundfish survey in Div. 4VsW by length groupings 36-59, 60-74 and 75+ cm.

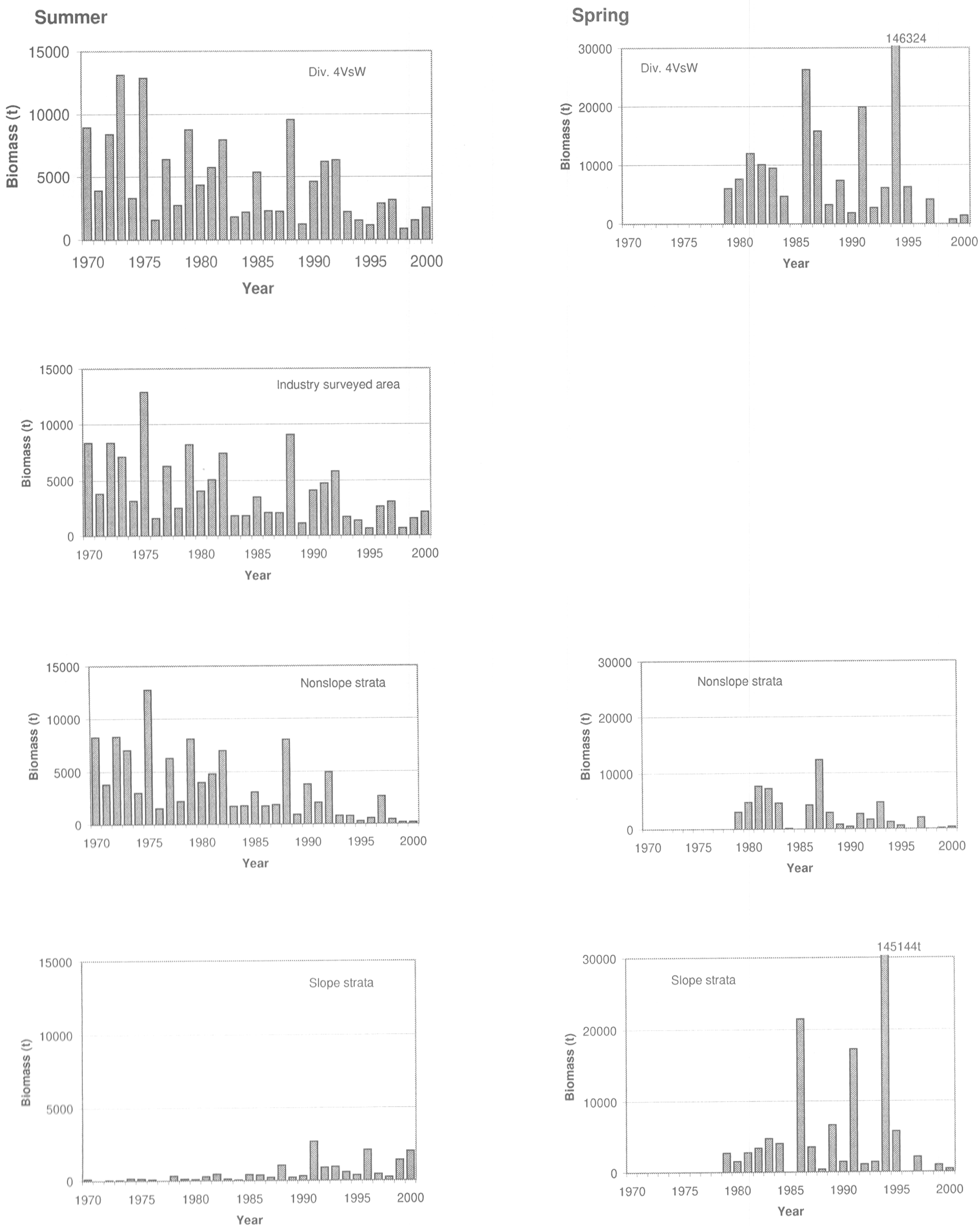


Figure 20. Biomass estimates of winter skate from the summer groundfish survey in Div. 4VsW.

