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An Assessment of the Skate Fishery In Division 4VsW

by

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Abstract

Most elasmobranch fisheries have followed a general pattern of high initial exploitation followed by a rapid collapse. It is intended that the developing skate fishery on the eastern Scotian Shelf not follow this course. There are, however, many limitations to our knowledge of skate on the Scotian Shelf. We currently lack information on age- or size-structure of the population, along with associated biological parameters such as size at maturity, growth rate and weight at age. Furthermore, five species of skates regularly co-occur, but are not reported separately. Winter and thorny skate are the focus of the commercial fishery. These species are most abundant in Division 4VsW with particularly high concentrations on Banquereau Bank. Lesser quantities occur in Division 4X. The low reproductive rate of skates combined with declining biomass, high discards of small skates during the directed fishery, and the need to limit by-catch of traditional species, all indicate continuation of a conservative approach to harvesting. For such a slow growing species, a low exploitation rate is appropriate. The 1985-94 mean trawlable biomass estimated from the summer survey for all skates combined in Division 4VsW was 12,000t. The harvest advice provided for 1994 was for a TAC of 1,200t. This is reiterated for 1995.

Résumé

La plupart des pêches d'élasmobranches ont suivi une même tendance générale, marquée par une forte exploitation initiale suivie d'un rapide effondrement. Nous souhaitons qu'il n'en soit pas ainsi de la pêche de la raie qui se développe dans l'est du plateau néo-écossais. Notre connaissance de la raie du plateau est toutefois très limitée. Nous manquons d'informations sur la composition de la population selon l'âge ou selon la taille, ainsi que sur des paramètres biologiques connexes comme la taille à la maturité, le taux de croissance et le poids selon l'âge. De plus, cinq espèces de raie sont simultanément présentes sur le plateau, mais ne sont pas distinguées dans les rapports. La pêche commerciale est axée sur la raie tachetée et sur la raie épineuse. Ces espèces sont surtout abondantes dans les divisions 4VsW, en particulier sur le banc Banquereau. On en trouve en moindre quantité dans la division 4X. Le faible taux de reproduction des raies, associé à une biomasse en diminution, à de nombreux rejets de petites raies durant la pêche sélective et à la nécessité de limiter les prises accidentelles d'espèces traditionnelles, invite à une prudence soutenue dans la récolte. Pour une espèce qui grandit si lentement, il convient d'opter pour un faible taux d'exploitation. La biomasse exploitable moyenne de 1985-1994, estimée d'après le relevé de recherche d'été pour toutes les espèces de raie des divisions 4VsW, était de 12 000 t. Le TAC recommandé pour 1994 était de 1 200 t. La même recommandation est maintenue pour 1995.

Introduction

This document contains information and analyses relevant to the developing skate fishery on the eastern Scotian Shelf. Here we provide the first comprehensive assessment of skates based upon a recent fishery, a cooperative industry/science skate survey, research vessel survey data, and scientific literature on elasmobranchs. There are many limitations to our assessment because of the lack of age- or size-structured data from the fishery, many biological parameters for skates are unknown (e.g. size at maturity, growth rate, weight at age) and because five species of skates regularly co-occur the exact species identity is not reported. We do suggest however that an appropriate management unit for the two species that are the focus of the commercial fishery (winter *Raja ocellata* and thorny skate *Raja radiata*) is Division 4VsW. General guidelines for a skate harvesting strategy are provided.

Fishery

Past

There has never been a regulated fishery for skates on the Scotian Shelf. Landings data exist since 1961, however the data only represent a fraction of the actual catches since there was no requirement to report incidental catches. Canadian landings have generally been very low (<25t) except during the mid-1970s when landings ranged between 60 - 700 mt (Table 1).

Foreign fleets have reported much greater landings than Canada. Prior to 1977 and the extension of jurisdiction, foreign landings were as high as 6,100 mt in Division 4Vs, 16,000 mt in Division 4W, and 2,100 mt in Division 4X (Table 1). After 1977, reported skate landings never exceeded 2,600 mt and were generally restricted to Division 4W. This changing pattern of high to low landings coincident with the extension of jurisdiction is believed not to reflect abundance changes in the skate populations but rather misreporting (Figure 1).

Present

In 1994, a combination of closures of traditional groundfish fisheries on the Scotian Shelf and openings in the markets for skate wings resulted in the development of a directed skate fishery. Four vessels landed over 1200 mt by mid-July 1994. This rapidly developing fishery was closed as a result of concerns within DFO, because no harvesting plan was in place and was not re-opened until scientific advise was reviewed. For what was thought to be a slow growing species, like skates, a conservative exploitation rate of 10% was chosen. Based on the 10 year mean minimum trawlable biomass in Division 4VsW of 12,000 mt , a catch of 1,200 mt was advised. Since this total had already been reached by the fishery, and a continual need for more biological information exits, an additional 800 mt was allocated in Division 4VsW to conduct joint industry/science surveys. The fishery resumed with landings reaching 2,152 mt by the end of the year. The existing flounder harvesting plan was used. This plan allowed the use of 155mm square or diamond mesh nets, with cod and haddock limited to a 5% by-catch. The fleet decided to use 255mm codends to

reduce by-catch of other species. Most skate, primarily thorny and winter, were caught in the Eastern Shoal area of Banquereau Bank with lesser amounts from areas west of Sable Island.

Data from the International Observer Program (IOP) was examined to determine the annual distribution of skate catches by the domestic fishery. During 1990-1993, winter skate catches were concentrated in two geographic areas: Banquereau Bank and Georges Bank (Figure 2). The same pattern was evident in 1994 with an additional concentration evident west of Sable Island. Clearly, the principal area of winter skate concentration supporting the fishery was Banquereau Bank. Thorny skate distributions were concentrated in the region south of Banquereau Bank and the Gully in 1990-1993. The pattern of thorny skate distribution was restricted more to the eastern shoal of Banquereau Bank in 1994 (Figure 3). Skate identification is problematic and has resulted in many observed sets for which skates are unspecified. Unspecified skate distributions parallel the winter and thorny skate distributions but also show a much broader spatial distribution (Figure 4).

Skates are a by-catch in the silver hake fishery which is largely prosecuted by foreign fleets. Foreign landings of skates since 1990 have fallen from 2,000 to 20 mt. due to restrictions in the silver hake fishery, both in terms of total allocations and areas fished. Observer coverage on the foreign fleets since 1990 has been high and it thus provides an opportunity to examine the distribution of skate catches. Composite distribution maps of catch per tow aggregated by 10' squares are shown in Figure 5. Winter and thorny skate distributions were overlapping and concentrated in Division 4W along the shelf edge. The problem of skate identity was also evident as many observed sets were categorized as unspecified skates (Figure 6). In general, the distribution of catches from both the foreign and domestic fishery are concentrated in Division 4VsW.

Research Vessel (RV) Surveys

Spring Distribution

Spring research vessel surveys of the eastern Scotian Shelf groundfish community have been conducted since 1979. Survey coverage for the 1988-94 period is restricted to the eastern half of the shelf. The 1988-93 surveys were combined with only the sets with catches greater than 0 plotted. All sets were plotted from the 1994 survey. During the 1988-93 and 1994 surveys only three skate species were routinely collected. Smooth skate *Raja senta* were generally collected in the Gully with low quantities elsewhere (Figure 7). Winter skate were distributed along the southern edge of the shelf adjacent to the offshore banks. In 1994 a remarkably large catch of winter skate (1,500 kg. per 30 minute tow) was made in the slope water adjacent to Banquereau Bank (Figure 8). Thorny skate were widely distributed throughout Division 4VsW but with high concentrations in the Gully and adjacent areas (Figure 9).

Summer Distribution

Summer research vessel surveys of the Scotian Shelf groundfish community have been conducted since 1970. Survey coverage is shelf wide with again only the positive sets plotted for the 1988-93 period and all sets from the 1994 survey. Historical information on distribution and abundance of the principal skate species has been developed recently by Simon and Comeau (1994). Here we show distributional information on five skate species from 1988-1993 relative to the 1994 survey. The five species considered are barndoor *Raja laevis*, smooth, little *Raja erinacea*, winter and thorny skate.

Barndoor skates were captured infrequently during the surveys (Figure 10) probably due to their large size and evasive behaviour (Edwards, 1968). Smooth skate are confined to the deeper waters of the eastern Scotian Shelf, the Gully and deep channels (Fundian and Laurentian) (Figure 11). Little skate are associated with the offshore banks and inner Bay of Fundy (Figure 12). Collectively, because of their rarity or small size these species are not the focus of the commerical fishery. Nevertheless, they do contribute to the difficulty of proper identification of the target species.

Winter skate distributions were somewhat different than what was expected from the fishery. In addition to the concentrations on Banquereau Banks, there were aggregations west of Sable Island, on Browns and the inner Bay of Fundy (Figure 13). The summer distribution was also very different than the shelf edge distribution noted in spring, suggesting an on-bank seasonal movement. Thorny skate were more widely distributed with high concentrations in both division 4Vn and 4Vs. Lesser quantities were evident in Division 4X (Figure 14). The distribution of these two species suggests a natural division between the eastern and western Scotian Shelf.

Spring Abundance

Survey catch rates of smooth skates were generally low in divisions 4Vs and 4W (Figure 15). Relative to Division 4W catch rates were higher in Division 4Vs (Figure 15). Little skate catch rates were low and sporadic in both divisions (Figure 15) and may partly be due to confusion with winter skate than with changes in abundance. Winter skate catch rates were slightly higher in Division 4Vs than in 4W, except for the 1994 survey when one large set inflated the number and weight per tow values, otherwise no trends in abundance were apparent. Thorny skate catch rates were higher in Division 4Vs than in Division 4W (Figure 16). No trends in abundance were evident in either Division.

Summer Abundance

Survey catch rates of smooth skate in divisions 4Vs and 4W were nearly equivalent between divisions (Figure 17), in terms of number and weight per tow and show a general decline since the early 1980s . Catch rates of little skate have been very low in Division 4Vs since 1970 and sporadic in Division 4W (Figure 17). It is felt that this pattern may again be due to same identification problem in the spring.

Winter skate catch rates show a variable pattern with no time trends evident in either Division 4Vs or 4W (Figure 18). Catch rates were higher in Division 4Vs and averaged 2 fish per tow (or 4 kg/tow). Thorny skates were the most abundant of the five species examined with catch rates frequently in excess of 20 fish per tow (or 15 kg per tow) in Division 4Vs (Figure 18). There was a declining trend in abundance in both 4Vs and 4W. Catch rates for both species were generally less than during the spring.

Spring Size Frequencies

Size frequency data was examined for male and female thorny and winter skate from 1990-93 and 1994. There was evidence of multiple modes in both male and female thorny skate during the 1994 survey (Figure 19) suggesting the existence of several age groups. Winter skate size frequencies in 1994 were dominated by larger individuals relative to the 1990-93 mean size frequency distribution (Figure 19). The difference was so large that growth alone would probably not explain the discrepancy.

Summer Size Frequencies

Size frequency data was examined for both male and female thorny and winter skates from 1990-1993 and 1994. The modal size of thorny skate in the 1994 survey was 22 cm for both male and females relative to the 1990-93 of 28 cm (Figure 20). Very few fish were captured greater than 40 cm with the maximum size reaching 79 cm. Modal sizes of winter skate were larger than thorny skate and roughly equivalent between males and females (about 40 cm). Also in contrast to thorny skate, much larger winter skate were collected with maximum sizes in excess of 90 cm (Figure 20). However, the sizes of winter skate collected in summer were much smaller in comparison to the spring collections in 1994.

Industry/Science Skate Directed Survey

Distribution

As part of the domestic harvesting plan established in 1994 the industry agreed to conduct two skate surveys during August and September. Observers (IOP) sampled the catch with costs incurred by industry. The surveys objectives were to map the extent of the resource in Division 4VsW, estimate by-catch levels of traditional species and better define the conversion ratio of skates wings to round weight. Science designated the fishing locations along transect lines spaced approximately 15 km apart. Three sets were made along each transect stratified by depth (<50 fm, 50-100fm, >100fm). The surveys were conducted by four vessels within a three day window each using 155 mm mesh gear. After the survey sets were completed, the vessels resumed normal fishing operations using 255 mm mesh gear.

The August survey revealed several interesting features. When using the 155 mm mesh gear, a broad band of winter skate was noted along the outer shelf region with a major concentration off

the eastern shoal of Banquereau Bank (Figure 21). When using the 255 mm mesh gear two centres of winter skate concentration were evident, one in the vicinity of Sable Island and the other on Banquereau Bank (Figure 21b). Winter skate catch rates using the 255 mm mesh type frequently exceeded 5,000 kg/h. Thorny skate catches were generally lower than winter skate catches during the August survey with the exception of good catch rates on the eastern half of Banquereau (Figure 22b) during the fishery-directed portion of the survey.

The results of the September survey for winter skate (Figure 23a) was quite similar to the August survey. It should be noted however that the September fishery-directed portion of the survey was prosecuted in a shallower portion of Banquereau Bank. The distribution of thorny skate was similar to winter skate in September, and only slightly different than their distribution in August (Figure 24).

Abundance

Abundance data were expressed as mean catch rates (kg/hour fished) for each month and mesh size for thorny and winter skate. As expected catch rates were lower, on average, during the science-directed portion of the surveys. However, September catch rates were 40-fold higher for thorny skate and 3-fold higher for winter skate (see table below).

CPUE (kg/tow(hr))	August	September
Number of sets	59.0	58.0
Thorny skate	7.5	280.9
Winter skate	104.5	349.8

* Note: 155 mm mesh

In contrast, the fishery-directed portion of the survey show little differences between August and September catch rates for each species. Winter skate catch rates were higher than those for thorny skate.

CPUE (kg/tow(hr))	August	September
Number of sets	24.0	32.0
Thorny skate	878.8	773.9
Winter skate	1636.7	1122.3

* Note: 255 mm mesh

Size Frequencies

Size frequency distributions have been compiled for both species collected during the two surveys. The data was not separated by mesh size so inter-comparisons are not possible. The August and September surveys yielded much larger individuals of the two species than the RV survey size frequency data (Figure 25).

Recall that an additional objective of the August and September surveys was to estimate the by-catch of traditional species in the skate directed fishery. It can generally be stated that the by-catch levels were quite low in the 255 mm mesh gear during both surveys. By-catch on a species by species basis was less than 1% (Table 2). This was not the situation when using the 155 mm mesh gear in August. Significant by-catch of three flounder species occurred (Table 2). By-catch levels using the small mesh gear in September was generally low for each species. Any comparison between the large and small mesh gear by-catch is confounded by different fishing locations.

The last objective of the two surveys was too better estimate the conversion ratio of wing weight to round weight. The initial conversion ratio for the fishery was 25%. This was revised to 37% in mid-August based on preliminary information from industry and was to be further examined on the survey. Unfortunately, not enough skates were sampled to justify a change in the 37 % conversion ratio.

During the course of the two surveys the observers reported high discards of undersized (<18" wingspread) skates. As well, a number of sets were released when small skates were noted in the codend. The survival rate of these skates is unknown.

Discussion

Elasmobranch fisheries are generally short-lived marked by high initial exploitation followed by a rapid collapse of the fishery. One of the few, long-standing elasmobranch fisheries that existed in the past was targeting members of the family Rajidae in the northeast Atlantic during the 1950s and 1960s (Holden, 1973). The reason for the ability of the family Rajidae to better withstand exploitation than sharks may be related to their higher fecundity.

There is very little detailed life history on those skate species on the Scotian Shelf that are currently being harvested. Maximum observed lengths for little, smooth, thorny, winter, and barndoor skates are 53, 58, 102, 109 and 152 cm, respectively (Scott and Scott, 1988). At present no information exists on growth or maturation rates for either winter or thorny skates and age information for both species is lacking. Recruitment estimates are not available and spawning times and locations are unknown. Relative to most groundfish species, skate are considered to be more difficult to capture using standard survey techniques (Edwards, 1968). This has obvious implications for accurate estimates of total biomass and size composition of the stocks. So for the

purposes of approximating exploitation strategies, literature information for other geographic areas and/or skate species was examined.

Growth data exists for little skate along the eastern seaboard of the United States (Waring, 1982) and for thorny skate (male and female) in the North Sea (Holden, 1972). Length at age data, fitted using the von Bertalanffy growth model, shows a pattern of relatively rapid growth up until age 5 (or 42 cm) in little skate (Figure 26). Thorny skates grow rapidly up until age 8 and asymptotes near 100 cm in females and about 85 cm in males at age 20 y (Figure 26). This information is useful because the Scotian Shelf skate fishery commonly discards thorny skates at sizes below 62 cm (6 yr old) and winter skates below 73 cm (8 yr old), assuming similar growth rates. Templeman (1982) demonstrated that male thorny skate begin to mature at 54 cm and females at 40 cm in the Newfoundland region. Mature females examined on the Grand Banks ranged from 60 to 94 cm range, however. This suggests that the discarding practices on the Scotian Shelf permit some unknown proportion of the thorny skate population to spawn at least once before capture.

Templeman (1982) showed that there was little or no seasonality in the spawning pattern of thorny skate. Egg capsules were collected in roughly equal proportions throughout the year and within each quarter examined the distribution of developmental stages was uniform.

The minimum trawlable biomass of skates from the summer RV has shown a slow decline since 1982 (Figure 27). The average biomass over the past 10 years (1985-1994) was 12,000 mt. Two species comprise most of the skate biomass: thorny and winter skate. Nearly all of the decline in skate biomass was due to the reduction in thorny skate biomass (Figure 28). The spring RV estimate of skate biomass was more variable and no temporal trend could be discerned. The 1994 estimate of 160,000 mt should not be considered representative of the total biomass because it was overly influenced by a single large set. This was in fact substantiated by the 1995 spring RV which yielded at total skate biomass close to the long term mean of 18,500 mt.

We can grossly approximate the exploitation of skates since 1989 on the eastern Scotian Shelf by comparing the minimum trawlable biomass of skates (all species) to the total removals of skates from the by-catches of other fisheries and the directed fishery. Skates are an important by-catch in many of the fisheries operating on the Scotian Shelf. Therefore to estimate these removals, IOP estimates of skate by-catch from the roundfish and flatfish fisheries were examined. For the roundfish fishery the by-catch amounted to 3% (Table 3). By-catch in the flatfish fishery was estimated at 30% and was based on examination of the limited data and discussions with fishermen. Using these methods resulted in bumping up the directed fishery landings by a minimum of 935 mt in 1994 to as much as 4400 mt in 1991.

