

**Assessment of the Winter Skate Fishery  
In Division 4VsW**

By

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## Abstract

The skate fishery on the Scotian Shelf began in 1994 with landings of 2152t. Since then landings have been progressively lower reflecting reductions in the TAC. In 1997 the TAC was 1200t and landings amounted to 1048t. There are indications that the Div. 4VsW winter skate stock is currently overexploited.

Abundance of winter skate from the summer research vessel (RV) survey has been below the long-term mean for the last four years. The spring RV survey suggests a progressive shift in the distribution towards the edge of the shelf. Both the spring and summer surveys show a reduction in the number of winter skate greater than 85cm. This was reflected in the commercial landings where a marked decline in the percentage of winter skate greater than 90 cm has occurred. The industry/science surveys have also shown a decline in abundance of larger winter skate.

Previous maturity studies suggested that female winter skate reached 50% maturity between 65 to 70 cm. Further research showed that 50% maturity of female winter skate was closer to 75cm. Estimates of total mortality (Z) of winter skate were derived from an analysis of commercial catches using a growth model of Scotian Shelf winter skate to convert lengths to ages. The resulting Z's were low in 1995 (0.35), reached a maximum in 1997 (0.76) and levelled off at 0.73 in 1998. In the previous assessments of this stock no reduction in the length range of winter skate was evident. This situation no longer holds true: declines in the abundance of all sizes of skate especially the larger sizes have occurred, and the estimates of total mortality are very high. Therefore, it is considered that either the developmental fishery continue in 1999 at a very much reduced level or the skate fishery be closed entirely.

## Résumé

La pêche de la raie sur le plateau néo-écossais a débuté en 1994 et les débarquements ont alors atteint 2 152 t. Ils ont ensuite diminué progressivement et ainsi reflété les réductions du TPA. Le TPA a été fixé à 1 200 t en 1997 et les débarquements ont atteint 1 048 t. Certains indices font état d'une surexploitation du stock de raie tachetée en 4VsW.

L'abondance de la raie tachetée déterminée au moment du relevé d'été par navire de recherche (NR) est inférieure à la moyenne à long terme depuis les quatre dernières années. Le relevé de printemps par NR indique un déplacement progressif de la répartition vers la bordure du plateau. Tant les relevés de printemps que les relevés d'été indiquent une réduction du nombre de raies tachetées de plus de 85 cm. Cela a été noté dans les captures de la pêche commerciale où un déclin marqué du pourcentage des raies tachetées de plus de 90 cm a été perçu. Les relevés conjoints industrie-science font aussi état d'un déclin de l'abondance des raies tachetées les plus grosses.

Des études antérieures sur la maturité portent à croire que la maturité à 50 % est atteinte entre les longueurs de 65 et 70 cm chez la femelle de la raie tachetée, mais d'autres travaux ont montré que la maturité à 50 % serait plutôt atteinte à une taille approchant 75 cm. Des estimations de la mortalité totale (Z) chez la raie tachetée ont été obtenues d'une analyse des captures commerciales en appliquant un modèle de croissance de la raie tachetée du plateau néo-écossais à une conversion des longueurs en âges. Les valeurs de Z ainsi obtenues étaient faibles en 1995 (0,35), atteignaient un maximum en 1997 (0,76) et plafonnaient à 0,73 en 1998. Aucune réduction de la gamme des longueurs des raies de ce stock n'a été décelée au moment des évaluations antérieures. Cela n'est pourtant plus exact : il y a eu déclin d'abondance de toutes les gammes de longueurs, particulièrement chez les plus grandes, et les estimations de la mortalité totale sont très élevées. Il est donc jugé que, si la pêche de développement devait se poursuivre en 1999 elle devrait l'être à un niveau de beaucoup réduit, ou que la pêche de la raie devrait être complètement interdite.

## 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, research vessel survey data, and biological observations from observers. 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 seasonal bycatch of thorny skate within the Div. 4VsW management unit (Figure 1).