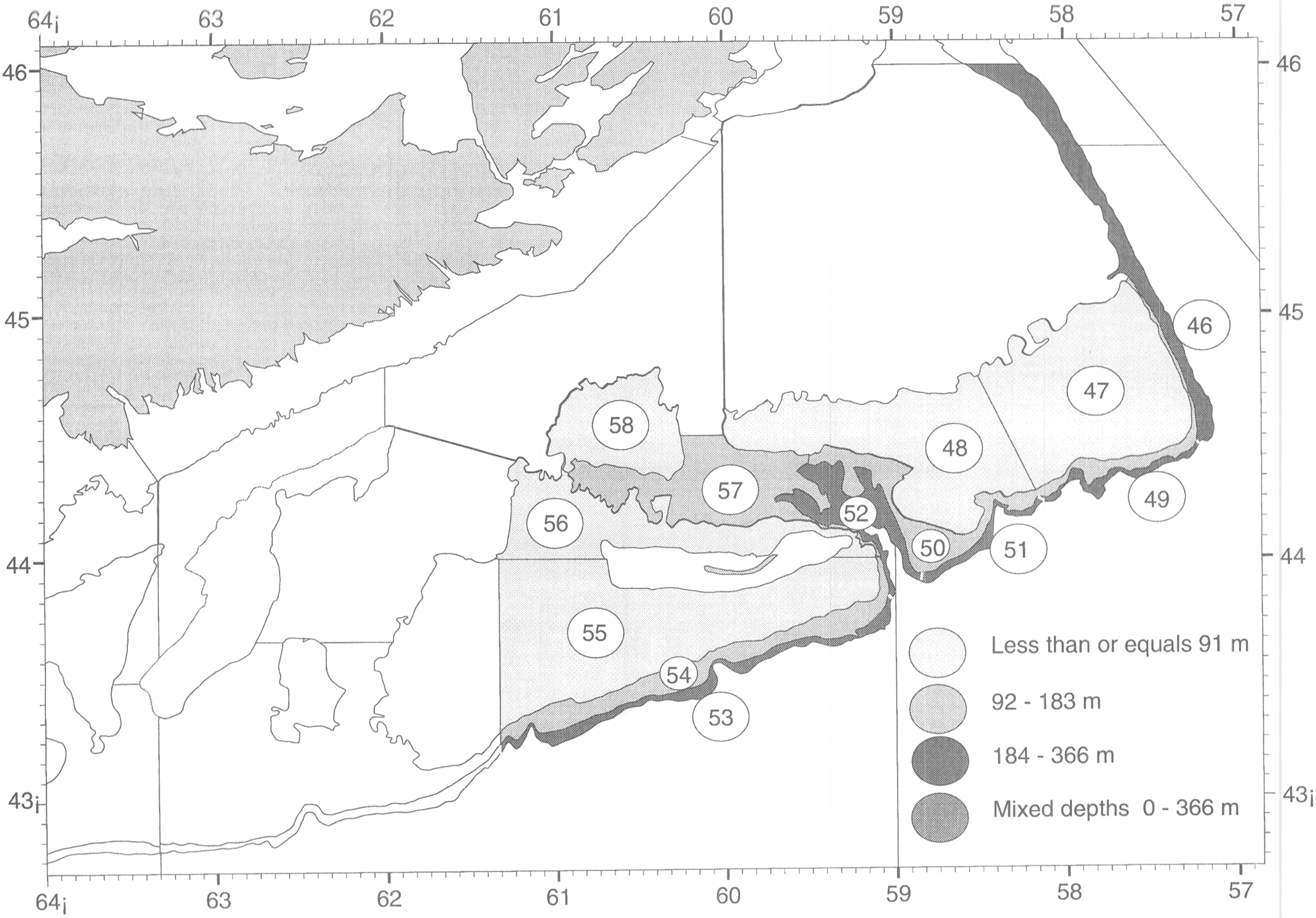


Figure 21. Summer research vessel groundfish strata surveyed during the joint industry/science skate survey.

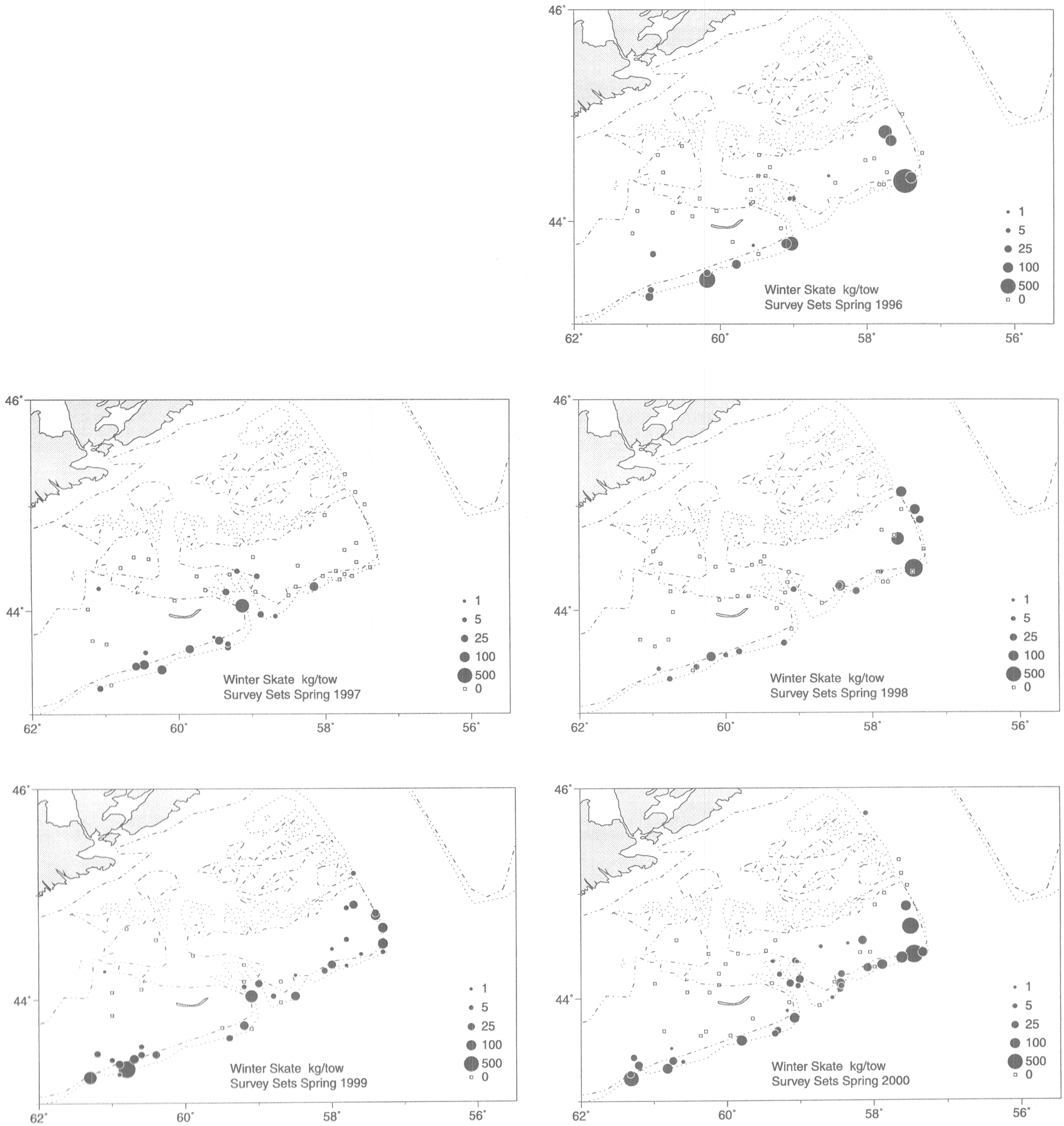


Figure 22. Annual distribution of winter skate caught during the survey sets of the spring industry/ science skate survey in Div. 4VsW.