The annual summer survey catch rates of skates (all species) since 1989 were scaled to the total number of trawlable units to provide an annual estimate of the minimum trawlable biomass in Division 4VsW. The ratios of total removals to trawlable skate biomass resulted in an estimated range of exploitation, from 1989 to 1994 of 18 to 66 %. The mean rate was 35% with no temporal trends evident, and may indicate that skate removals are exceeding the low exploitation

goal for the directed fishery. One should bear in mind that for all groundfish stock assessments natural mortality is assumed to be a constant and equal to 0.2.

The low reproductive rate of skates combined with declining biomass, high discards of small skates during the directed fishery, and the need to limit by-catch of traditional species, all indicate continuation of a conservative approach to harvesting. For such a slow growing species, a low exploitation rate of 10% is appropriate. The 1985-94 mean trawlable biomass estimated from the summer survey for all skates combined in Div. 4VsW was 12000t. The harvest advice provided for 1994 was for a TAC of 1200t. This is reiterated for 1995. As well, the continued sustainability of this level is critically dependent upon limitations of the high discard rates in the directed fishery.

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

Year	4Vn				4Vs				4W				4X			
	Canada	USSR	Others	**Total**	Canada	USSR	Others	**Total**	Canada	USSR	Others	**Total**	Canada	USSR	Others	**Total**
1961	-	-	-	0	-	-	-	0	1	-	-	1	177	-	-	177
1962	-	-	-	0	-	-	-	0	4	-	-	4	104	-	2	106
1963	-	-	-	0	-	-	-	0	-	-	-	0	95	-	2	97
1964	1	-	22	23	-	-	-	0	-	-	1	1	52	-	-	52
1965	-	-	-	0	17	-	4	21	51	-	-	51	94	-	-	94
1966	-	-	9	9	-	-	1	1	14	-	-	14	36	-	-	36
1967	-	-	-	0	-	-	-	0	16	-	-	16	61	-	-	61
1968	-	-	4	4	3	780	4	787	56	5397	-	5453	45	-	-	45
1969	-	-	4	4	4	269	8	281	10	4122	-	4132	9	15	-	24
1970	-	-	10	10	2	60	6	68	24	3802	-	3826	6	-	-	6
1971	2	-	7	9	12	1519	3	1534	1	15970	-	15971	3	149	-	152
1972	-	-	8	8	1	894	10	905	-	4325	5	4330	-	22	-	22
1973	1	-	55	56	3	364	38	405	2	6287	1	6290	-	821	1	822
1974	17	-	41	58	-	-	89	89	61	8323	18	8402	-	553	-	553
1975	-	-	66	66	2	633	81	716	-	15451	5	15456	-	2103	-	2103
1976	72	78	15	165	705	6026	108	6839	57	1738	-	1795	126	253	-	379
1977	101	-	5	106	382	-	-	382	52	489	-	541	48	105	-	153
1978	20	-	9	29	109	-	20	129	26	755	29	810	44	-	-	44
1979	48	-	3	51	52	-	-	52	36	287	5	328	27	-	-	27
1980	92	-	14	106	59	-	-	59	12	756	6	774	15	21	-	36
1981	53	-	10	63	7	5	-	12	2	297	-	299	1	-	-	1
1982	-	-	-	0	-	-	-	0	-	-	-	0	17	-	1	18
1983	-	-	5	5	-	-	-	0	9	130	18	157	1	26	5	32
1984	-	-	4	4	7	-	-	7	9	141	-	150	49	-	9	58
1985	1	-	9	10	7	-	-	7	-	421	5	426	2	-	-	2
1986	-	-	19	19	6	-	-	6	6	1467	-	1473	17	-	-	17
1987	9	-	-	9	17	-	-	17	28	1632	*107	1767	27	4	-	31
1988	1	-	-	1	3	-	-	3	4	2580	*29	2613	14	45	-	59
1989	1	-	-	1	3	-	-	3	7	1364	*167	1538	17	21	-	38
1990	0	-	-	0	0	-	-	0	2	1655	*315	1972	15	28	-	43
1991	3	-	-	3	5	-	-	5	8	1112	*721	1841	5	36	-	41
1992	0	-	-	0	0	-	-	0	2	279	*158	439	1	11	-	12
1993	1	-	-	1	66	-	-	66	101	*117	*658	876	27	-	-	27
1994	2	-	-	2	1971	-	-	1971	181	*0	*20	201	95	-	-	95

1961-1988 NAFO data
1989-present ZIF data (Canadian)
* - IOP data

Table 2. By-catch estimates from the August & September industry/science experimental surveys.

August			September		
Gear 1-155mm			Gear 1-155mm		
Species	Catch(kg)	Bycatch %	Species	Catch(kg)	Bycatch %
Cod	23	0.46	Cod	1	0.00
Haddock	64	1.27	Haddock	25	0.09
Redfish	5	0.10	Wh. hake	1	0.00
Halibut	25	0.50	Redfish	4	0.01
Am.plaice	490	9.72	Halibut	38	0.14
Witch	148	2.94	Am.plaice	23	0.08
Ytail	217	4.30	Witch	102	0.37
LHS	13	0.26	Ytail	370	1.35
Sea raven	16	0.32	LHS	5	0.02
Angler	66	1.31	Sculpins	6	0.02
			313	63	0.23
Est. skate catch		5042	Sea raven	16	0.06
			Sea robin	5	0.02
			Angler	101	0.37
			Est. skate catch -27497		
Gear 2-255mm			Gear 2-255mm		
Species	Catch(kg)	Bycatch %	Species	Catch(kg)	Bycatch %
Cod	13	0.02	Cod	20	0.02
Haddock	21	0.04	Haddock	71	0.06
Halibut	47	0.09	Halibut	17	0.01
Am.plaice	166	0.30	Am.plaice	28	0.02
Witch	27	0.05	Ytail	787	0.69
Ytail	366	0.67	Atl. torpedo	14	0.01
Dogfish	5	0.01	Porbeagle	100	0.09
LHS	2	0.00	313	155	0.14
313	250	0.46	Sea raven	12	0.01
Sea raven	6	0.01			
Angler	24	0.04			
Est. skate catch		54889	Est. skate catch-114760		

Table 3. Skate by-catch in the Canadian and foreign fisheries in Divs. 4VsW as estimated by the International Observer Program.

	Foreign 4W			Canadian Groundfish(4VsW)			Canadian Flatfish(4Vs)				Total Skates
	USSR	Others	Total	Landings(t)	Bycatch estimate	Est. skate removals	Landings	Actual	Estimate	Est. skate removals	(Cdn.+For.)
1989	1364	167	1531	62051	0.03	1862	3424	0.09	0.3	1027	3830
1990	1655	315	1970	58549	0.03	1756	4246	0.34	0.3	1274	5002
1991	1112	721	1833	56002	0.03	1680	2506	2.57	0.3	752	4278
1992	279	158	437	47420	0.02	948	3149	0.46	0.3	945	2332
1993	117	658	775	8578	0.03	257	2916	0.77	0.3	875	2074
1994	0	20	20	8218	0.03	247	2226	0.9	0.3	668	3087

Note: Foreign IOP coverage 100% 1989 -1994
Canadian skate landings as a percentage of all cod,haddock,pollock,redfish landings
Percentage of skates observed in the flatfish fishery

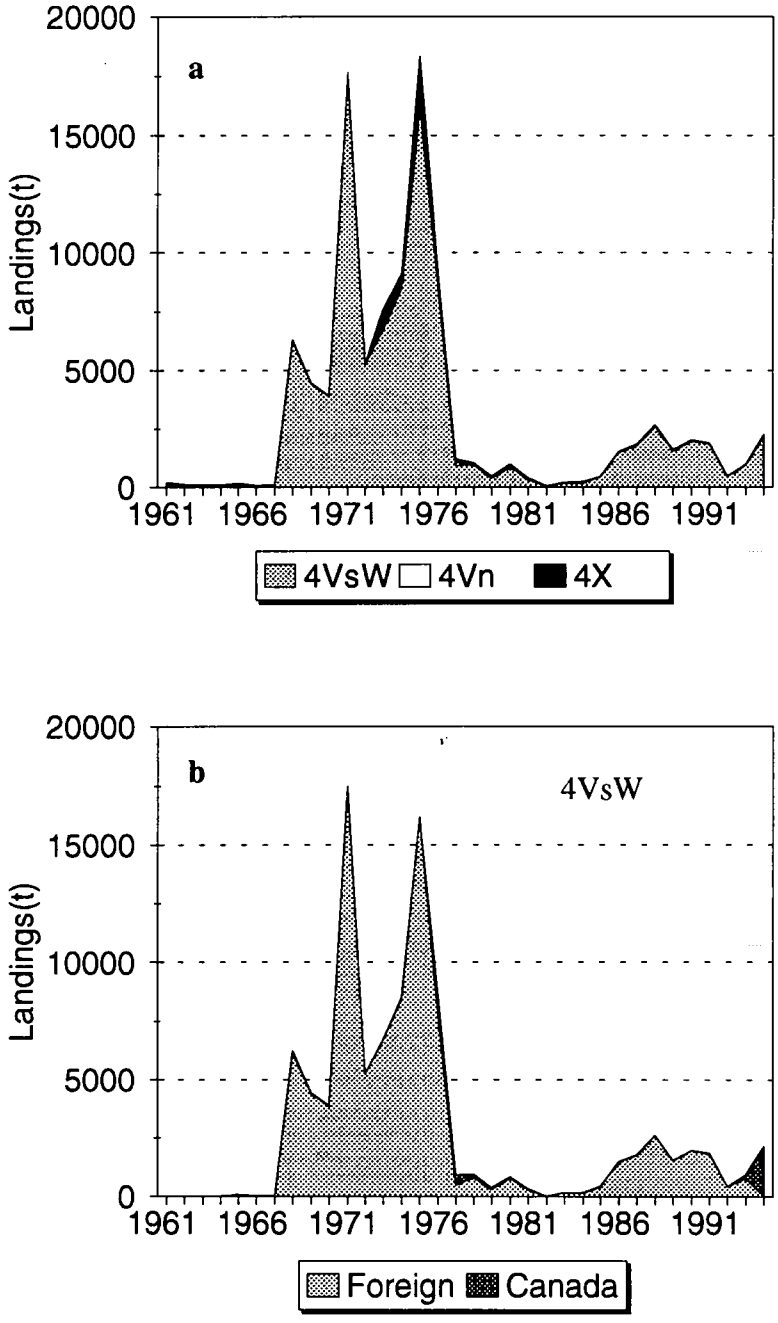
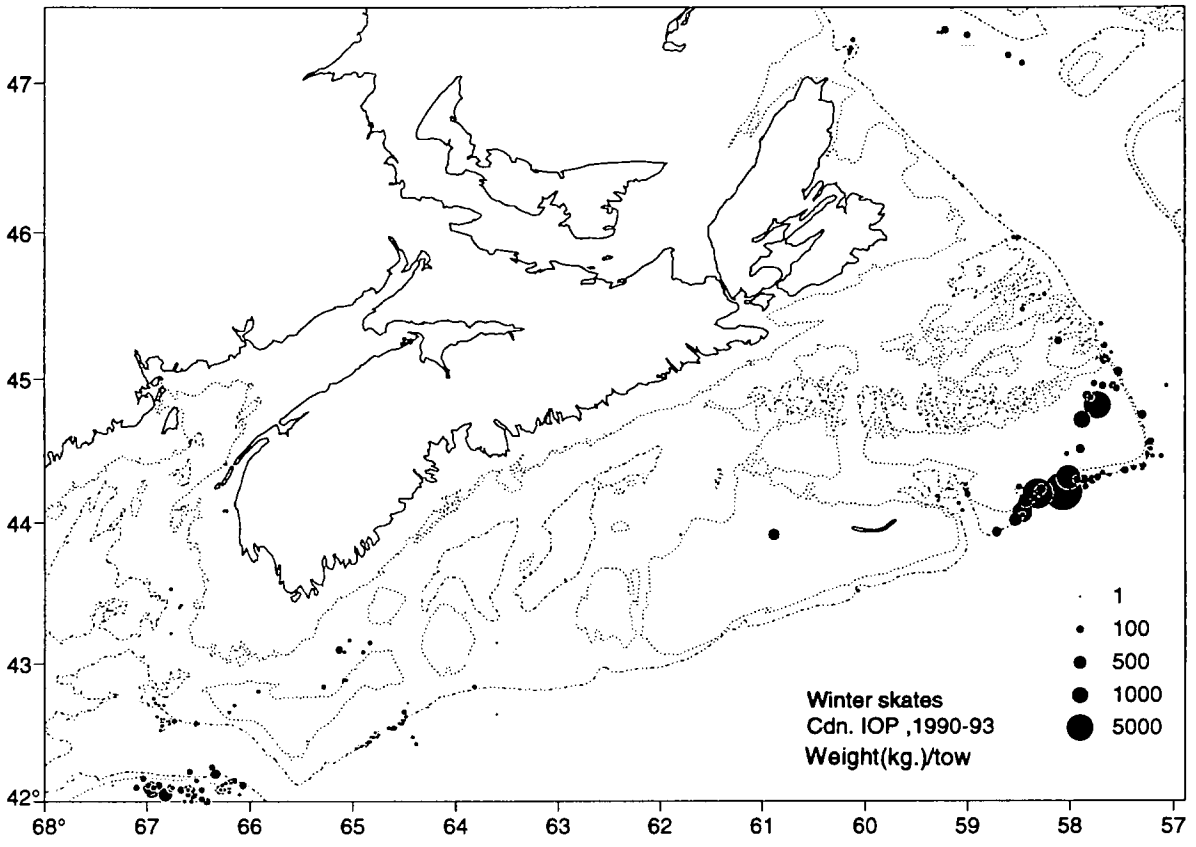


Figure 1. Reported nominal landings of skate (all species combined) by a) division and b) country in Divs. 4VsW.



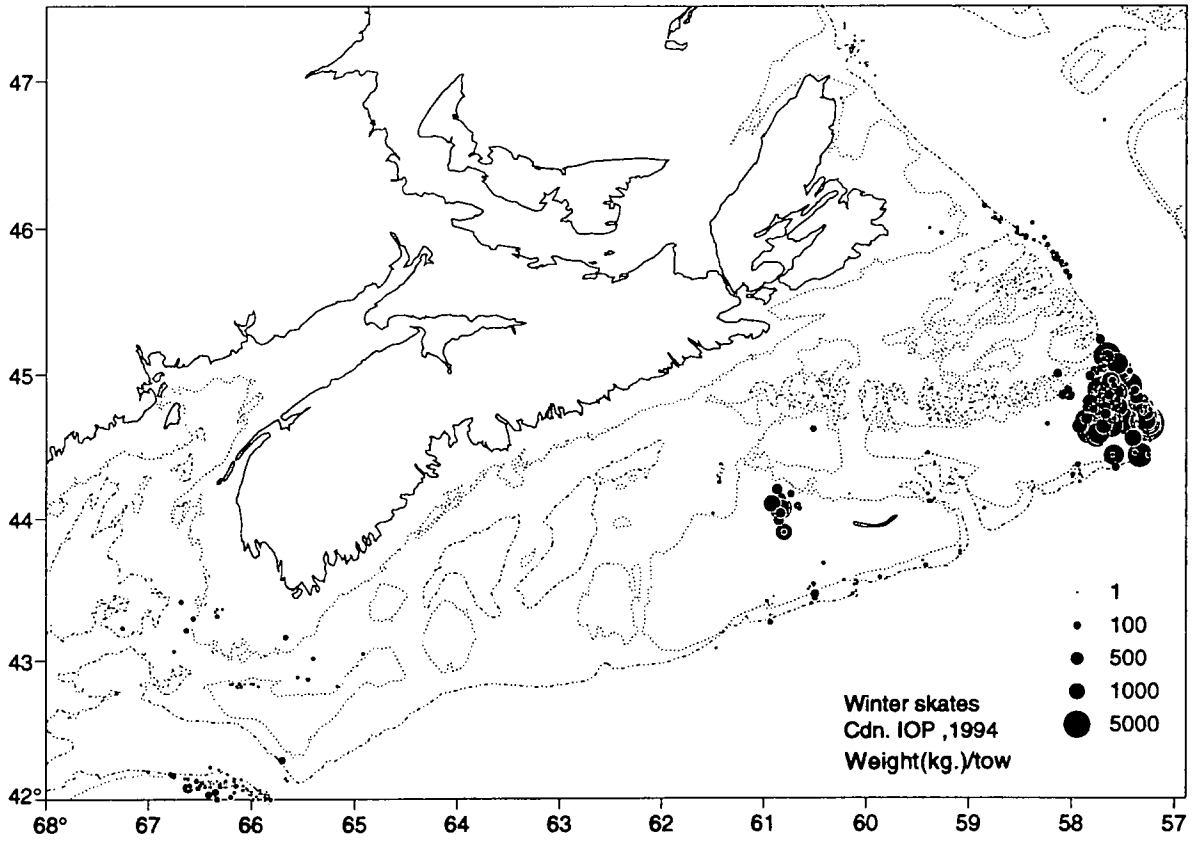


Figure 2. Distribution of winter skate from IOP observed Canadian catches ;1990-93,1994.