## Fishery

### Past

There has never been a regulated fishery for skates on the Scotian Shelf before 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. Canadian landings have generally been low with the exception in Divs. 4VW during the mid-1970s when landings ranged between 60 - 700t (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 6,100t in Div. 4Vs, 16,000t in Div. 4W, and 2,100t in Div. 4X (Table 1). 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

A brief history of the current directed skate fishery on the eastern Scotian Shelf and the rationale for the harvesting plan was reviewed in Simon and Frank (1995,1996). In 1995, the allocation of 1,600t of skates was not reached (Table 1). Two factors contributed to this shortfall: i) a developing skate fishery in Div. 3LNOPs that contributed to an oversupply of skate causing a weakening of prices and a suspension of fishing on the Scotian Shelf during the months of July and August, and ii) with the resumption of fishing in the fall inclement weather resulted in lower catches. In 1996, there was a slight overrun of the 1600t TAC. A 20% by-catch in the directed flatfish fishery was also permitted and this contributed to the total landings. In 1997, the TAC was reduced to 1,200t due to concerns about the health of the stock. This allocation was not reached due in part, to the fact that one of the four vessels participating in the fishery was sold and its allocation was not redistributed until late in the fishing season. In 1998, the TAC remained the same as the previous year. Indications are that the same situation has developed

with one of the license holders. Industry has indicated that the TAC will not be reached in 1998 due to this problem.

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 this document we have attempted to determine the by-catch of winter skate only in those fisheries that were examined previously. Unfortunately only the species identification from the last 4 years was considered valid. An average of the last four years was calculated from each of these fisheries and applied to the entire time series (1989-1998). Winter skate removals from the foreign fisheries in Div. 4W were calculated to be as high as 1180t in 1990 and as low as 12t in 1994 (Table 2). The by-catch of all skate in the Canadian groundfish fisheries in Div. 4VW ranged between 1 and 3% and recently has sharply fallen to very low levels due to the closure of the cod and haddock fisheries in the region. Winter skate make up approximately 50% of the total skate by-catch resulting in a peak of 872t in 1989. In the directed flatfish fishery a by-catch estimate of 5% winter skate was applied over all years yielding removals ranging from 52 to 212t. Estimates of the total removals by these fisheries peaked in 1990 at 2193t and were low (100t) in 1997. In 1997, the combination of catches from the directed fishery and by-catch totalled 1148t (Table 2).

Other recent sources of removals of skates not included in the above totals are associated with the DFO/Industry Sentinel Survey that use longlines for fishing in Div. 4VsW from 1995 to 1998. Skates were a significant by-catch in the surveys and between 3.7 and 10.1t were caught. The percentage of these catches that are winter skate is not exactly known due to a species identification problem but were estimated to range from 10-25%.

### Commercial Catch Rates

Estimates of commercial catch rates (t/hr) were calculated for the four vessels targeting skates from 1994-1998 (Figure 3). Except for 1994 a similar pattern has occurred each year. Catch rates at the beginning of the fishing season are greater than 1 t/hr. They fall sharply in May and remain low until December. The annual CPUE in Div. 4Vs was 1.8 t/hr in 1994 falling to .9 t/hr in 1996 and rising to 1.2 t/hr in 1997 and 1998. One of the four vessels began fishing in Div. 4W in 1995. Catch rates (.5 t/hr) have been lower than in Div. 4Vs and have remained steady in the three years that data has been available.

### Distribution

Previous observer data indicated that winter skate catches were concentrated along the slope waters adjacent to Sable Island and Banquereau Banks during the first and second quarter. During the third quarter observer coverage of the skate fishery was limited. During the fourth quarter winter skates were distributed in shallower water suggesting a movement from deep water had occurred sometime after the second quarter (Simon and Frank, 1996).

Distribution information from the 1995 Sentinel Survey in Div. 4VsW revealed the highest concentrations of skate were on the eastern shoal area of Banquereau Bank and along the banks southern edges. Unfortunately the skates in that year were not identified to species. The 1996 and 1997 Sentinel surveys were identified to species but identification problems arose in a couple of trips. In those cases where identification was considered to be accurate, the highest concentration of winter skate was found west of Sable Island. A secondary concentration was observed on the eastern shoal of Banquereau Bank.