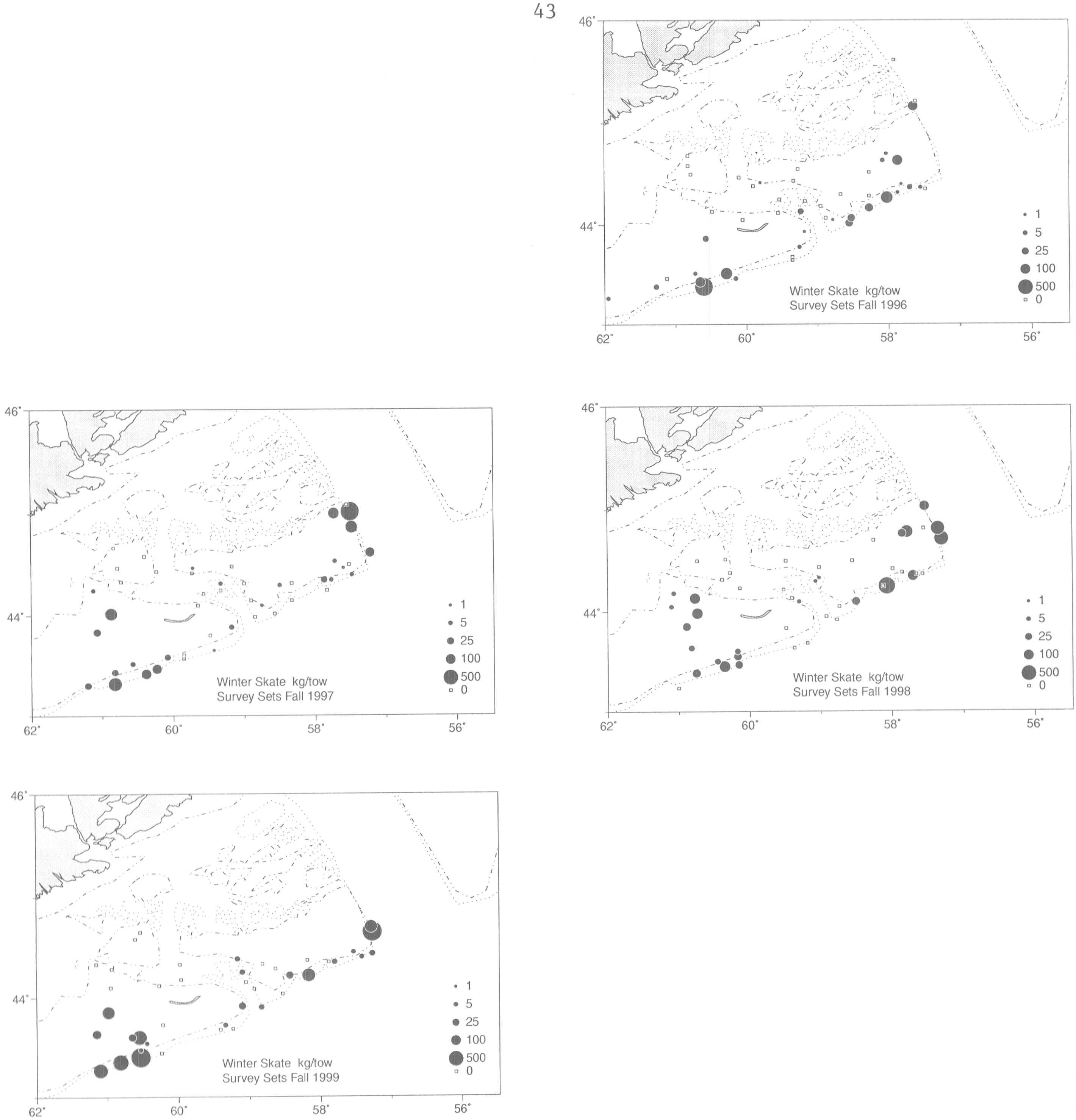


Figure 23. Annual distribution of winter skate caught during the survey sets of the fall industry/science skate survey in Div. 4VsW.