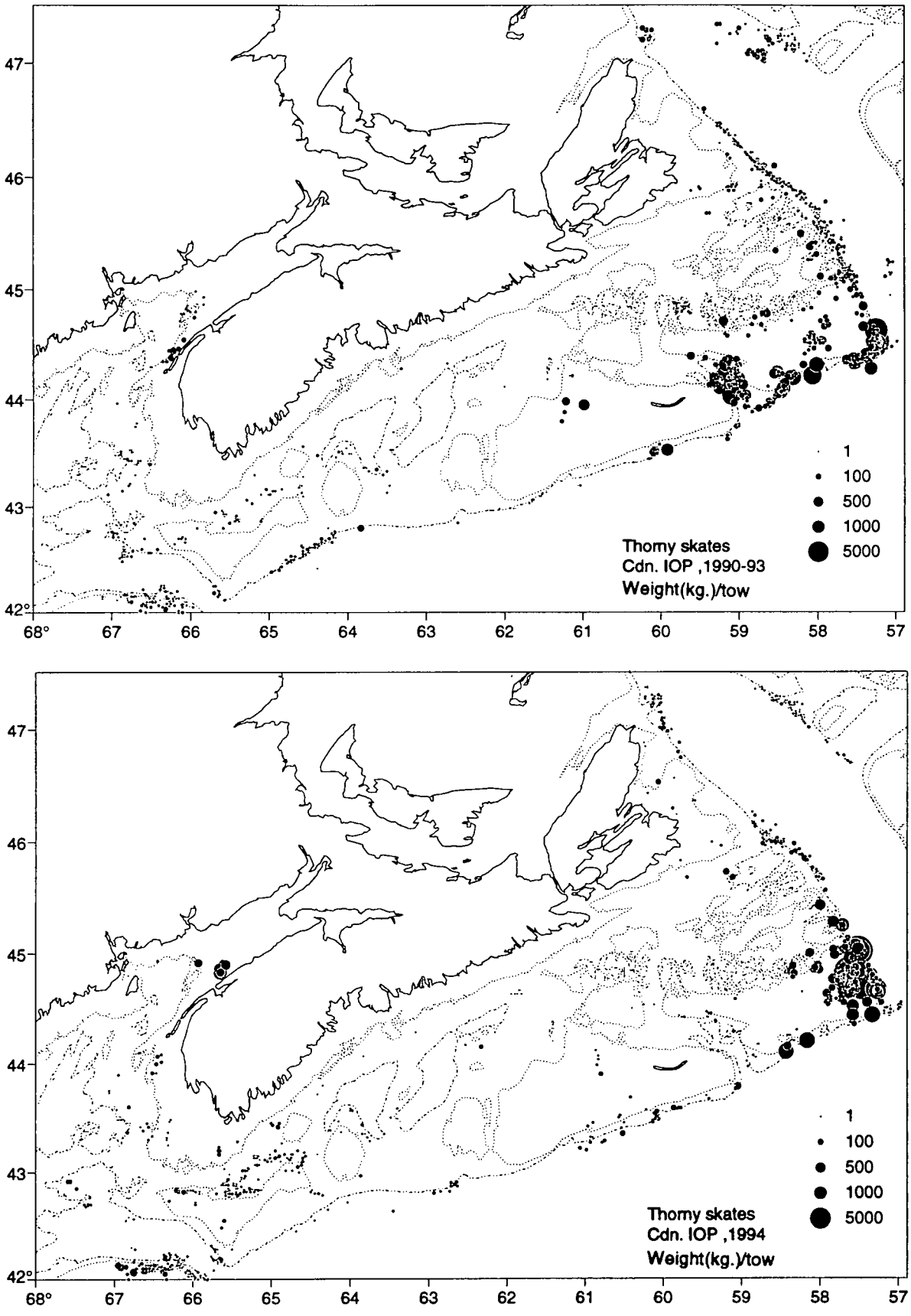
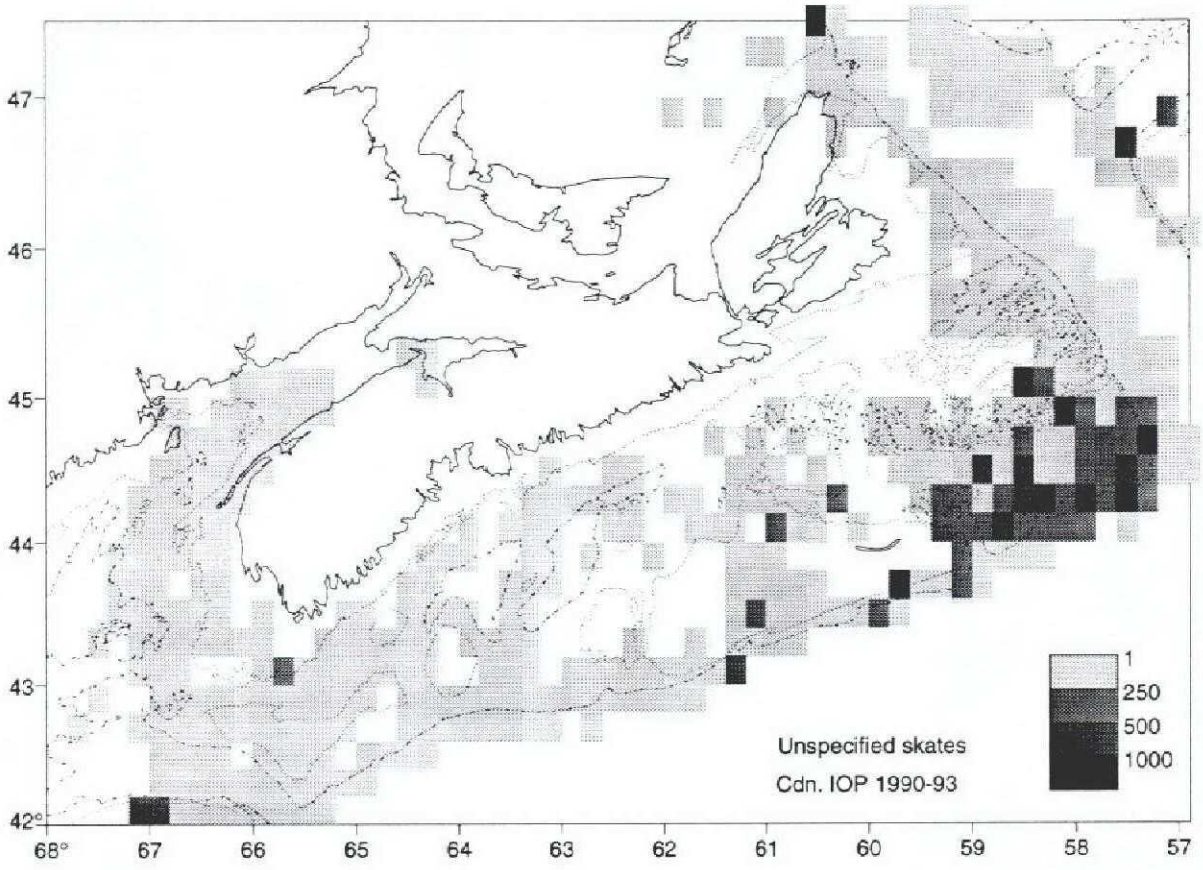


Figure 3. Distribution of thorny skate from IOP observed Canadian catches ;1990-93,1994.



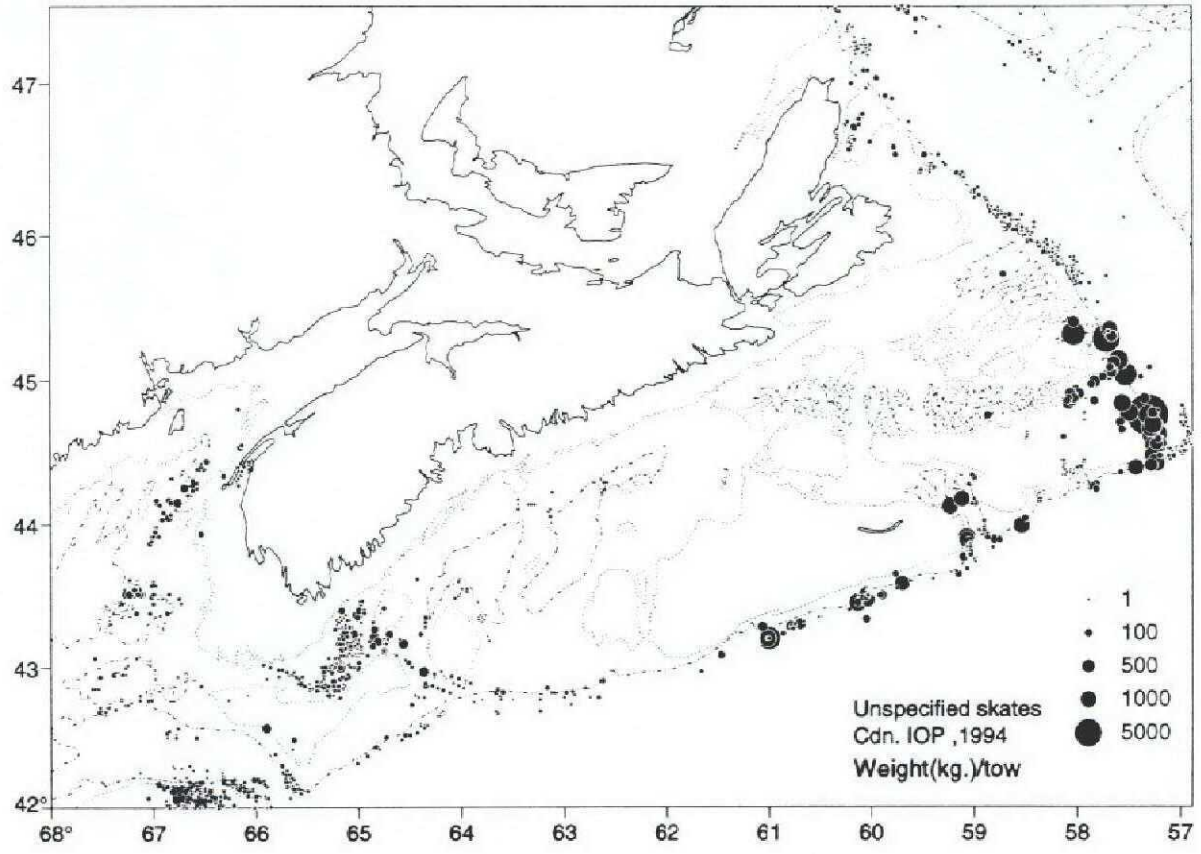
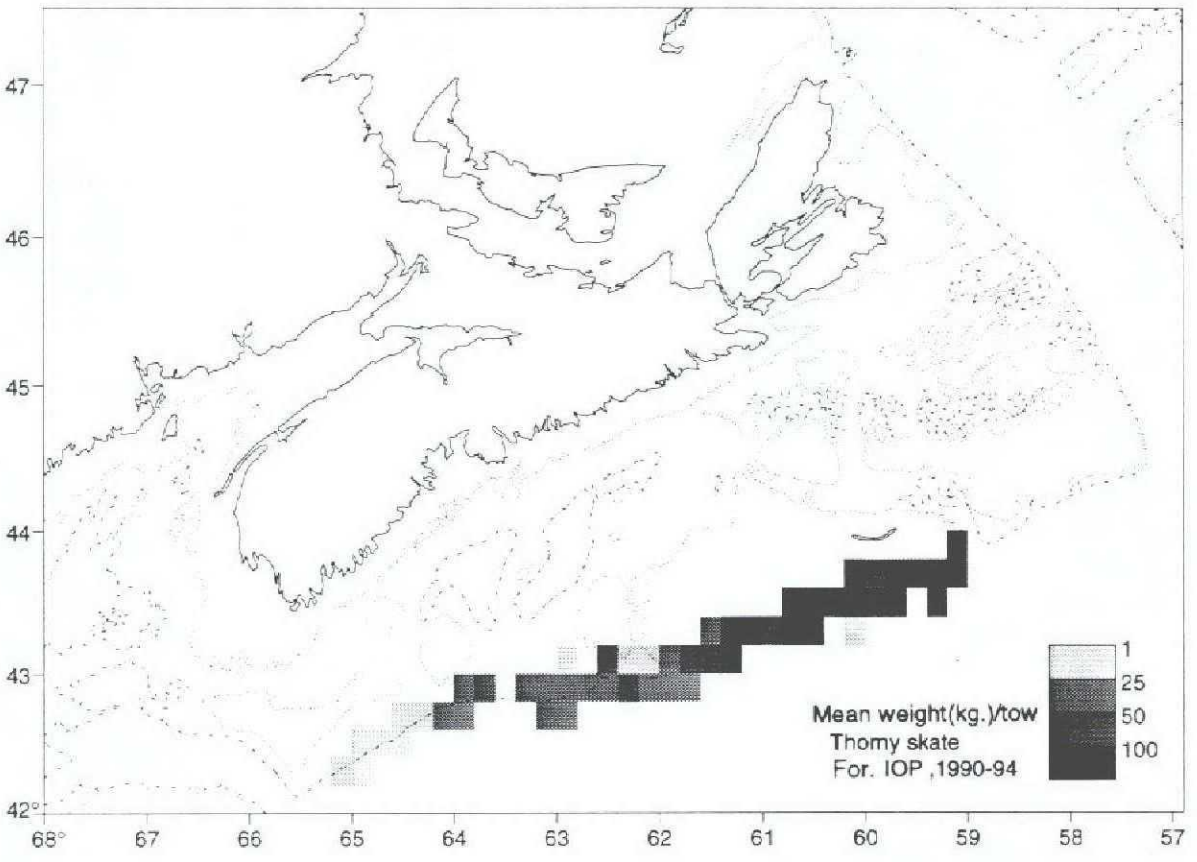


Figure 4. Distribution of unspecified skate from IOP observed Canadian catches ;1990-93,1994.



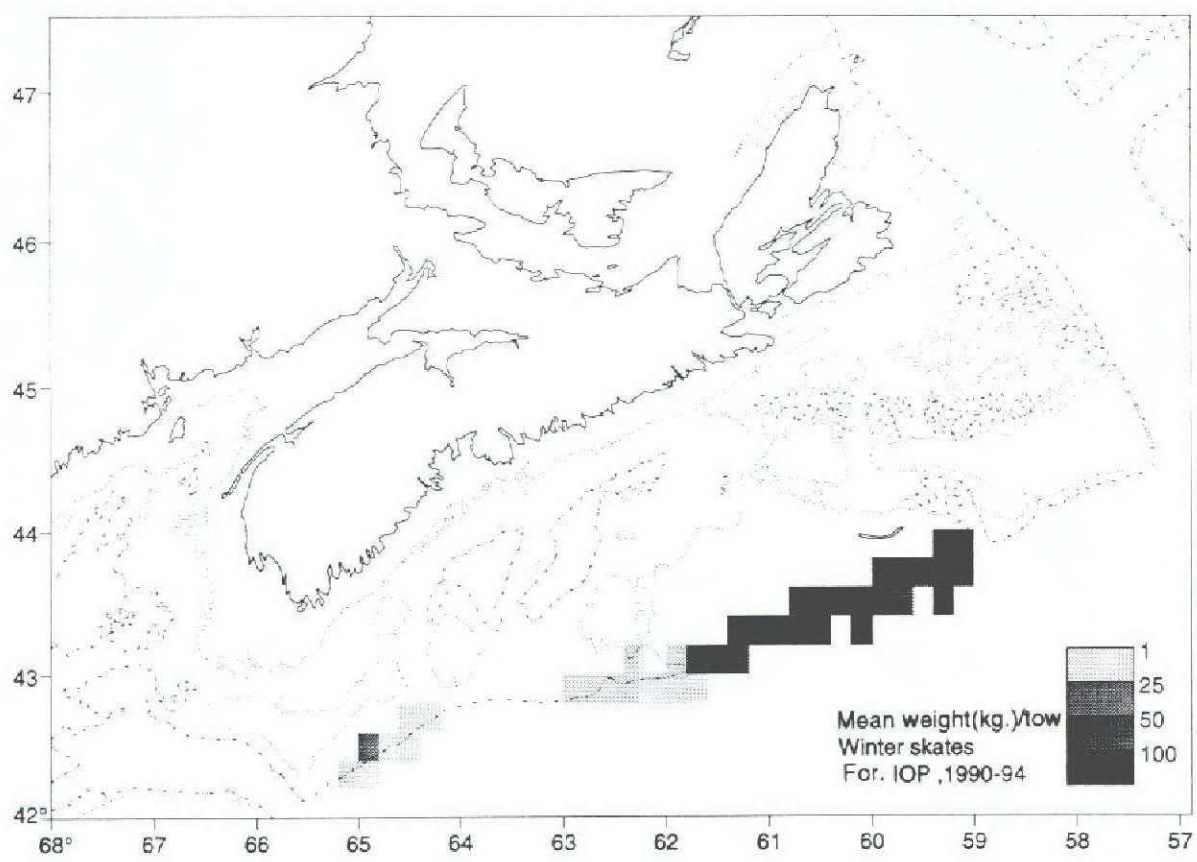


Figure 5. Distribution of thorny and winter skate from IOP observed Foreign catches ;1990-93,1994.