### Commercial Catch at Length

Commercial sampling of winter skates from DFO port technicians began in 1995 with the collection of 11 winter skate length frequencies (Table 3). Sampling of the fishery has continued with 16, 17 and 4 samples collected in 1996, 1997, 1998 respectively (Table 3). These catches have been adjusted to the total number of removals at length by the fishery (Figure 4). 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. In 1996, 1997, and 1998 catches in the fishery peaked between 71-73cm. The percentage of fish greater than 90 cm has declined from 25% in 1995, to 6% in 1996 and less than 3% in 1997 and 1998 (Figure 5).

### **Research Vessel (RV) Surveys**

#### Distribution

##### Spring

Spring research vessel surveys of the eastern Scotian Shelf groundfish community have been conducted from 1979 to 1997. The 1996 spring survey was not considered comparable to previous spring surveys because coverage was incomplete. The results of these surveys were aggregated into time blocks for comparison with each other (Figure 6) and the summer RV survey. Since 1979, there has been a progressive shift 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 most recent period (1995-1997).

##### 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 7). 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 4X, winter skate appear to have increased in the Browns Bank region and to have remained stable in the Bay of Fundy (Figure 7).

## 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 estimate in 1997 of 2.75 fish per tow is slightly above the long-term mean (based on the entire time series excluding the anomalous 1994 value) while the weight per tow estimate of 1.98 is one half the long-term mean (Figure 8).

### Summer

Winter skate catch rates have exhibited a variable pattern of abundance with the exception of the recent past four years where the mean number per tow have been below the long-term mean of .79 fish per tow (Figure 8). The mean weight per tow indicates a progressive reduction since the beginning of the survey series and the 1998 estimate is the lowest in the series (Figure 8).

## Condition Factor

A decline in the mean weight of an individual fish from 5-6 kg in the early 1970's to a present value of 1.5 kg was noted from the summer RV survey in Div. 4VsW and may indicate a population under stress. This decline was not evident in the spring RV in Div. 4VsW or winter skate in Div. 4X (Figure 9).

## Size composition

### Spring

The annual catch at length was examined for trends in the data (Table 4), (Figure 10). Based on the apparent reduction in the length range in the most recent period the catch at length was aggregated into two time block representing the pre- and post-fishery periods. The size composition of winter skate during the pre-fishery period revealed a wide distribution of sizes with a peak near 52 cm. This was followed by a near-uniform representation of individuals from 60 to 100cm (Figure 11). The post-fishery size composition revealed fewer fish larger than 70cm and greater number of fish in the 35-50cm size range. It should be noted that the 1994 survey was excluded due the anomalous high catch that occurred in a single set in Div. 4Vs.

## Summer

The catch at length was examined in the same manner as the spring survey (Table 5) (Figure 12) except the 1994 value was included in the pre-fishery period. The size composition of winter skate during the pre-fishery period was bi-modal with peaks occurring near 52 and 88cm with reasonable numbers of fish occurring at sizes greater than 100cm. The post-fishery period showed a reduction in the abundance of winter skate greater than 85cm (Figure 11).

We have the opportunity to compare these size compositions to winter skate occurring in Div. 4X where no directed fishing occurs. The size compositions in Div. 4X were compiled into similar time blocks and revealed that during the early period (1970-94) a wide distribution of sizes with a peak near 49cm was evident and declined thereafter (Figure 13). The size composition during the later period (1995-98) revealed an increase in the numbers of fish below 50cm with no apparent reduction in the abundance of larger sizes relative to the earlier period.

## **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 14) with surveys conducted during April and October. Mesh sizes used ranged from 255 to 315mm. Since 1996 the same 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 sets per vessel allocated to the survey design, three directed fishing sets were permitted by each boat (designated as Captain's own or C.O.).

Results from the 1994 and 1995 surveys were summarised in Simon and Frank (1996). The results of the 1996 and 1997 and spring 1998 surveys are summarized here. Both 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 (Figure 15). This pattern is similar to what was observed in the recent spring RV surveys. In both surveys, very few sets were allocated in the area west of Sable Island. The DFO/Industry Sentinel Survey caught high numbers of winter skate in this region suggesting it is an area of concentration under sampled by the Skate Survey.