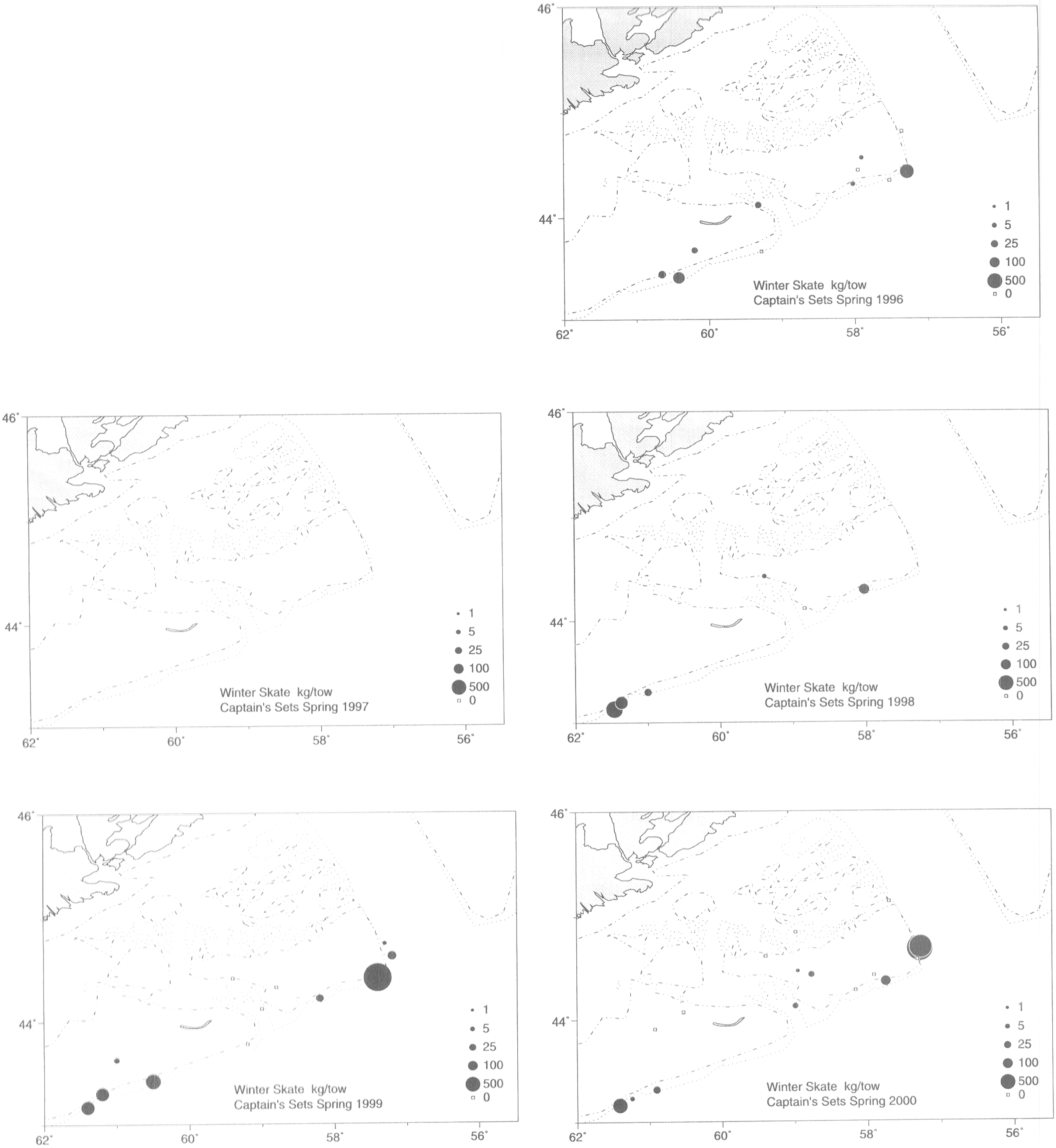


Figure 24. Annual distribution of winter skate from the captain's sets of the spring industry/science skate survey in Div. 4VsW.

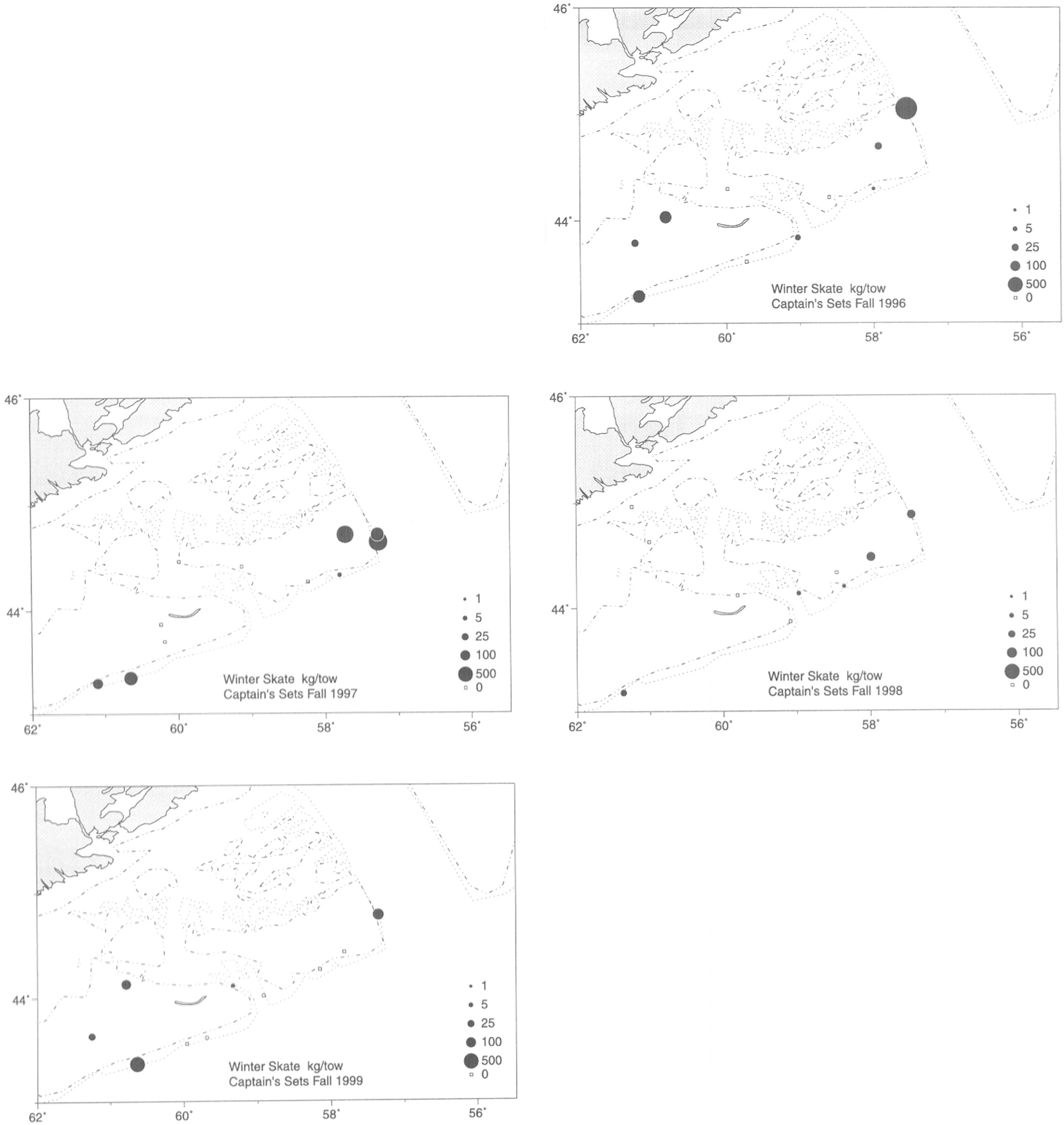


Figure 25. Annual distribution of winter skate from the captain's sets of the fall industry/science skate survey in Div. 4VsW.