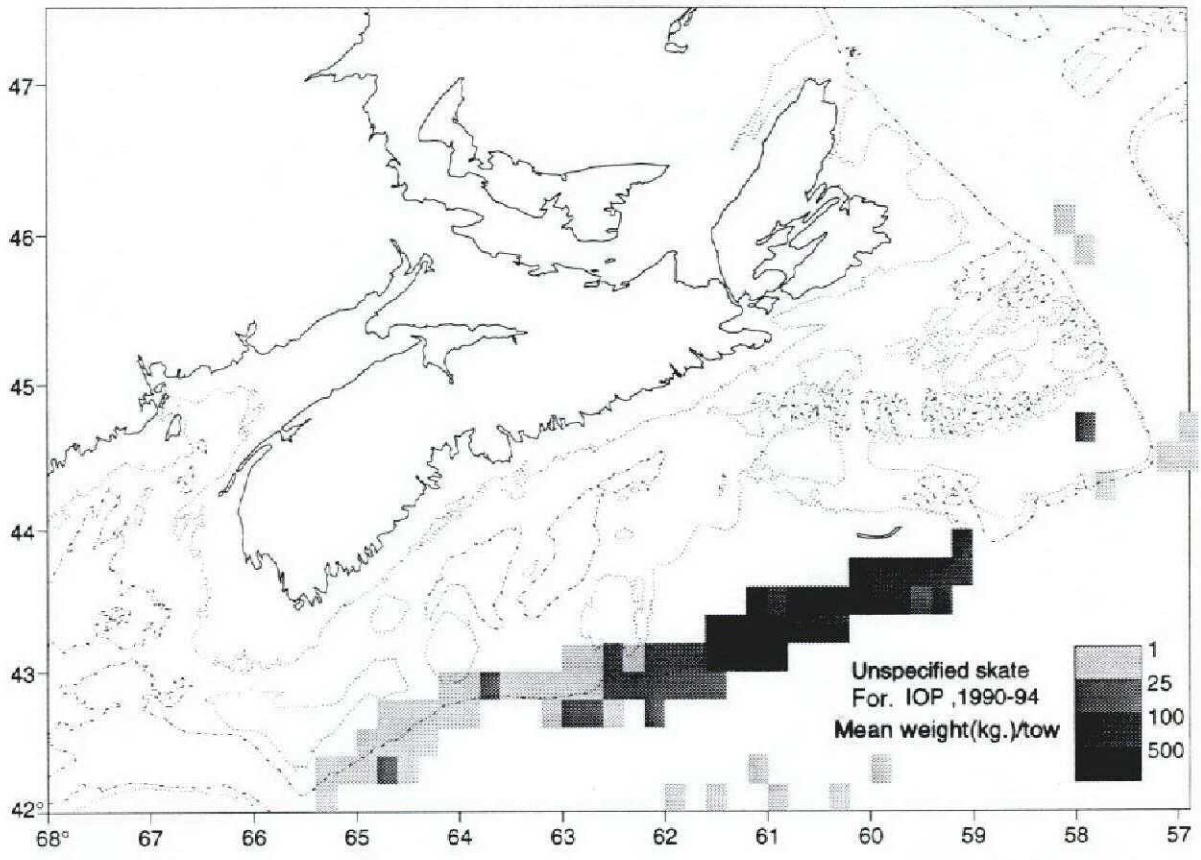


Figure 6. Distribution of unspecified skate from IOP observed Foreign catches ;1990-93,1994.

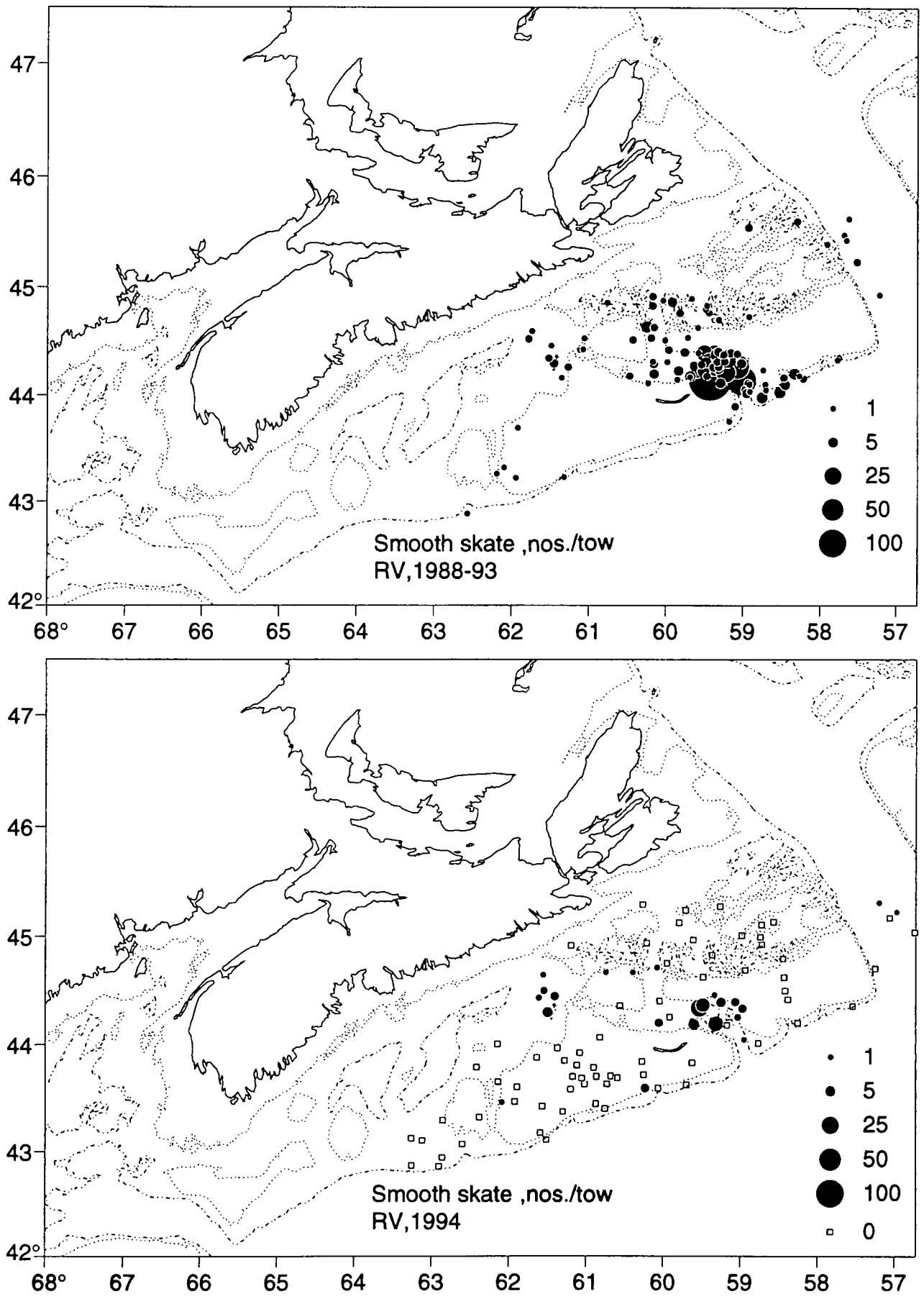
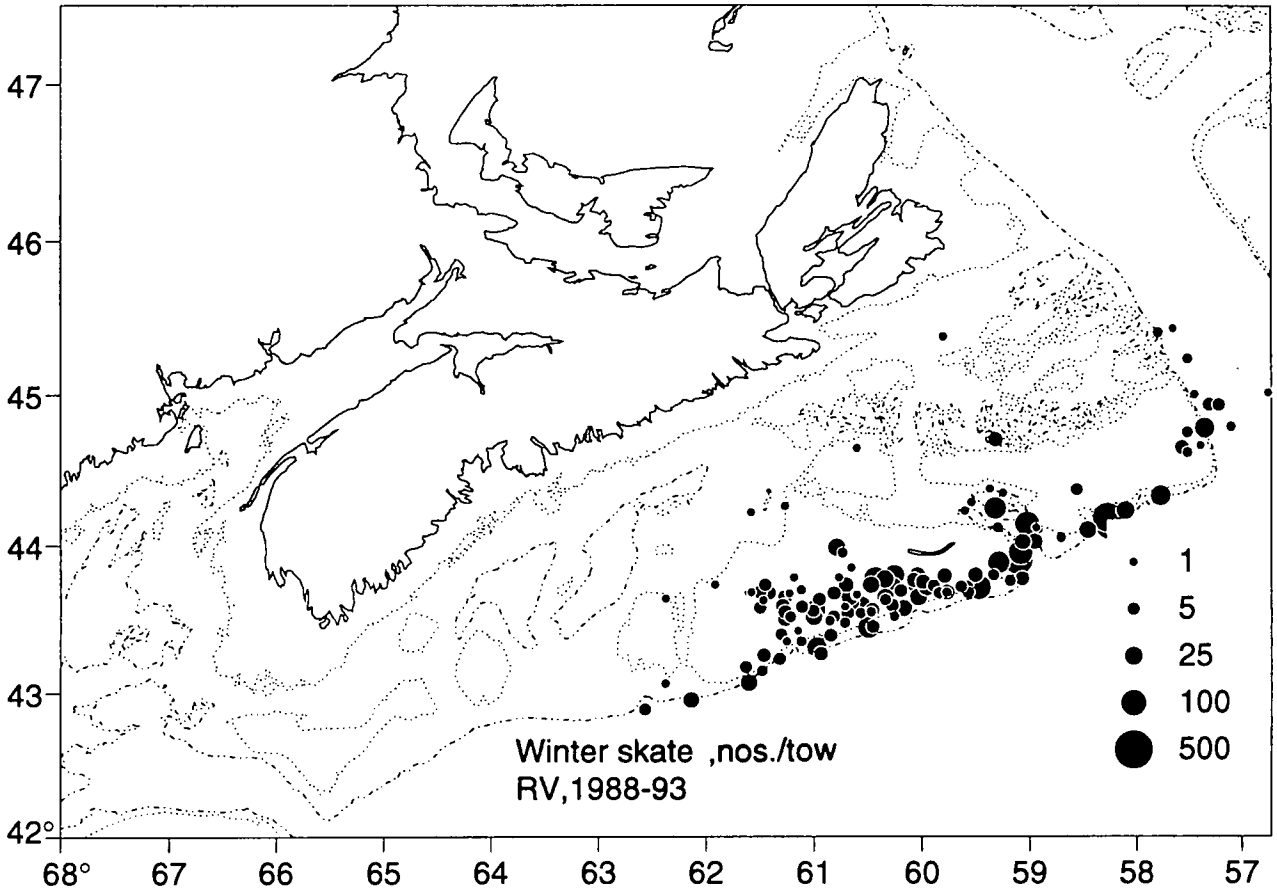


Figure 7. Distribution of smooth skate caught during the 1988-93 and 1994 spring groundfish surveys.



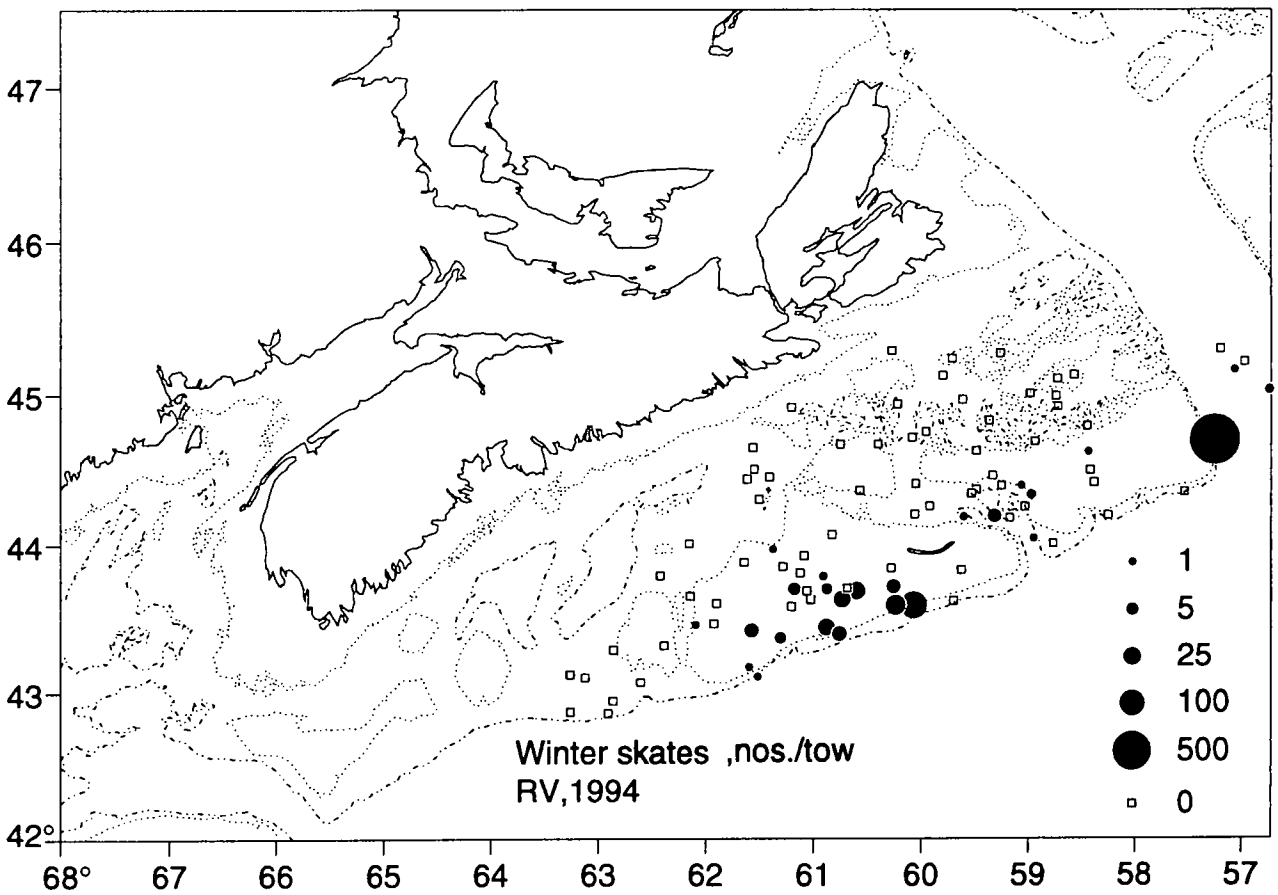


Figure 8. Distribution of winter skate caught during the 1988-93 and 1994 spring groundfish surveys.

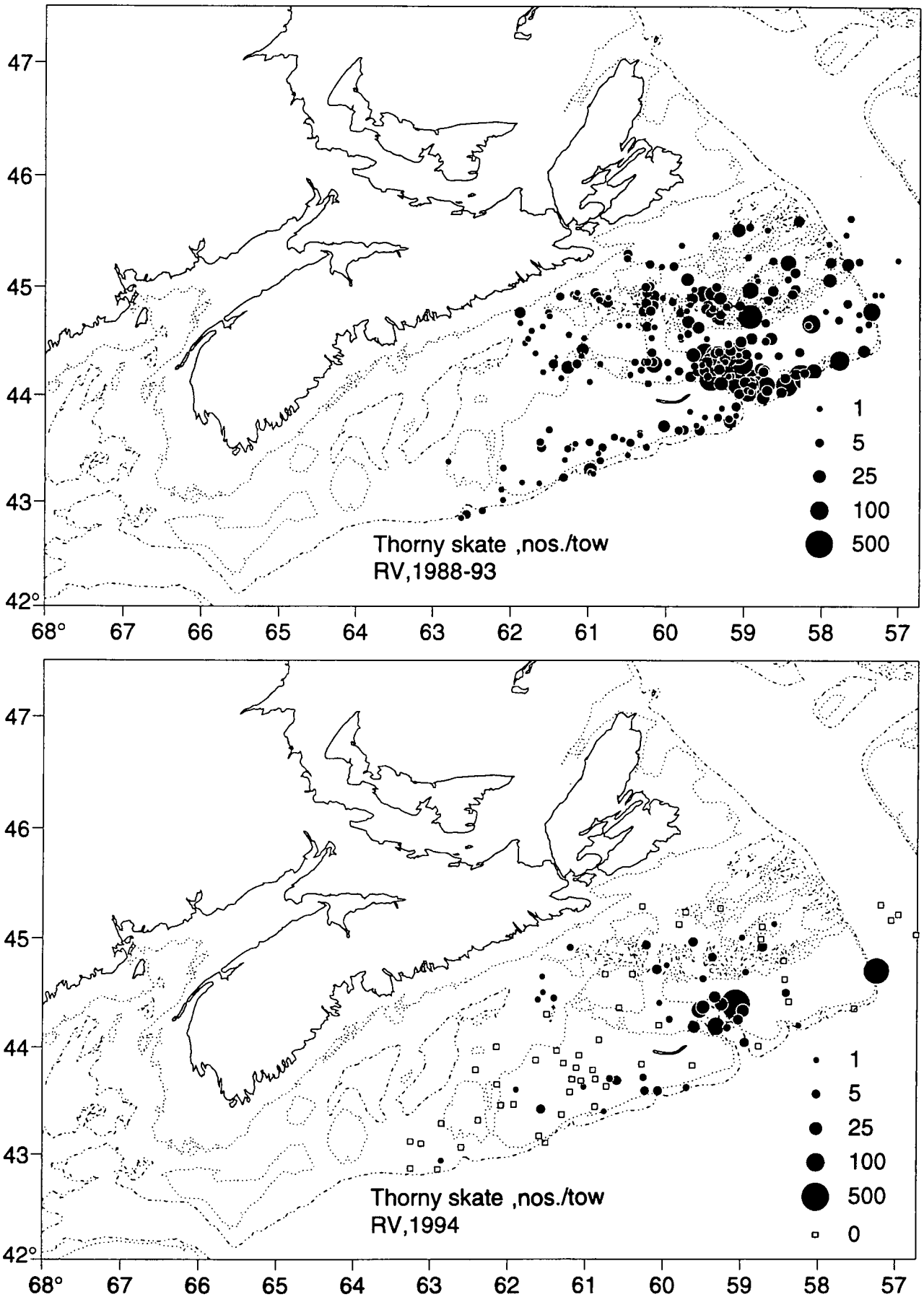


Figure 9. Distribution of thorny skate caught during the 1988-93 and 1994 spring groundfish surveys.