### Abundance

We calculated catch rates for the industry surveys and compared these to the summer RV survey. When geographically similar areas are compared similar trends were evident between the fall industry catch rates and those from the summer RV (Table 6) (Figure 16). A comparison of catch rates from the slope region (RV strata 46,49,50,51,52,53,54) alone revealed a similar pattern between the spring industry and the summer RV (Table 7)(Figure 16) in 1995-1997. Also the slope strata from the summer RV show an increasing trend from 1970 -1990 and are variable afterwards.

### Size composition

The length frequency data from the spring and fall surveys are shown in Figures 17 and 18. The industry survey sets are shown separately from the fishing sets that occurred at the same time. A pattern common to all of the surveys was a declining percentage of winter skate greater than 90 cm (Figure 19). This pattern was not unexpected given the decline in abundance of larger skate seen in the commercial landings.

### Biology

During the conduct of the industry surveys, observers were trained to evaluate the degree of maturation of female winter skate. There were 5 maturation stages assessed ranging from immature to spawning condition (Appendix A). The first three stages were considered to be immature and would not spawn during the current year. The final two stages were considered to be mature and capable of spawning in the current year. The result of this assessment showed that reproductive development begins near a length of 50cm while the onset of maturity begins at 65cm. Fifty percent maturity was estimated to occur at a length of 75cm (Figure 20).

Industry has noted females extruding complete purses (a leathery case containing the skate embryo) only in the last summer/early autumn west of Sable Island. Some of these purses, maintained in an aquarium, have remained viable for over a year without hatching.

### 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 ageing study of winter skate on the Scotian Shelf was used to convert lengths to ages. A second growth model was also applied, however it was derived from a species of skate from the Irish Sea (*Raja brachyura*) (Holden, 1972) that exhibited growth patterns similar to those of winter skate.

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 0.54 in 1996, further increased to 0.76 in 1997, and levelled off at 0.73 in 1998 (Figure 21). Using the Irish Sea skate growth model resulted in a



similar pattern although the magnitude of the mortality estimates were 20-30% higher (Figure 22).

## Discussion

Our understanding of the impact of the experimental skate fishery on the eastern Scotian Shelf has evolved as more information on the biology of the species has become available. The initial TAC set for this management unit was based on the total biomass of all skate species and is no longer valid given that industry has selectively harvested winter skate. In our previous assessment of this stock no reduction in the length range of winter skates was apparent, either in the commercial fishery or the various surveys. However, we are now witnessing declines in the abundance of all skate, especially the larger sizes, and our estimation of total mortality appears to be unacceptably high. Maturity and reproductive information shows that an increasing proportion of the fish caught are now sexually immature and have not had a chance to spawn.

Winter skate are at their northern limits of distribution on the eastern Scotian Shelf (Simon and Frank 1996). This suggests that they may be vulnerable to colder-than-normal environmental conditions. A recent change in distribution towards the slopes of the banks has occurred. The more localised nature of the fishery has resulted in the depletion of mature winter skate concentrations in these areas.

Therefore it is considered either that the experimental fishery continue in 1998 at a much reduced level or be closed entirely. The continuation of this fishery should only be considered if it is conducted with very low removals to increase our understanding of the biology of the species in relation to its ability to withstand harvesting.

## Acknowledgements

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## References

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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	12	159	454	1655	12	160	1827	1600
1997	911	-	-	911	137	-	53	190	1048	-	53	1101	1200
1998	257	-	0	257	69	4	43	116	326	4	43	373	1200

1961-1988 NAFO data  
 1989-present ZIF data (Canadian)  
 \* - IOP data  
 1998, partial data

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

	Foreign <sup>1</sup> 4W			Canadian <sup>2</sup> Groundfish(4VsW)			Canadian <sup>3</sup> Flatfish(4Vs)			Canadian Directed fishery	Total	
	USSR	Others	Total	Landings(t)	Bycatch % estimate	Est. skate removals	Landings t	Bycatch estimate	Est. skate removals		Bycatch +	Directed Fishery
1989	818	100	918	60127	0.015	872	3424	0.05	171	10	1971	
1990	993	189	1182	57117	0.015	799	4246	0.05	212	2	2195	
1991	667	433	1100	56591	0.015	735	2506	0.05	125	13	1973	
1992	167	95	262	47698	0.01	500	3149	0.05	158	2	922	
1993	70	395	465	8972	0.015	144	2916	0.05	145	167	921	
1994	0	12	12	8211	0.005	25	2226	0.05	111	2152	2300	
1995	0	70	70	6328	0.005	45	1614	0.05	81	1523	1719	
1996	7	96	103	4789	0.005	24	1137	0.05	57	1655	1839	
1997	0	32	32	4398	0.005	16	1036	0.05	52	1048	1148	
1998	2	26	26									