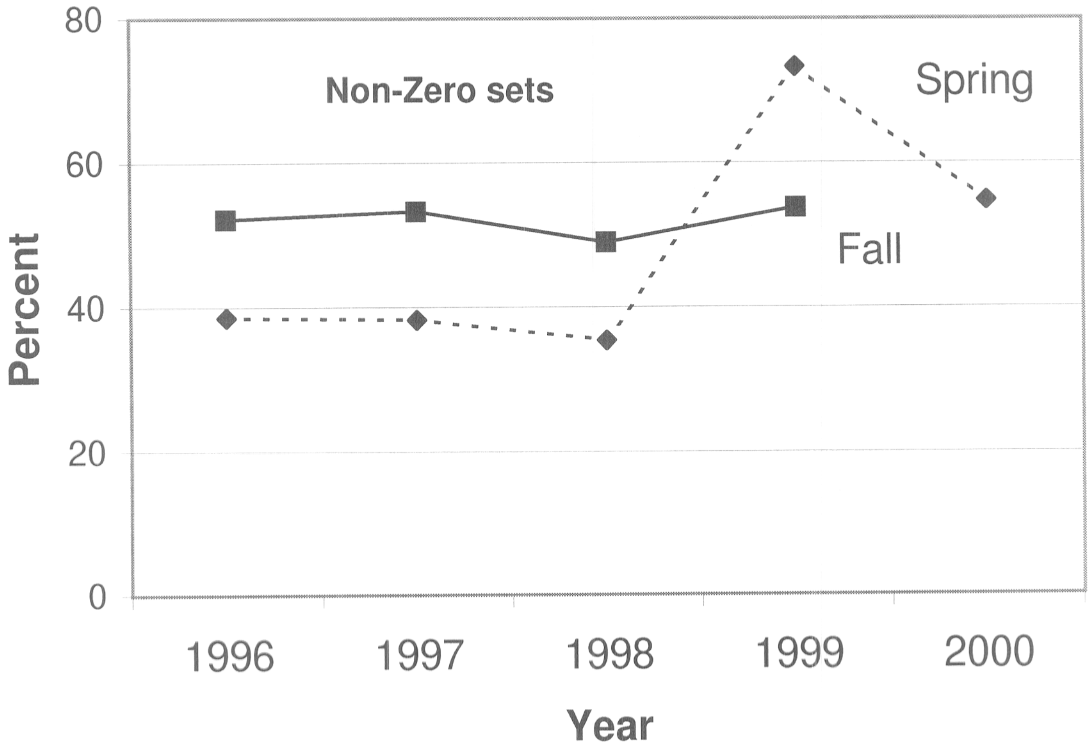


Figure 26. Percentage of sets with catches of winter skate in the spring and fall industry/science skate surveys.