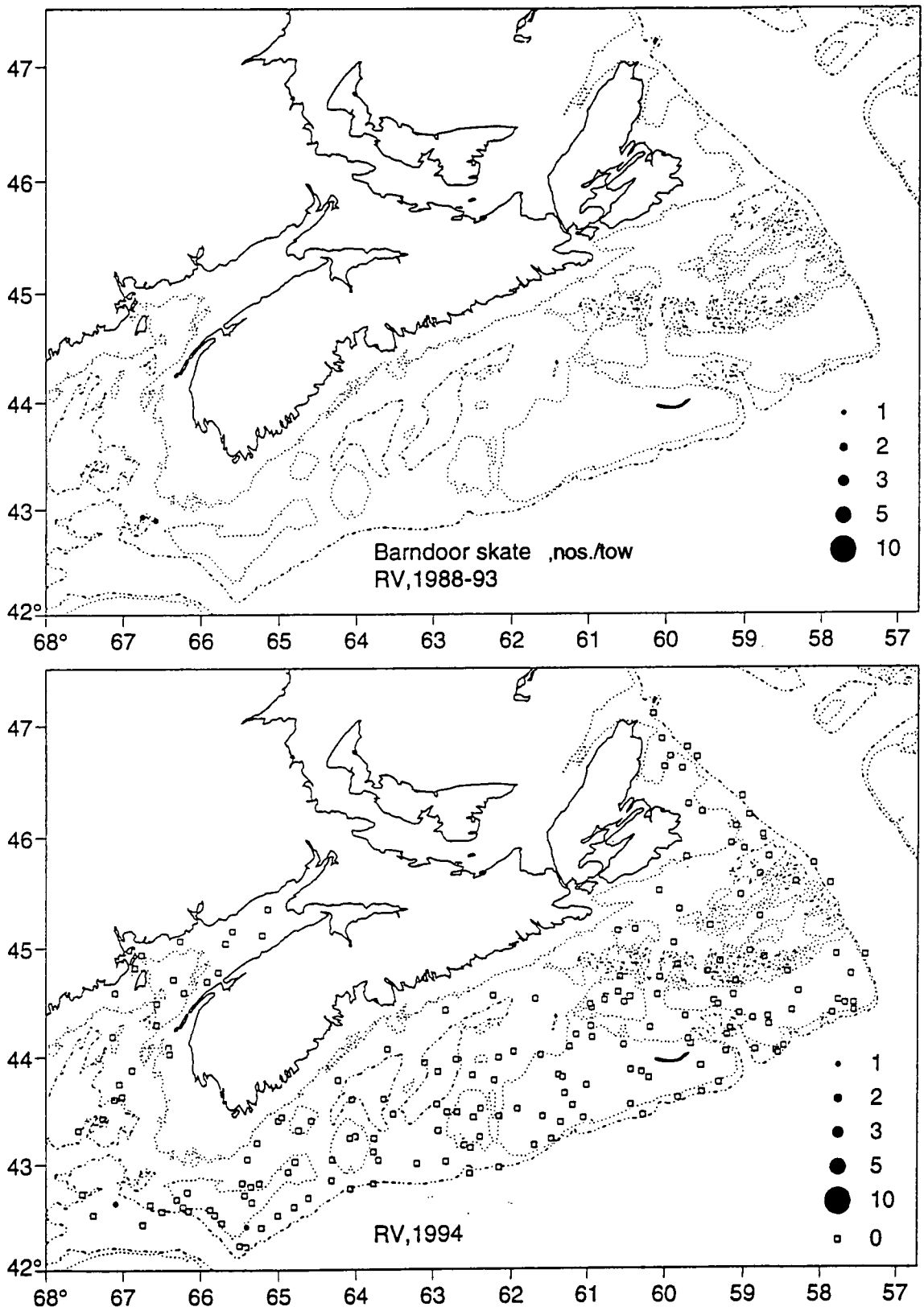


Figure 10. Distribution of barndoor skate caught during the 1988-93 and 1994 summer groundfish surveys.

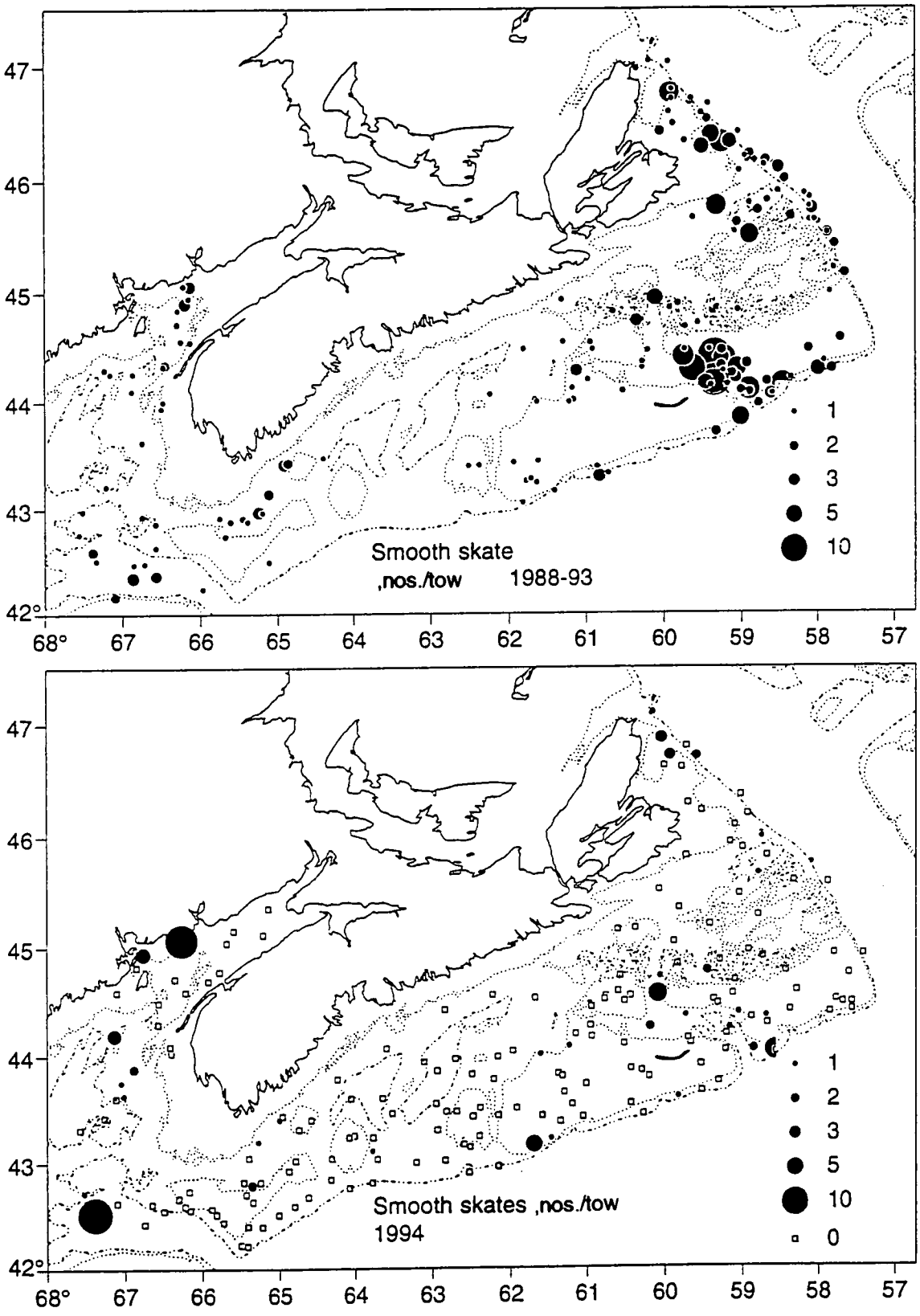


Figure 11. Distribution of smooth skate caught during the 1988-93 and 1994 summer groundfish surveys.

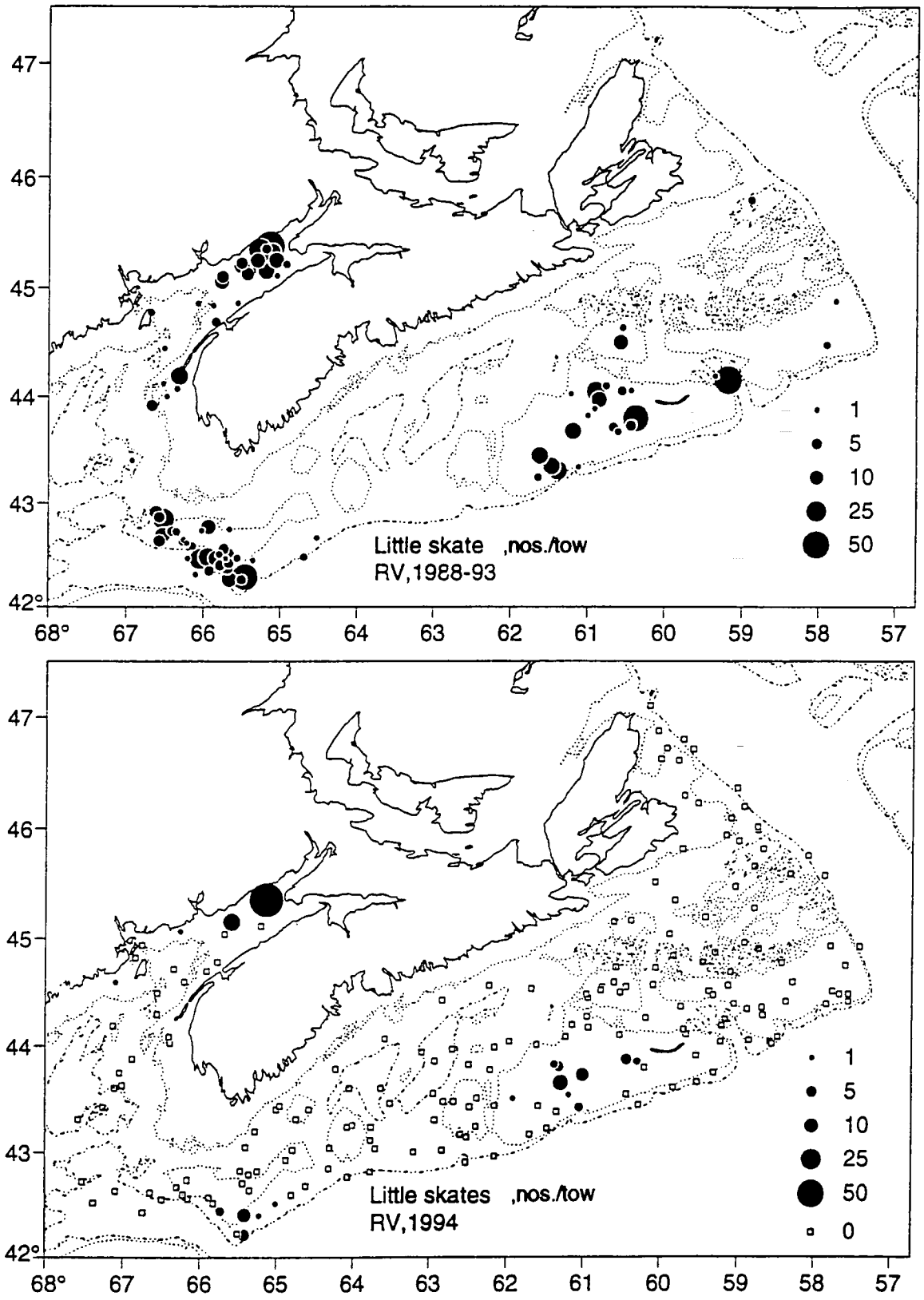


Figure 12. Distribution of little skate caught during the 1988-93 and 1994 summer groundfish surveys.

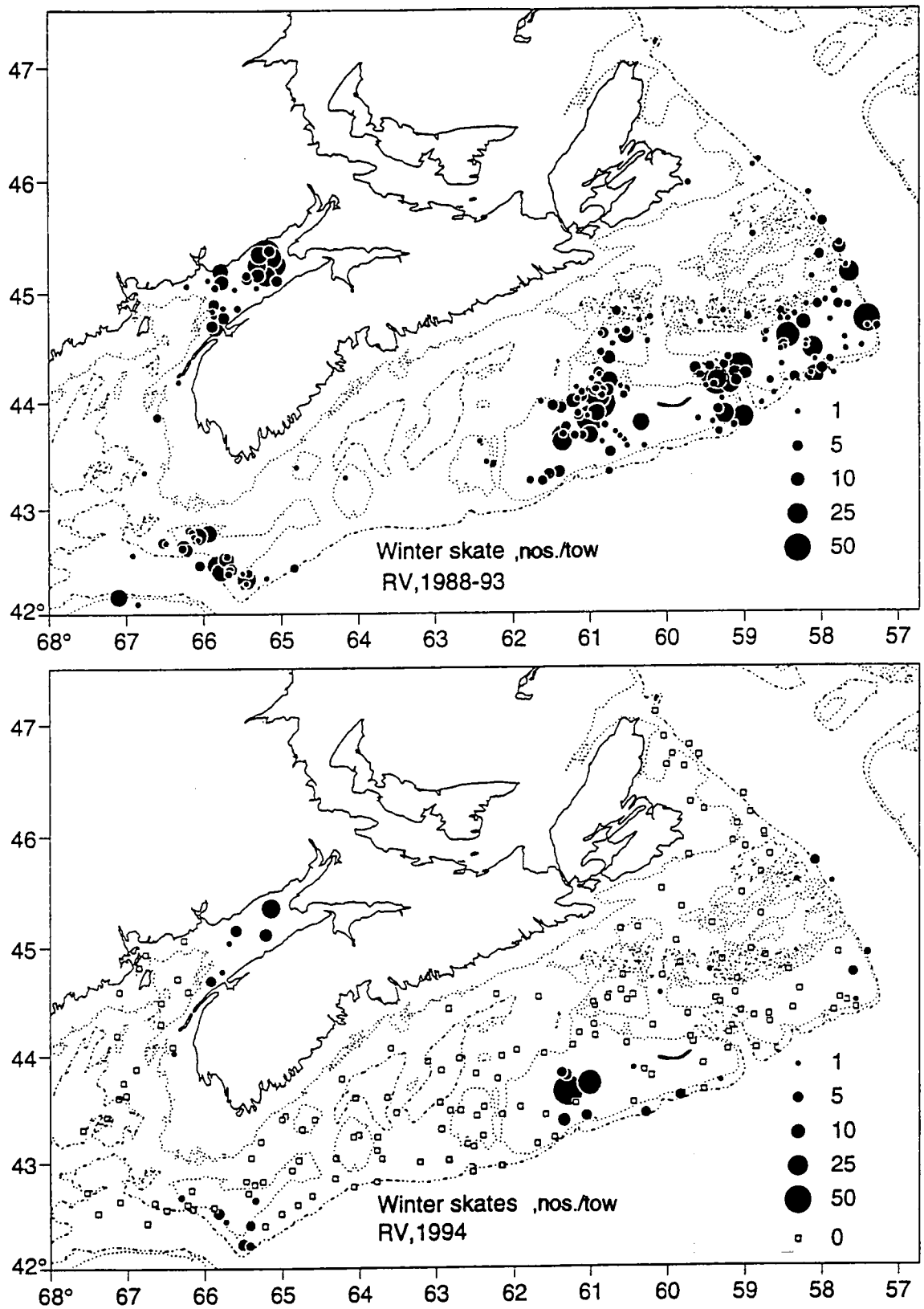


Figure 13. Distribution of winter skate caught during the 1988-93 and 1994 summer groundfish surveys.

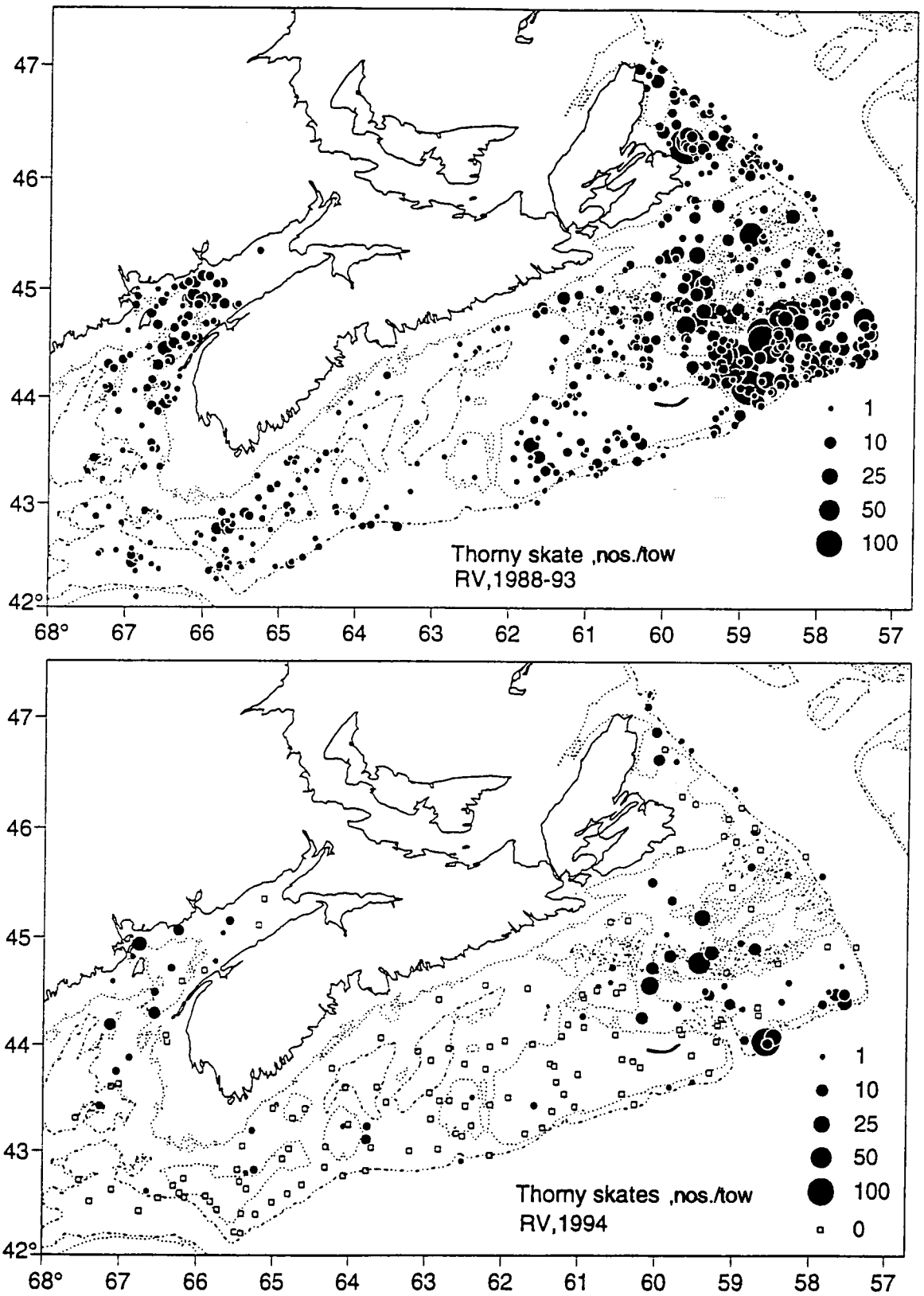
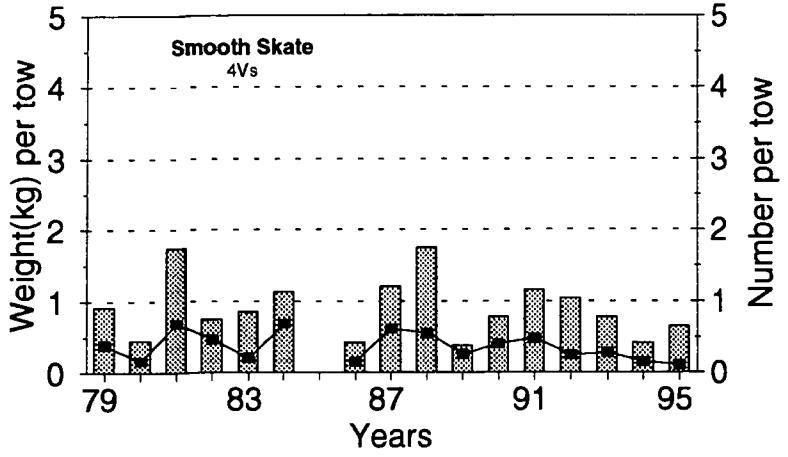
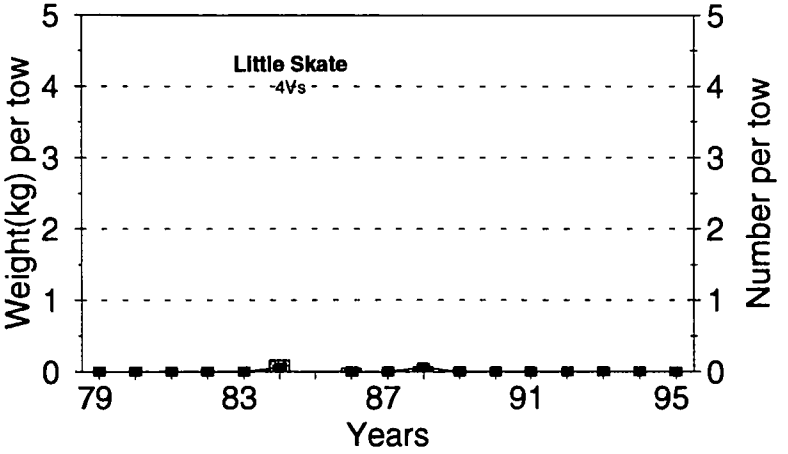
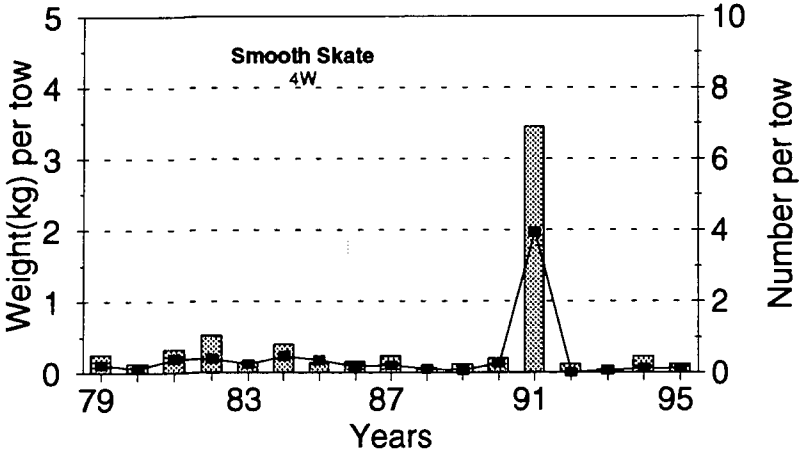