- Note:
1. Foreign IOP coverage 100% in 1989 -1998.(winter skate catch 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
1	-	1640 3	308 1	-
2	335 1	765 2	1349 4	485 2
3	176 1	1658 4	259 1	411 2
4	4038 9	2504 7	3544 11	-
Sum	4549 11	6567 16	5460 17	896 4

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

Length(cm)	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97
1	0	0	0	0	0	0	-	0.01	0	0	0	0	0	0	0	0	0	-	0.01
4	0	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	-	0
10	0	0	0	0	0	0	-	0	0.02	0	0.02	0	0	0	0	0	0	-	0.01
13	0	0	0	0	0	0	-	0	0.05	0	0.01	0.04	0	0.01	0	0	0.02	-	0.01
16	0	0	0	0.02	0	0	-	0	0.3	0.03	0.11	0.09	0.07	0.02	0.1	0	0	-	0
19	0.01	0	0	0.06	0	0	-	0.01	0.31	0.08	0.12	0.06	0.15	0	0.1	0.03	0.03	-	0
22	0.01	0.01	0.01	0.04	0.01	0	-	0.04	0.26	0.1	0.16	0.09	0.22	0	0.05	0.01	0.05	-	0.01
25	0.03	0.1	0.01	0.03	0.01	0	-	0.04	0.18	0.1	0.23	0.09	0.13	0.01	0.13	0.08	0.1	-	0
28	0.01	0.06	0.02	0.07	0.01	0	-	0.07	0.29	0.22	0.15	0.07	0.12	0.01	0.1	0.2	0.17	-	0.03
31	0.06	0.11	0.03	0.06	0.01	0	-	0.08	0.28	0.2	0.08	0.04	0.09	0.01	0.33	0.47	0.18	-	0.11
34	0.04	0.11	0.04	0.1	0.01	0.01	-	0.03	0.45	0.22	0.08	0.05	0.12	0.02	0.47	0.41	0.34	-	0.3
37	0.05	0.1	0.14	0.05	0.03	0.01	-	0.09	0.25	0.12	0.07	0.04	0.15	0.01	0.89	0.29	0.36	-	0.59
40	0.07	0.17	0.15	0.05	0.02	0	-	0.11	0.31	0.07	0.04	0.04	0.26	0	0.82	0.26	0.48	-	0.61
43	0.11	0.21	0.32	0.07	0.05	0	-	0.1	0.37	0.06	0.02	0.02	0.28	0.01	0.62	0.12	0.66	-	0.2
46	0.14	0.38	0.23	0.05	0.07	0.03	-	0.09	0.19	0.07	0.03	0.01	0.24	0.01	0.53	0.05	0.65	-	0.13
49	0.16	0.35	0.36	0.15	0.06	0.04	-	0.24	0.46	0.09	0.04	0.03	0.13	0	0.27	0.04	0.81	-	0.11
52	0.15	0.47	0.42	0.05	0.18	0.03	-	0.24	0.5	0.08	0.08	0.02	0.16	0.02	0.21	0.44	0.33	-	0.15
55	0.12	0.25	0.25	0.06	0.09	0.02	-	0.2	0.34	0.05	0.08	0.04	0.15	0.01	0.03	0.4	0.21	-	0.1
58	0.07	0.15	0.11	0.08	0.12	0.02	-	0.08	0.14	0.01	0.05	0.02	0.04	0.01	0.11	1.02	0.16	-	0.04
61	0.04	0.04	0.13	0.06	0.06	0	-	0.16	0.11	0.02	0.02	0.03	0.04	0	0.04	1.41	0.11	-	0.04
64	0.01	0.06	0.04	0.07	0.01	0.03	-	0.14	0.12	0	0.07	0	0.03	0.04	0.01	1.61	0.07	-	0.09
67	0.01	0.03	0.04	0.03	0.07	0.02	-	0.22	0.06	0.01	0.07	0	0.07	0.02	0.01	1.2	0.04	-	0.08
70	0.02	0.08	0.04	0.04	0.03	0.03	-	0.3	0.14	0.01	0.02	0	0.08	0.01	0	1.71	0.02	-	0.04
73	0.04	0.05	0.04	0.05	0.02	0.02	-	0.16	0.06	0.01	0.08	0	0.07	0.01	0.01	1.5	0.04	-	0.02
76	0.01	0.03	0.05	0.02	0.03	0.04	-	0.19	0.15	0	0.09	0	0.09	0.03	0	1.3	0.01	-	0.04
79	0	0.01	0.04	0.02	0.04	0.03	-	0.13	0.02	0.02	0.05	0	0.11	0.03	0	1.2	0.01	-	0.01
82	0.02	0.02	0.17	0.04	0.04	0.02	-	0.09	0.08	0.03	0.09	0	0.15	0	0.01	2.81	0.01	-	0
85	0.02	0	0.05	0.02	0.05	0.05	-	0.22	0.04	0.01	0.04	0.02	0.1	0.02	0	1	0.01	-	0.01
88	0.02	0.03	0.04	0.03	0.03	0.01	-	0.09	0.04	0.01	0.03	0.05	0.15	0	0	0.9	0	-	0
91	0.01	0.02	0.03	0.04	0.06	0.03	-	0.25	0.15	0	0.05	0.01	0.21	0.02	0.02	0.9	0	-	0.01
94	0.01	0.05	0.05	0.02	0.03	0.04	-	0.24	0.07	0	0.05	0.02	0.2	0.03	0	0.3	0	-	0
97	0	0.02	0.01	0.01	0.09	0.01	-	0.09	0.05	0	0.07	0	0.13	0.02	0.02	0.3	0.01	-	0
100	0.02	0.02	0.01	0.04	0.02	0.01	-	0.06	0.03	0	0.02	0.01	0.1	0.01	0.02	0.4	0	-	0
103	0.02	0.01	0.02	0.02	0	0.01	-	0.05	0.02	0	0.01	0.01	0.04	0.01	0	0.4	0	-	0
106	0.01	0	0	0	0.04	0	-	0.03	0.03	0	0.01	0	0.01	0	0	0	0	-	0
109	0	0	0	0	0.01	0	-	0	0	0	0.01	0	0.01	0	0	0	0	-	0
112	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	0	-	0
115	0	0	0	0.01	0	0	-	0	0.01	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	-	0
121	0	0	0	0.01	0	0	-	0	0	0	0	0	0	0	0	0	0	-	0
Total	1.29	2.94	2.85	1.47	1.30	0.51		3.85	5.88	1.62	2.15	0.90	3.90	0.40	4.90	20.76	4.88		2.75