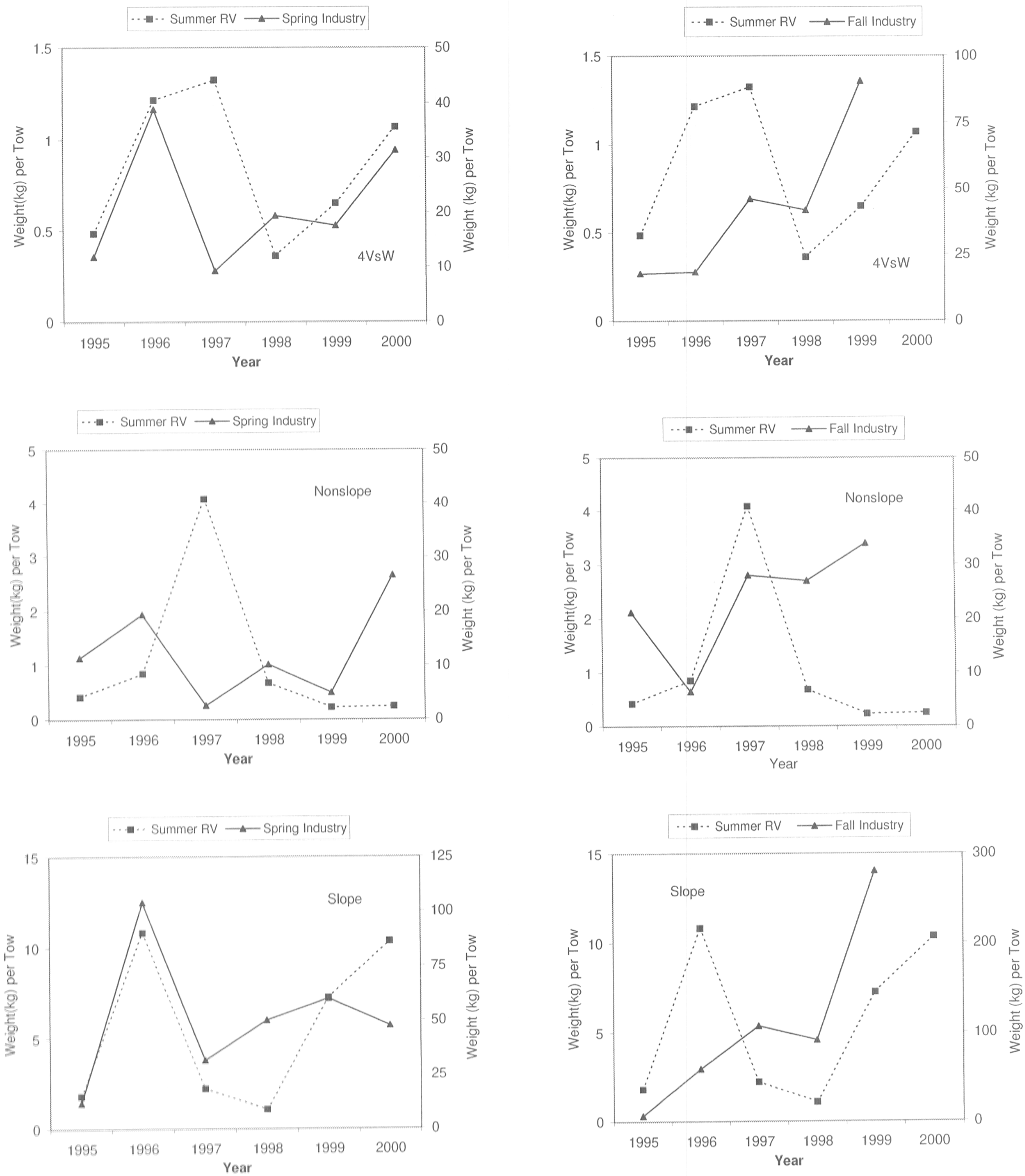


Figure 27. Stratified catch rates (kg per tow) of winter skate from the spring and fall industry/science surveys and summer RV survey in Div. 4VsW. These are calculated separately for the slope, nonslope and entire division.

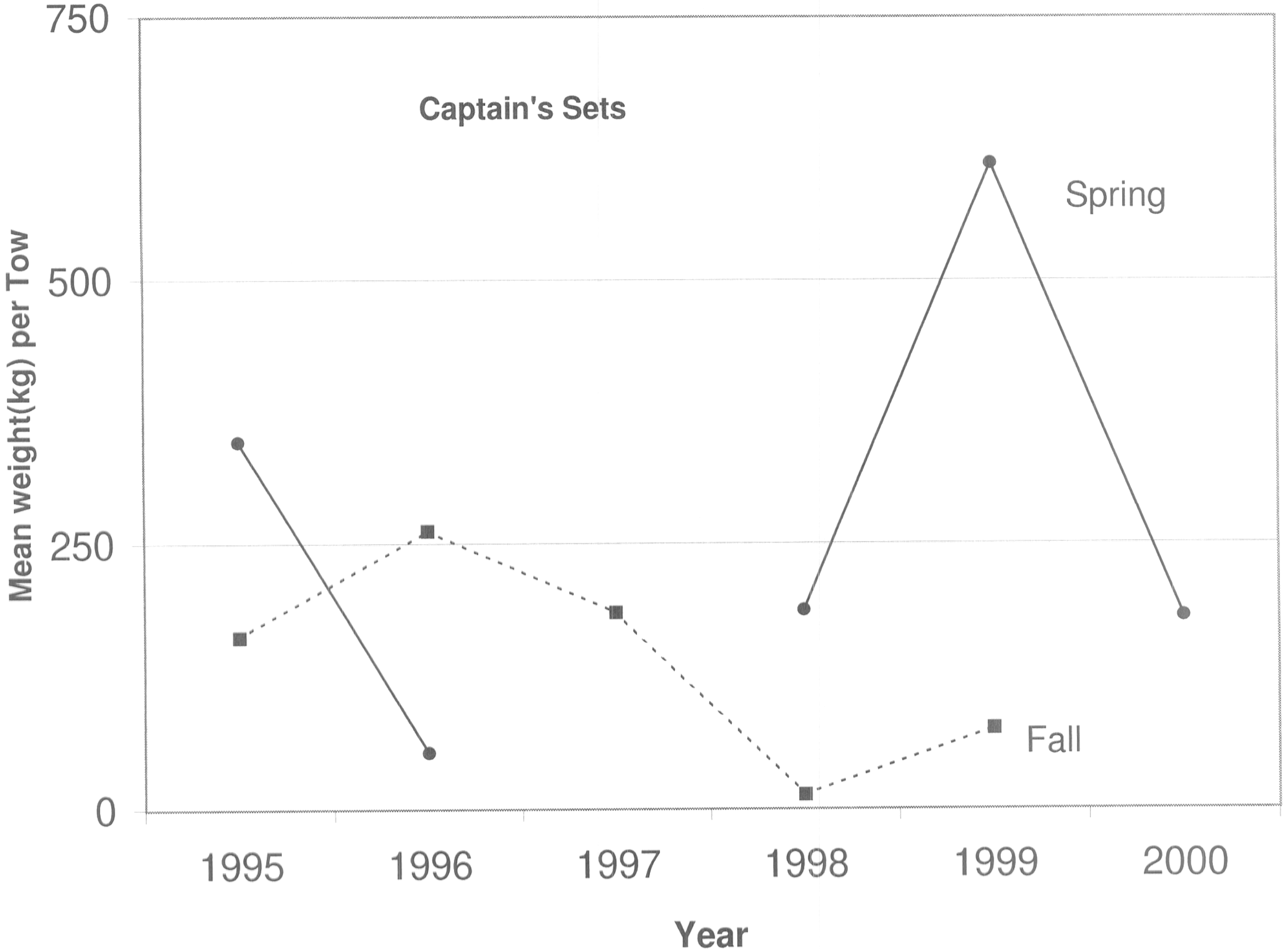


Figure 28. Mean catch rates from the captain's sets during the spring and fall industry surveys.