Figure 14. Distribution of thorny skate caught during the 1988-93 and 1994 summer groundfish surveys.







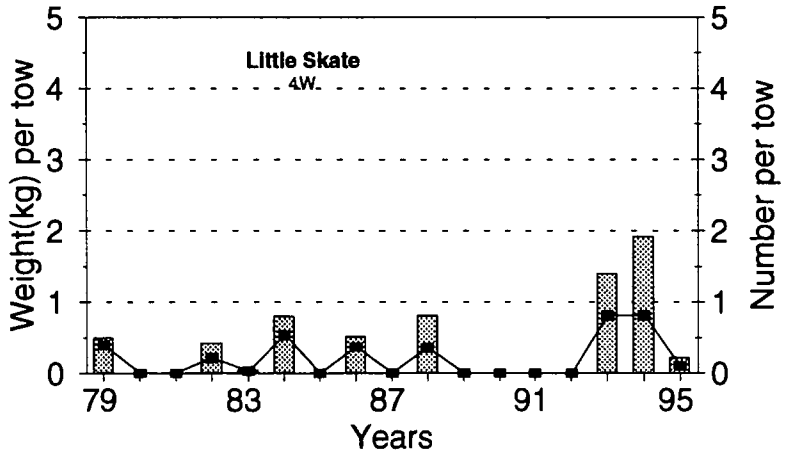


Figure 15. Abundance trends (numbers and weights per tow) of smooth and little skates in Divs. 4Vs and 4W from the spring RV groundfish survey. The histograms indicate number per tow and the line indicates weight (kg.) per tow.

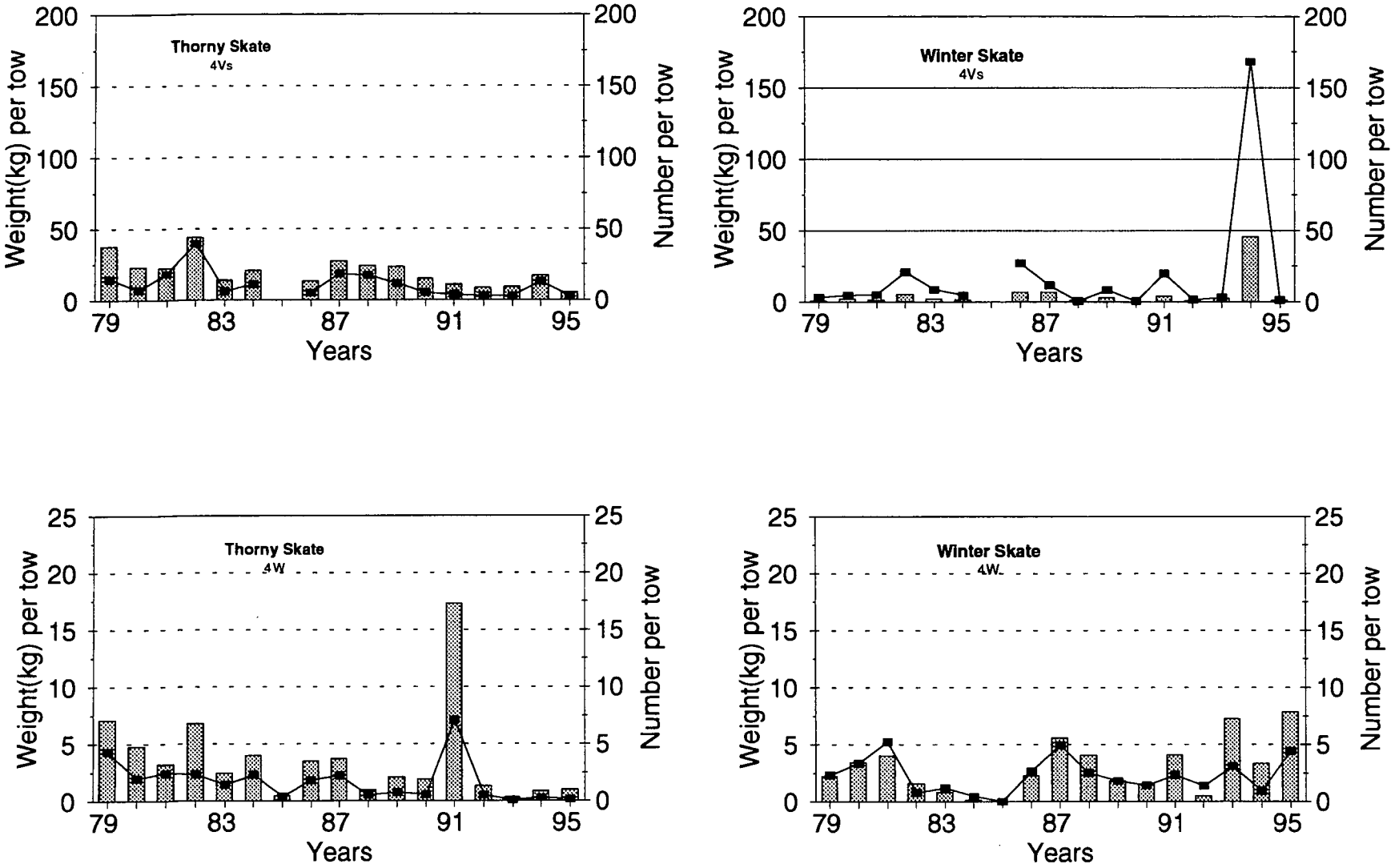


Figure 16. Abundance trends (numbers and weights per tow) of thorny and winter skates in Divs. 4Vs and 4W from the spring RV groundfish survey.

The histograms indicate number per tow and the line indicates weight (kg.) per tow.

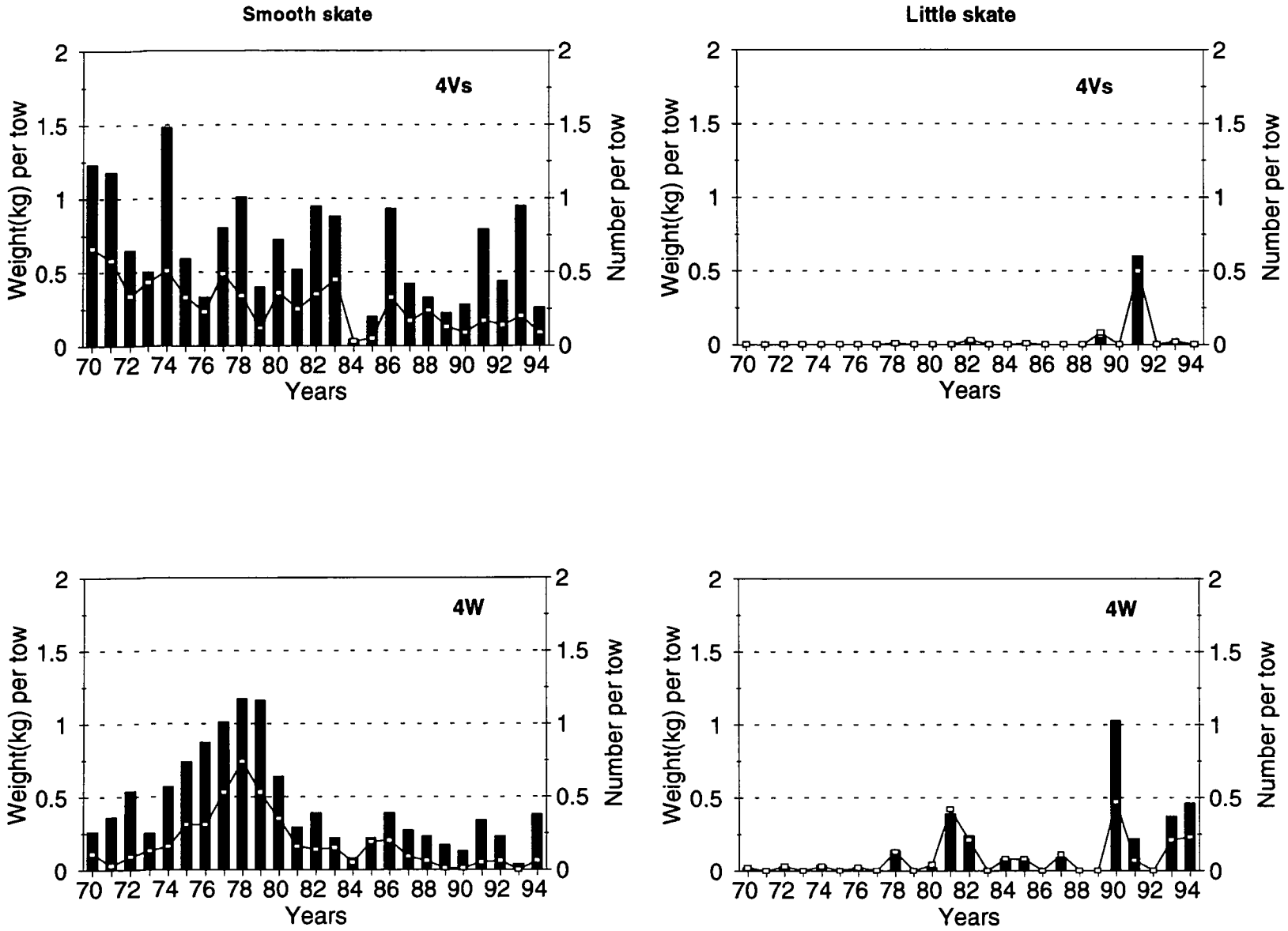


Figure 17. Abundance trends (numbers and weights per tow) of smooth and little skates in Divs. 4Vs and 4W from the summer RV groundfish survey. The histograms indicate number per tow and the line indicates weight (kg.) per tow.

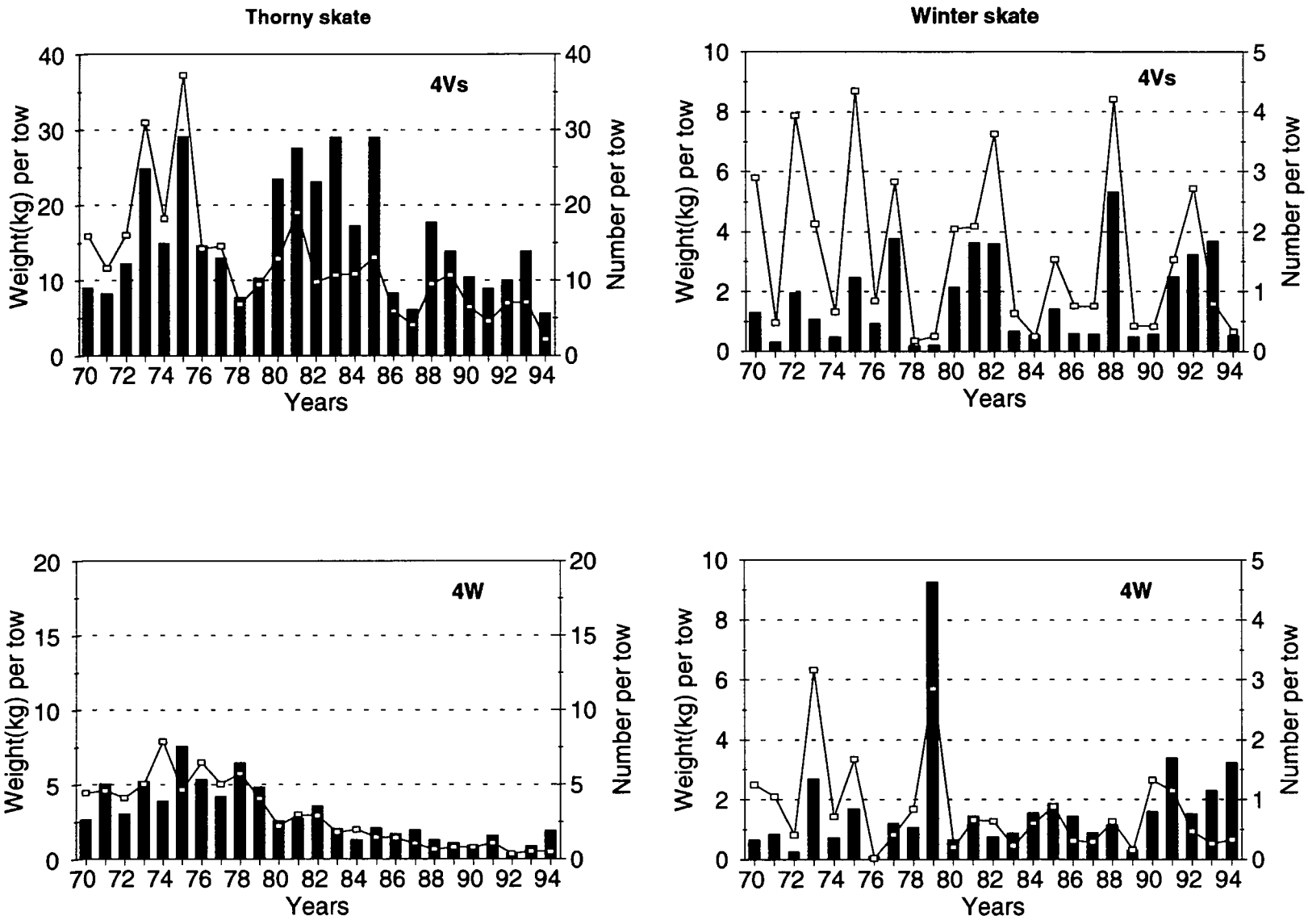


Figure 18. Abundance trends (numbers and weights per tow) of thorny and winter skates in Divs. 4Vs and 4W from the summer RV groundfish survey. The histograms indicate number per tow and the line indicates weight (kg.) per tow.