\* valid surveys were not completed in 1985,1996

Table 5. 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
1	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
7	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
13	0	0.01	0	0	0	0	0	0	0	0	0	0	0.01	0.01
16	0	0.03	0	0.01	0	0	0	0	0	0	0	0	0	0.01
19	0	0.02	0.02	0.01	0	0	0	0	0	0.02	0	0.01	0	0
22	0	0.01	0	0.01	0	0	0	0.00	0	0.01	0.01	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
28	0	0.01	0.02	0.03	0	0	0.01	0.02	0.05	0.03	0	0	0.01	0
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
34	0	0	0	0.06	0	0	0.12	0.04	0.12	0.21	0.02	0	0.01	0.02
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
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
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
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
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
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
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
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
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
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
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
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
73	0.06	0	0	0.12	0	0.02	0.07	0.06	0	0.01	0.03	0.03	0.03	0
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
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
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
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
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
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
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
97	0.04	0.01	0.03	0.04	0	0.02	0.01	0.01	0	0.01	0	0	0	0
100	0	0	0	0.03	0.01	0	0.01	0.01	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
106	0	0	0.01	0.01	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
112	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
118	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
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

Table 6. Comparison of catch rates (wt/tow) in the various surveys used based on summer rv survey strata (446-458).

Survey	1995	1996	1997	1998
Spring RV	3.5	-	2.6	-
Spring industry	11.9	46.1	9.3	19.4
Summer RV	0.7	3.1	3.7	0.8
Fall industry	17.8	18.4	46.1	

Table 7. Comparison of catch rates (wt/tow) in the various surveys used based on slope strata only (446,449,450,451,452,453,454).

Survey	1995	1996	1997	1998
Spring RV	17.2	-	6.3	-
Spring industry	11.9	135.5	31.7	50.1
Summer RV	1.8	10.8	2.2	1.07
Fall industry	6.3	59	107.2	