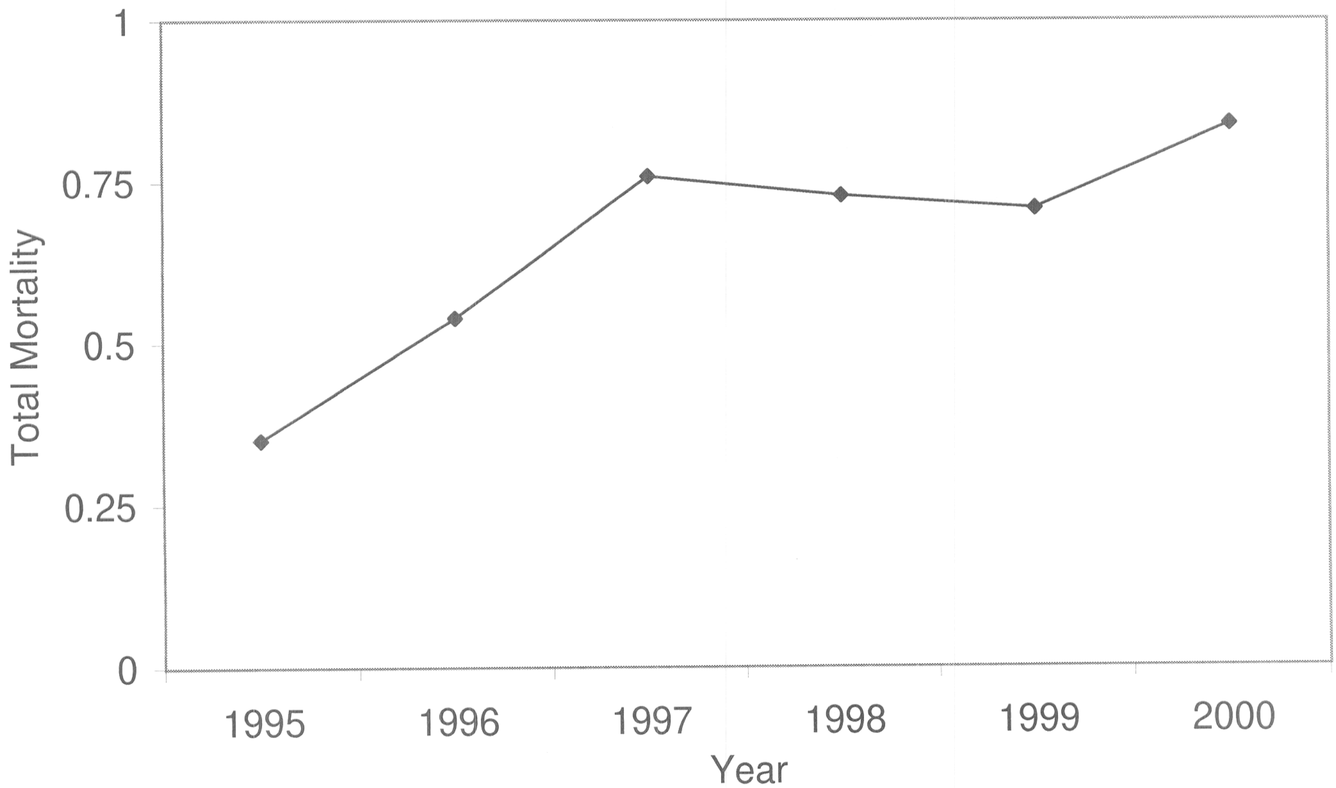


Figure 29. Estimates of total mortality (Z) as calculated from commercial skate samples and a growth model for winter skate.

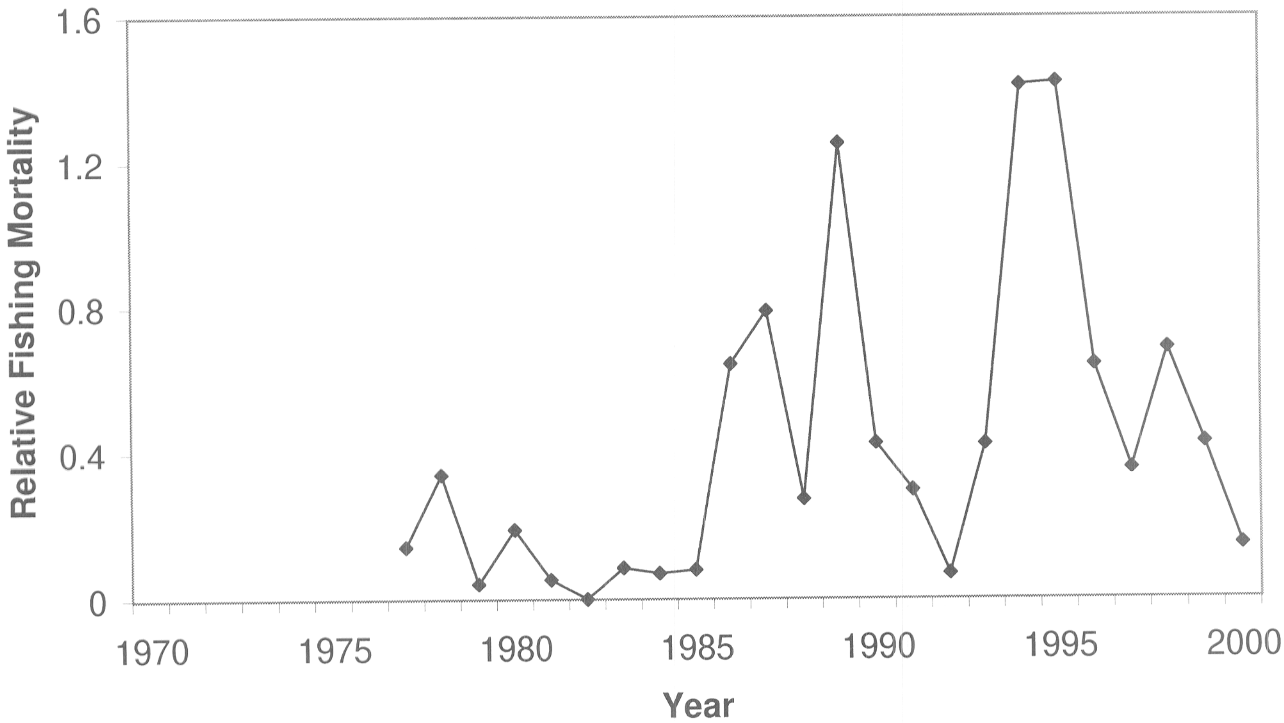


Figure 30. Relative fishing mortality as calculated from the ratio of catch of skate in Div. 4VsW divided by the minimum trawlable biomass of winter skate from the summer RV survey.