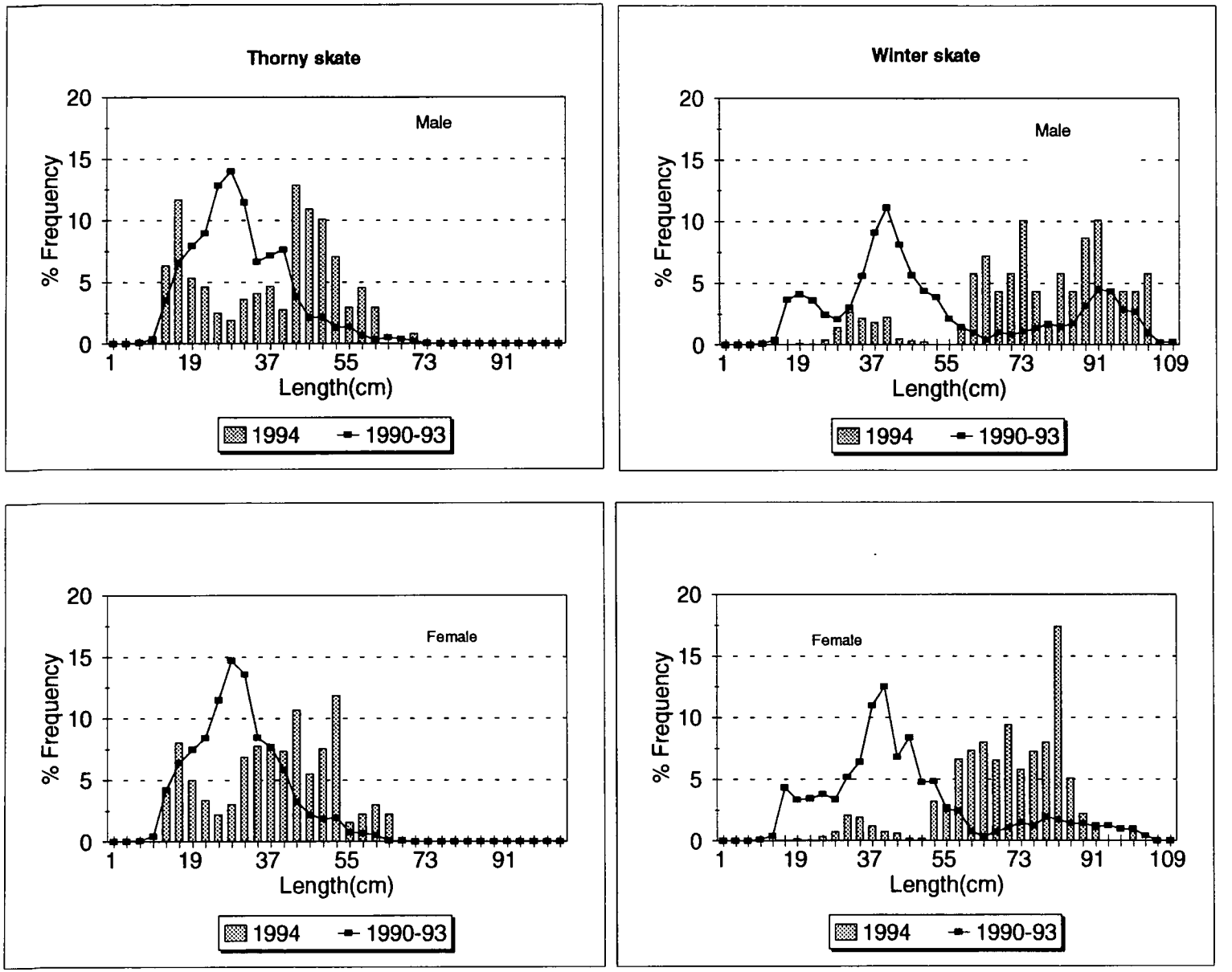


Figure 19. Length frequencies of thorny and winter skates by sex in Divs. 4VsW from the spring RV groundfish survey.

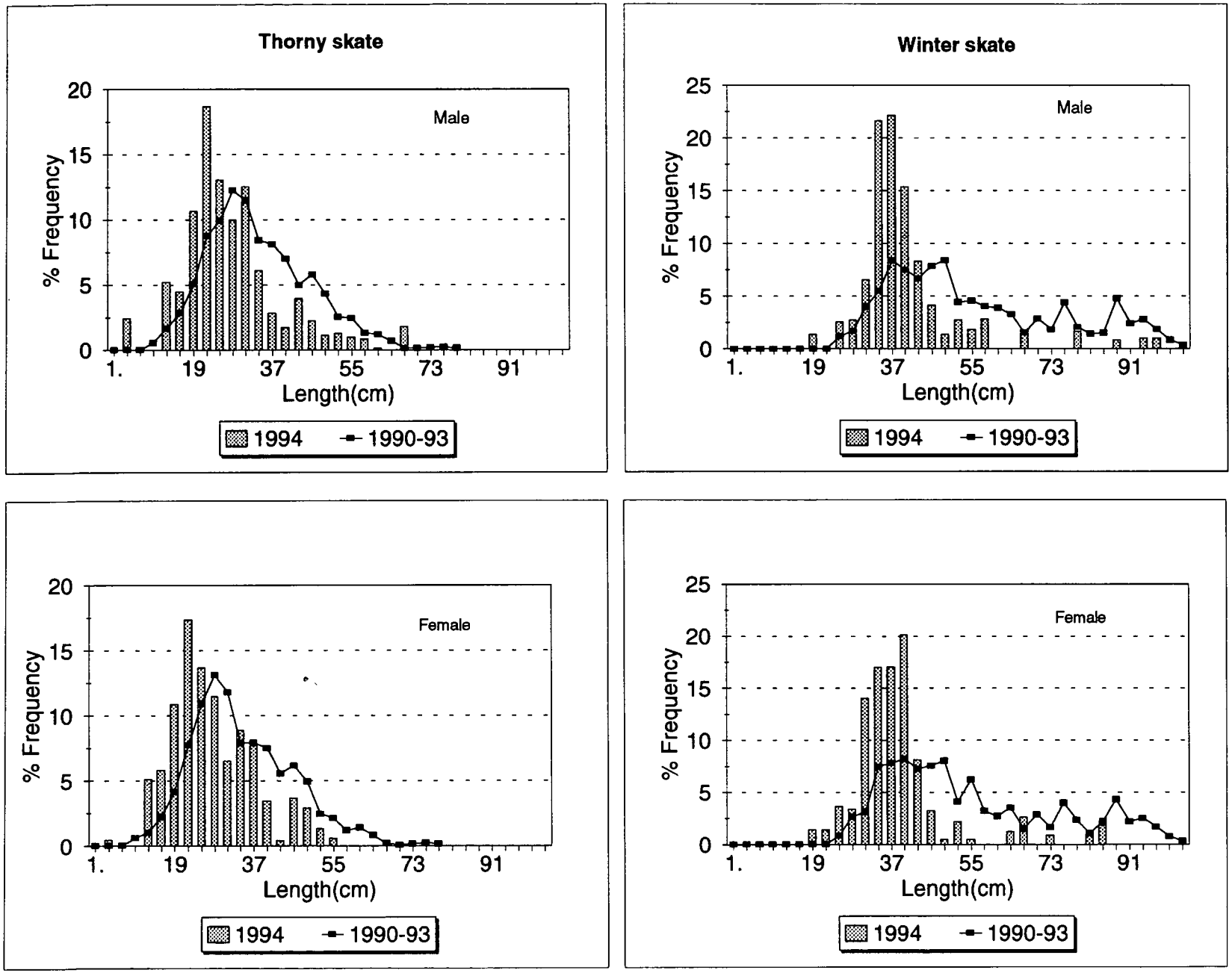


Figure 20. Length frequencies of thorny and winter skates by sex in Divs. 4VsW from the summer RV groundfish survey.

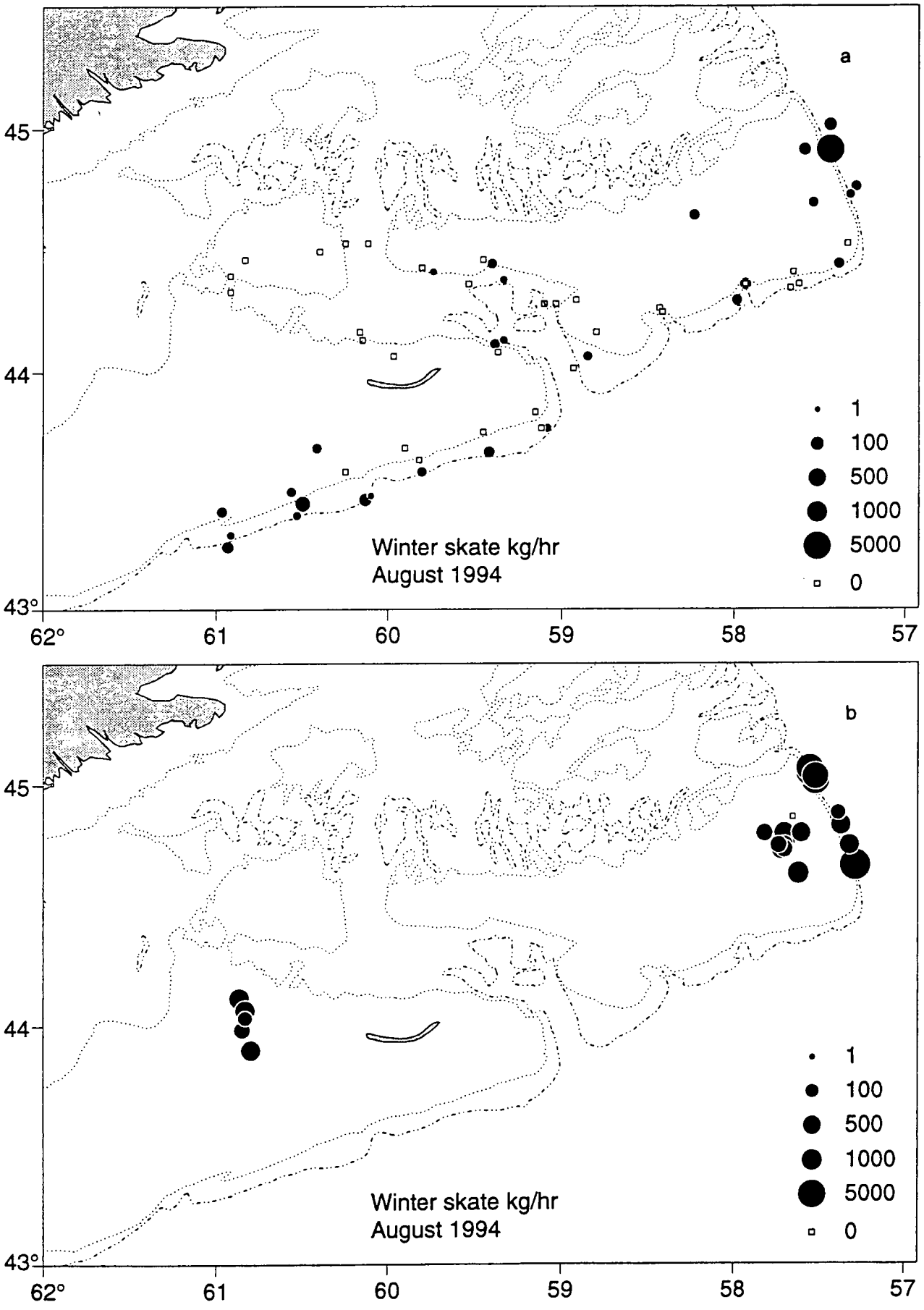


Figure 21. Distribution of winter skate caught during August of the industry/science skate survey, using a) 155 mm mesh and b) 255 mm mesh.

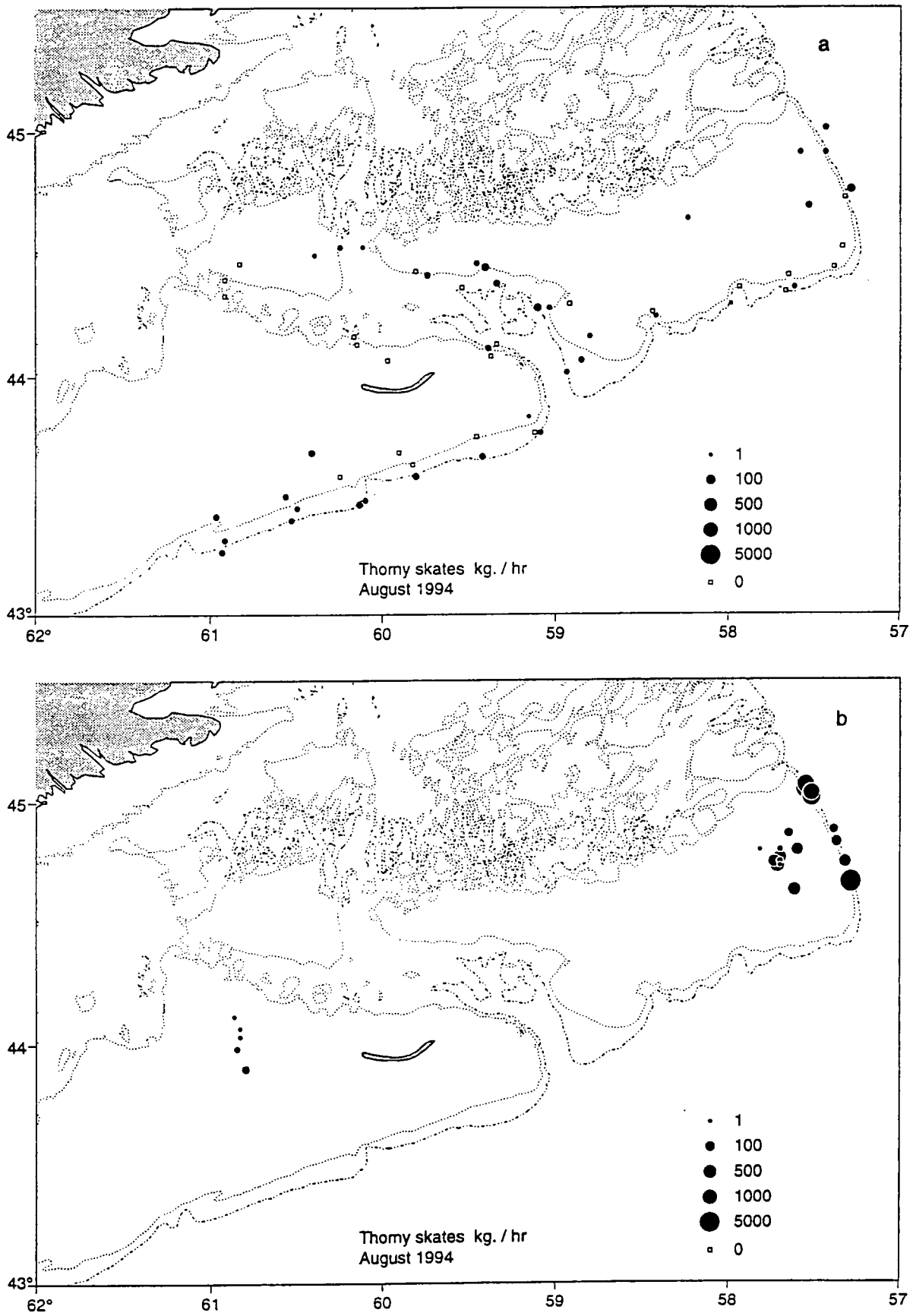


Figure 22. Distribution of thorny skate caught during August of the industry/science skate survey, using a) 155 mm mesh and b) 255 mm mesh.

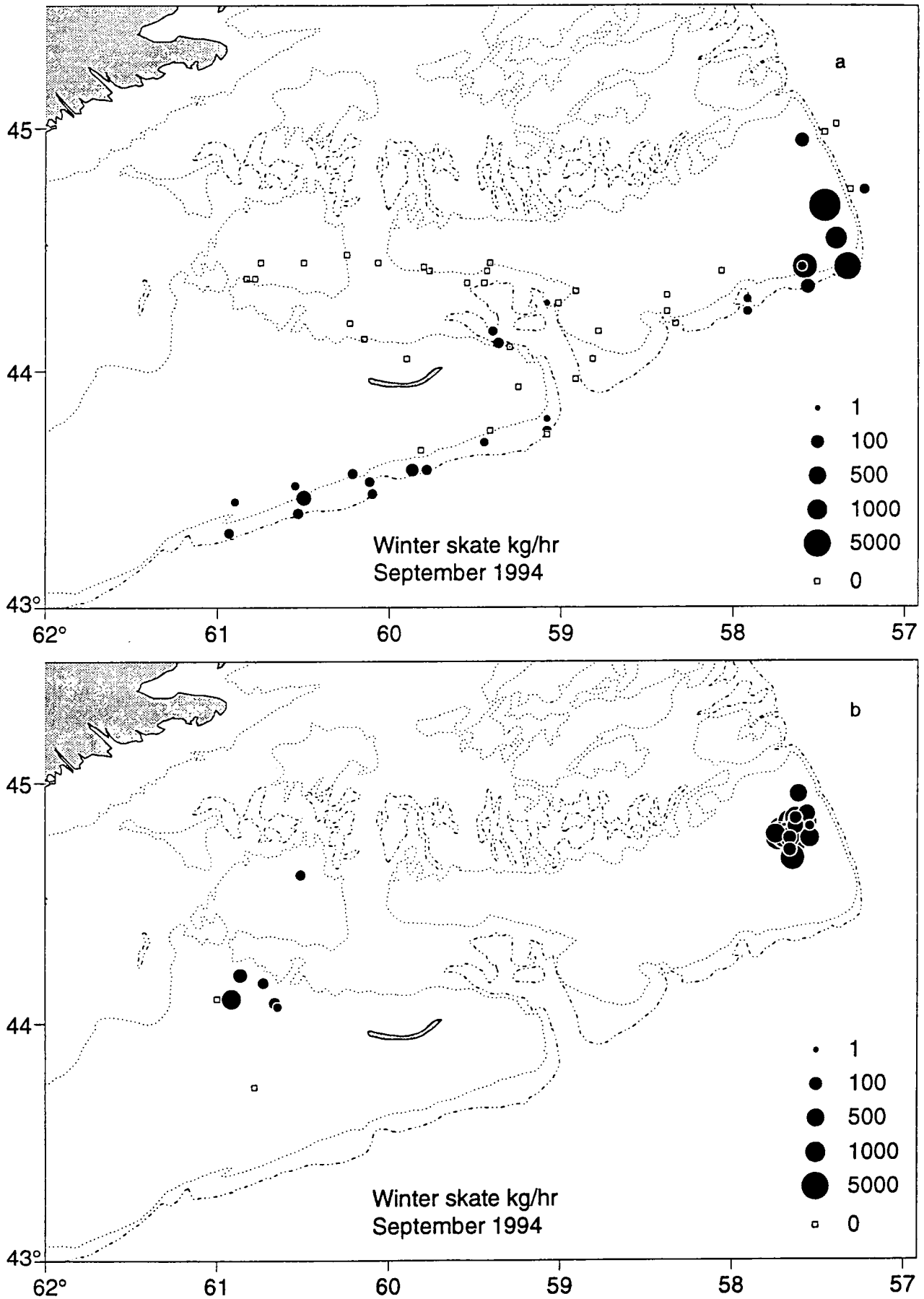


Figure 23. Distribution of winter skate caught during September of the industry/science skate survey, using a) 155 mm mesh and b) 255 mm mesh.