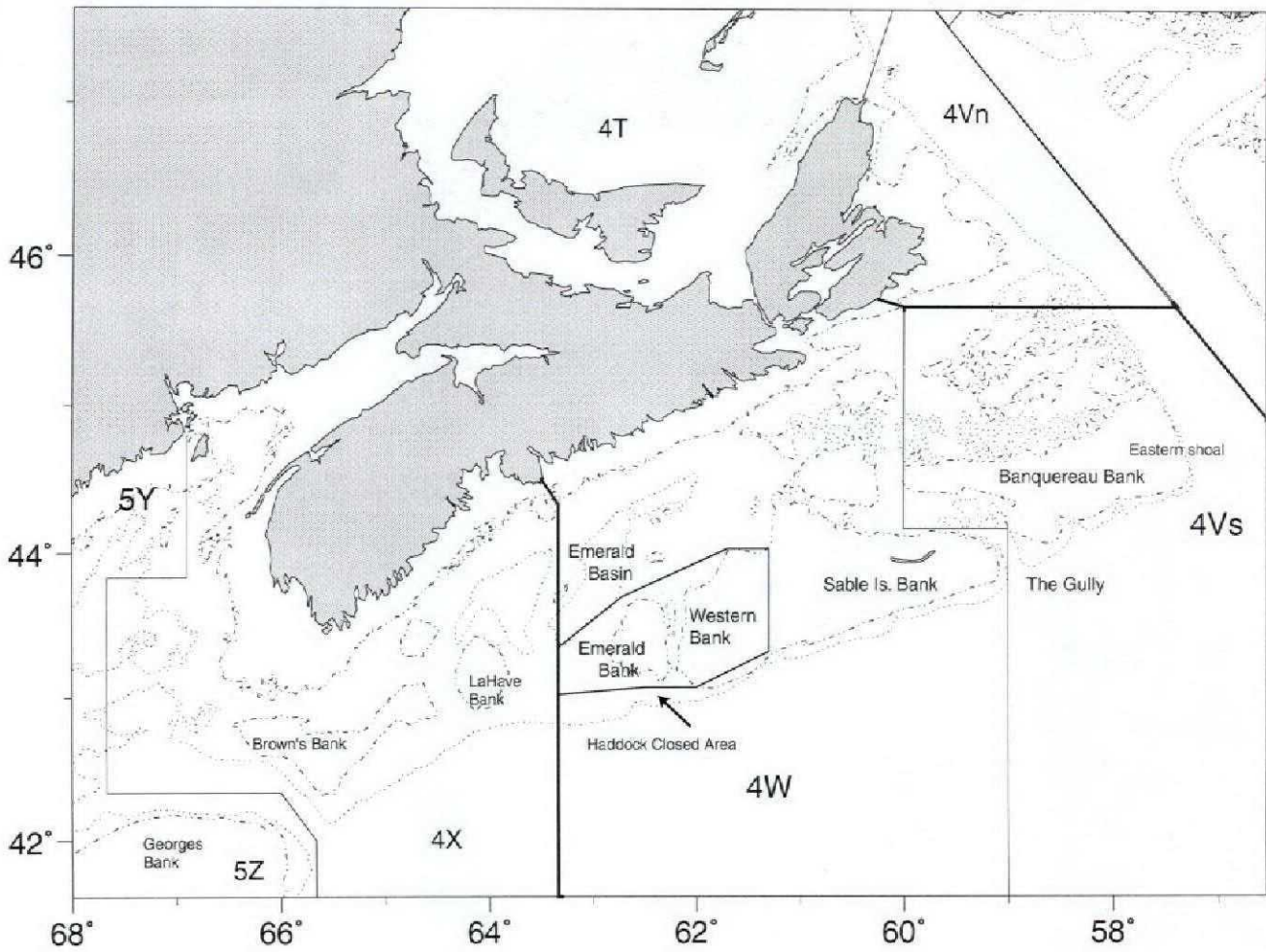


Figure 1. Geographic display of the Div. 4VsW skate management unit. Note the location of the closed area.