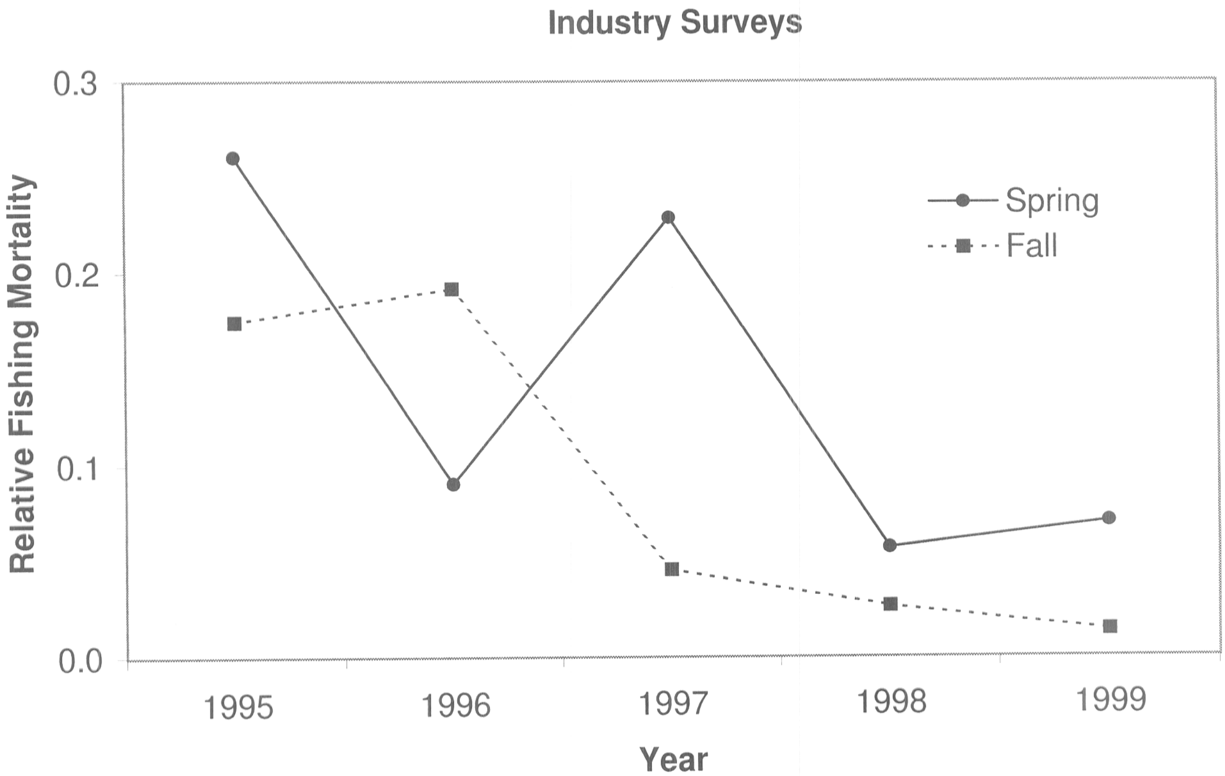


Figure 31. Relative fishing mortality as calculated from the ratio of reported catch of skate in Div. 4VsW divided by the minimum trawlable biomass of winter skate calculated from the the spring and fall industry/science skate surveys.

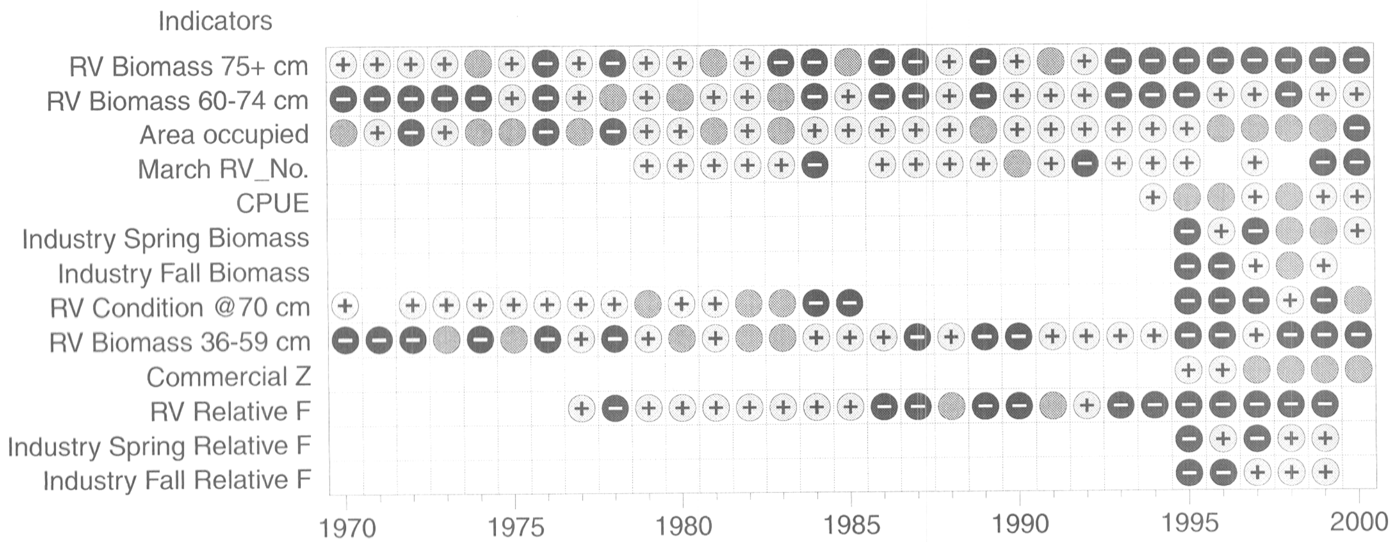


Figure 32. Traffic light indicators for Div. 4VsW winter skate. No summary or characteristics results were produced for this stock.