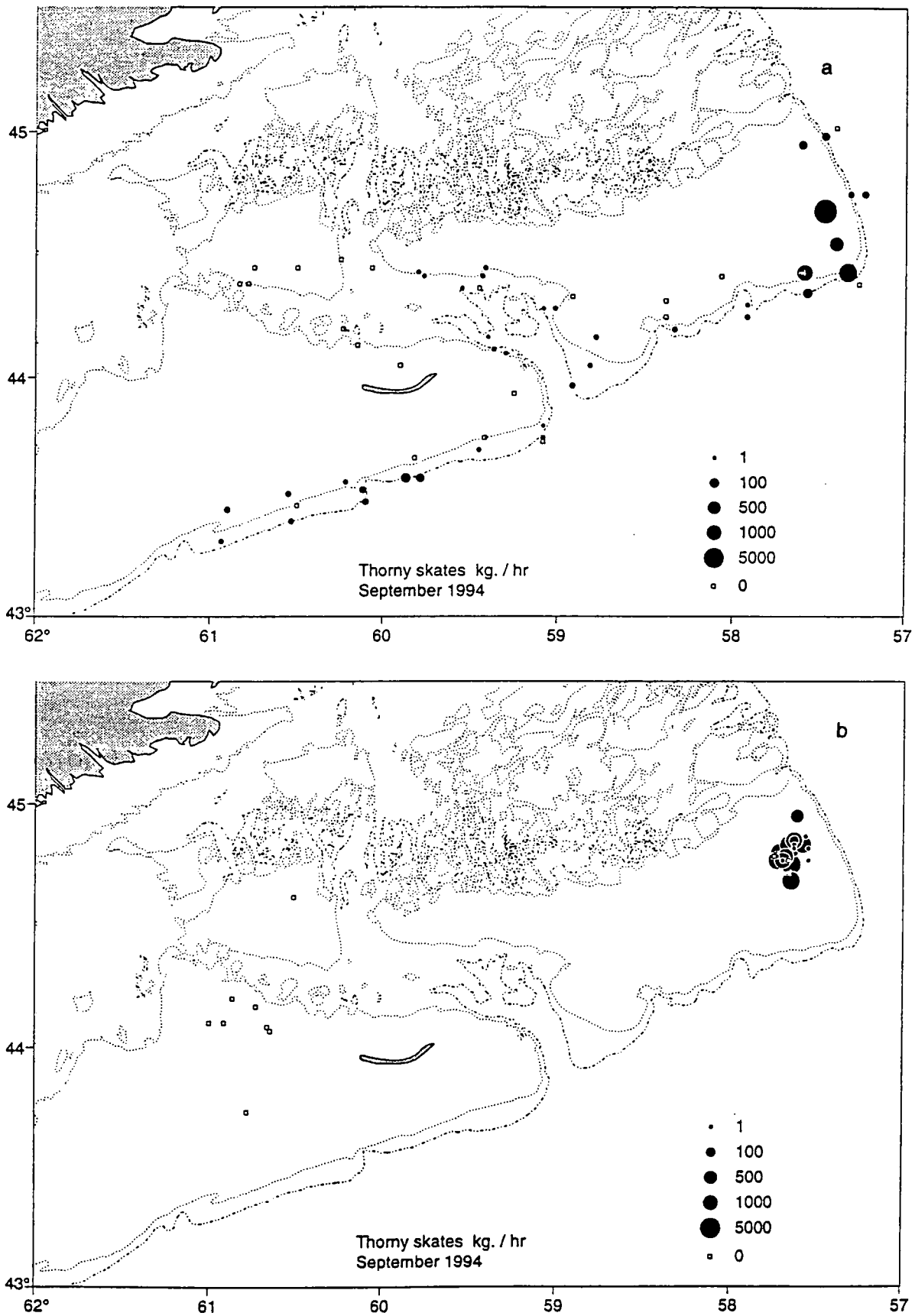


Figure 24. Distribution of thorny skate caught during September of the industry/science skate survey, using a) 155 mm mesh and b) 255 mm mesh.

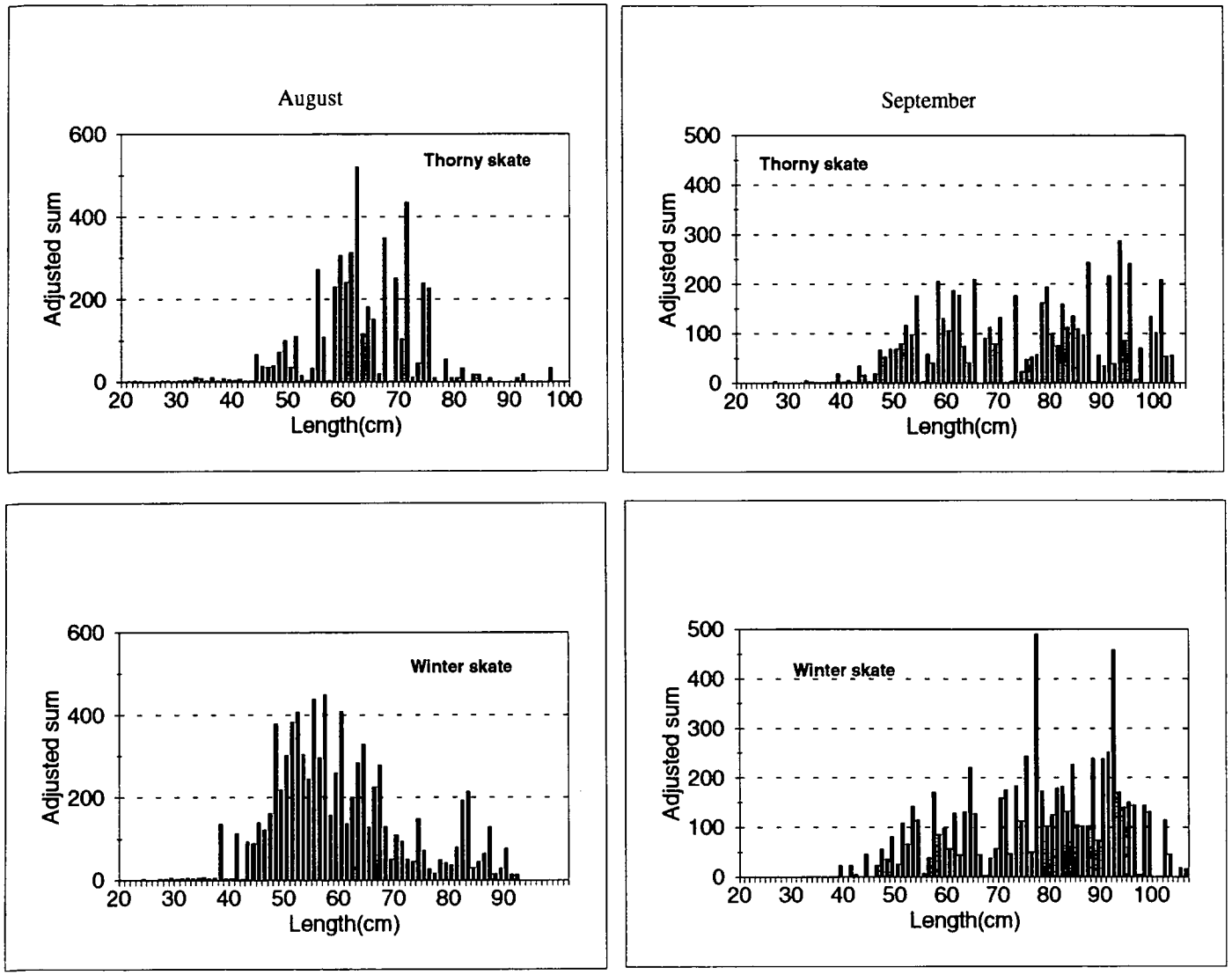


Figure 25. Length frequencies of thorny and winter skate from the industry/science surveys of August and September 1994.

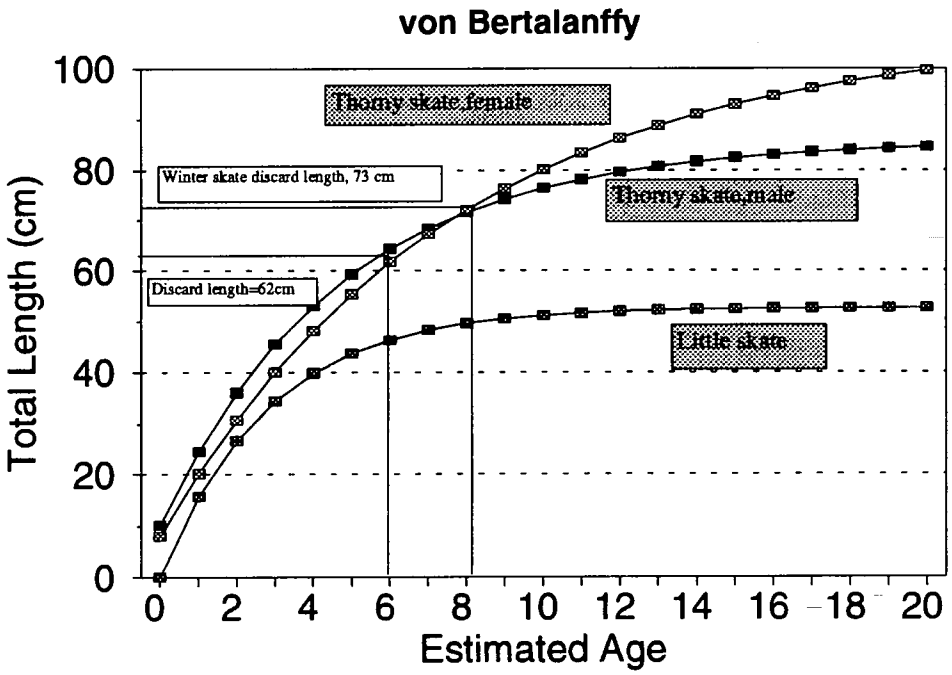
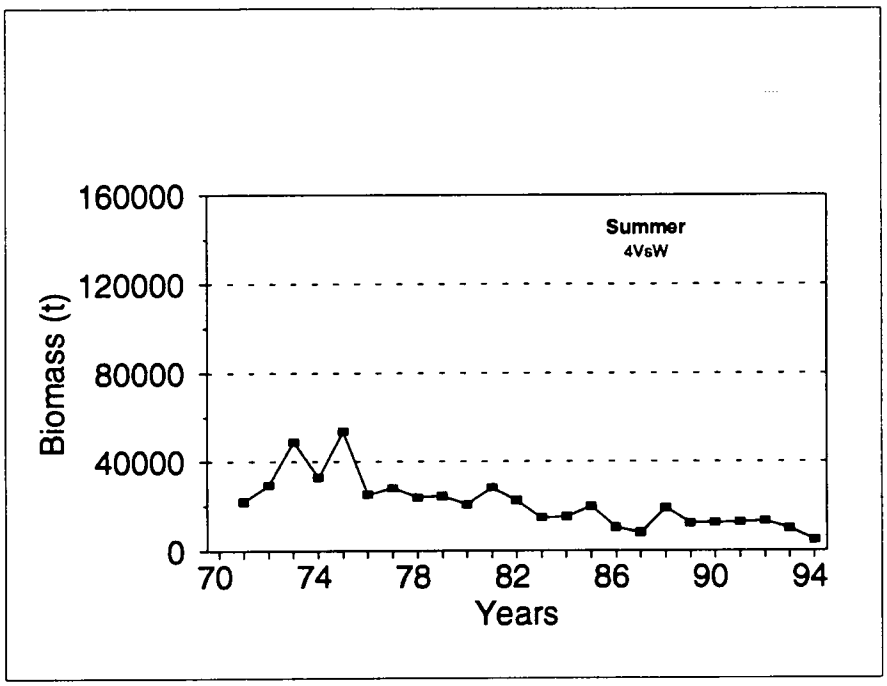


Figure 26. Growth rate of thorny and little skates as estimated by the vonBertalanffy growth equation.



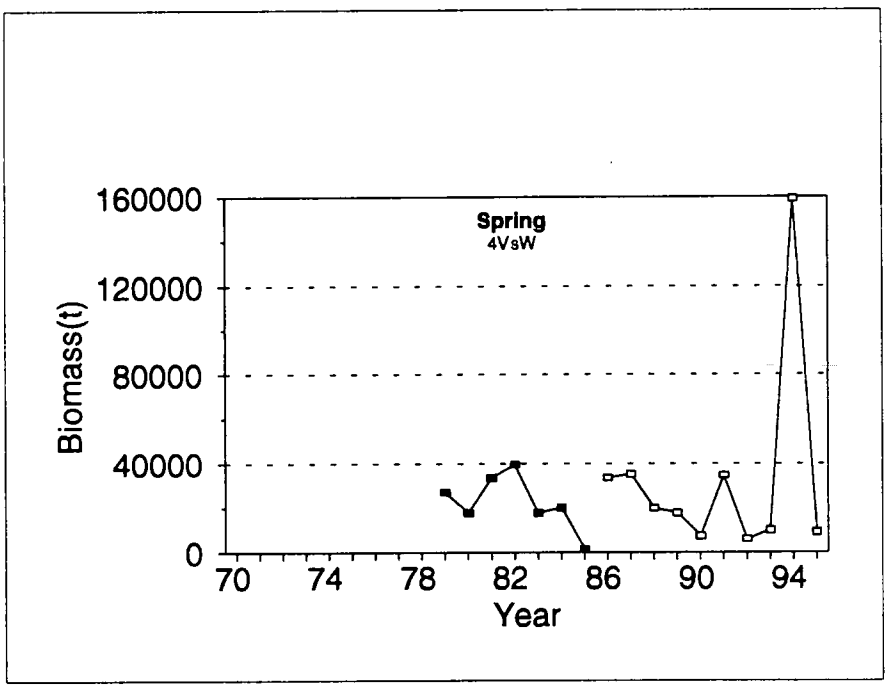


Figure 27. Minimum trawlable biomass of Divs. 4VsW skates (all species combined) as estimated by the summer and spring groundfish surveys.Break in spring trend due to stratification differences.

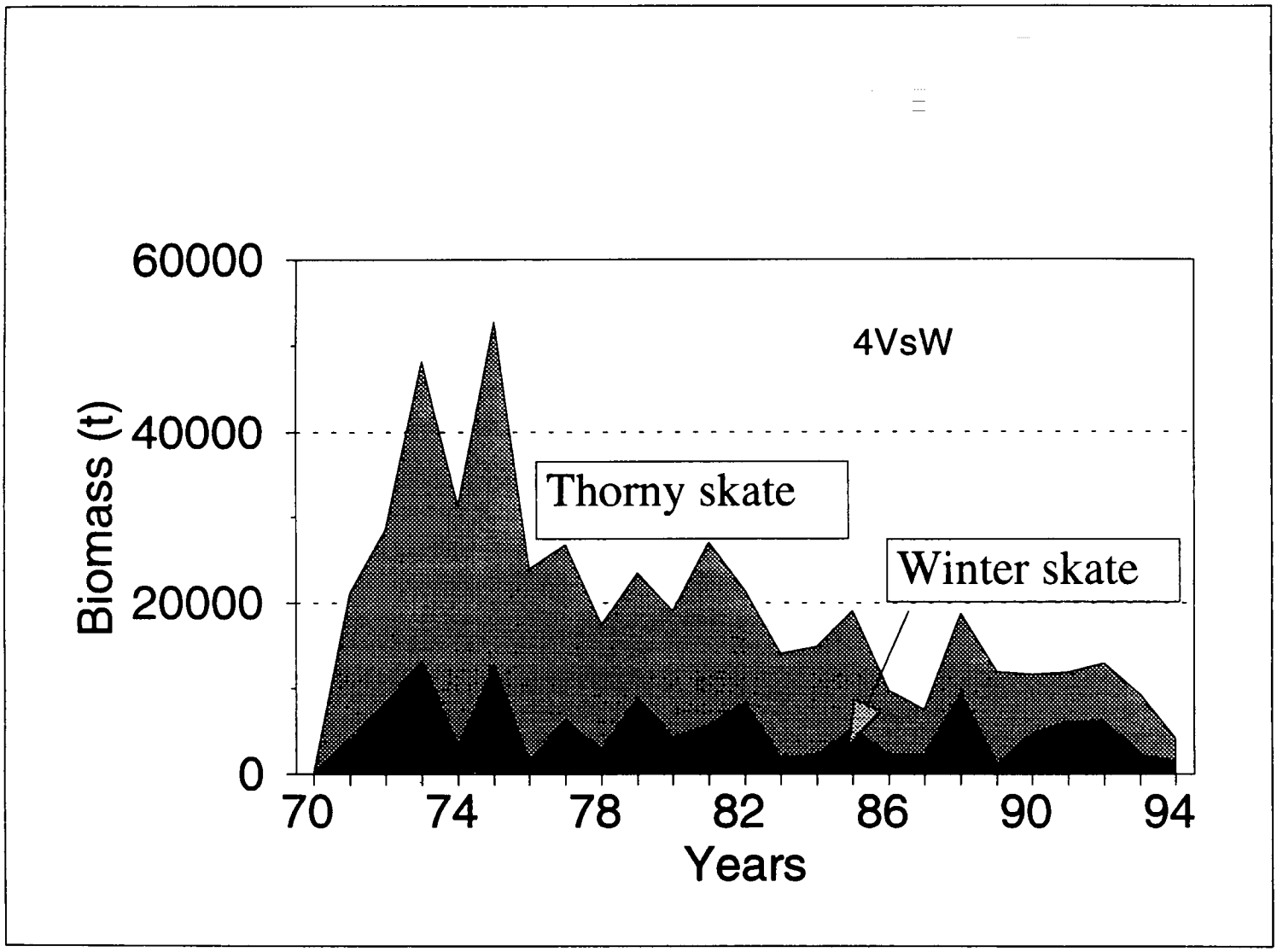


Figure 28. Minimum trawlable biomass of thorny and winter skates in Div. 4VsW as estimated by the summer groundfish survey.