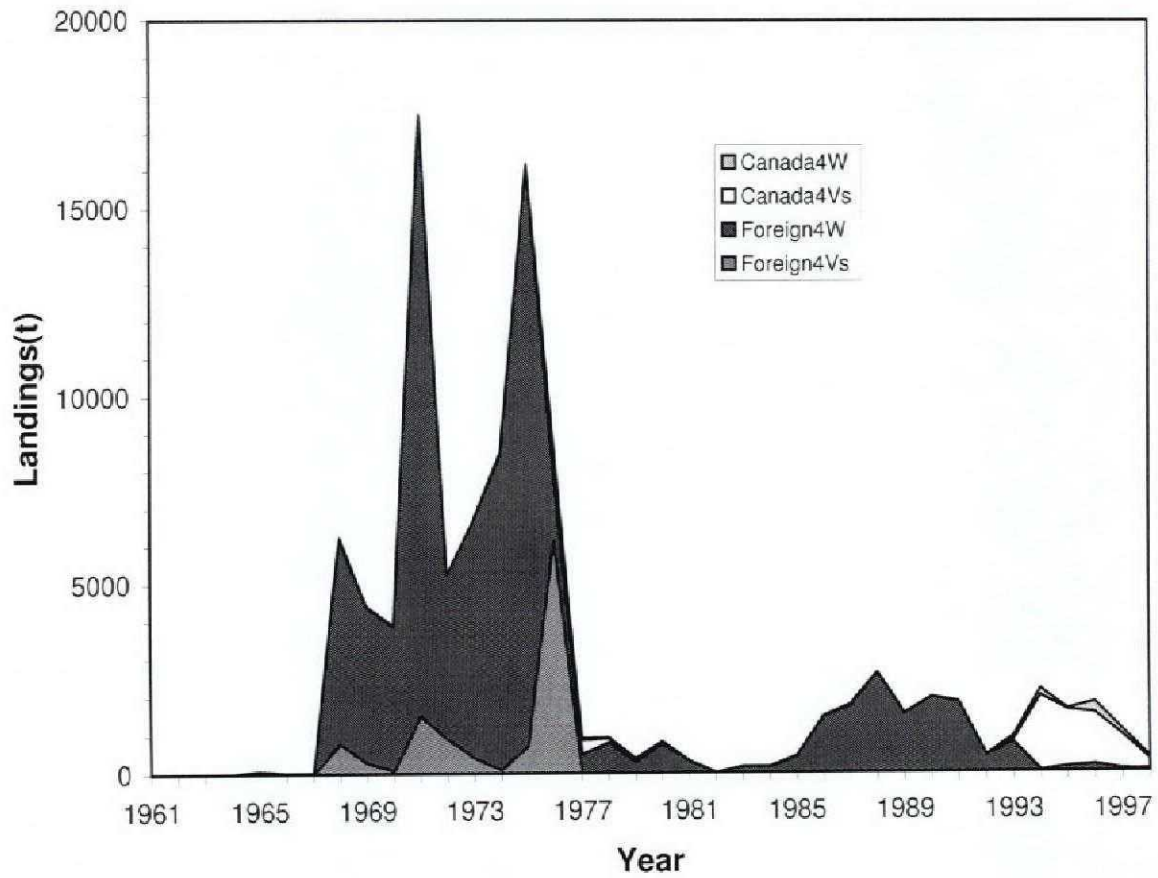


Figure 2. Reported nominal landings of skate (all species combined) in Div. 4VsW by division and country.

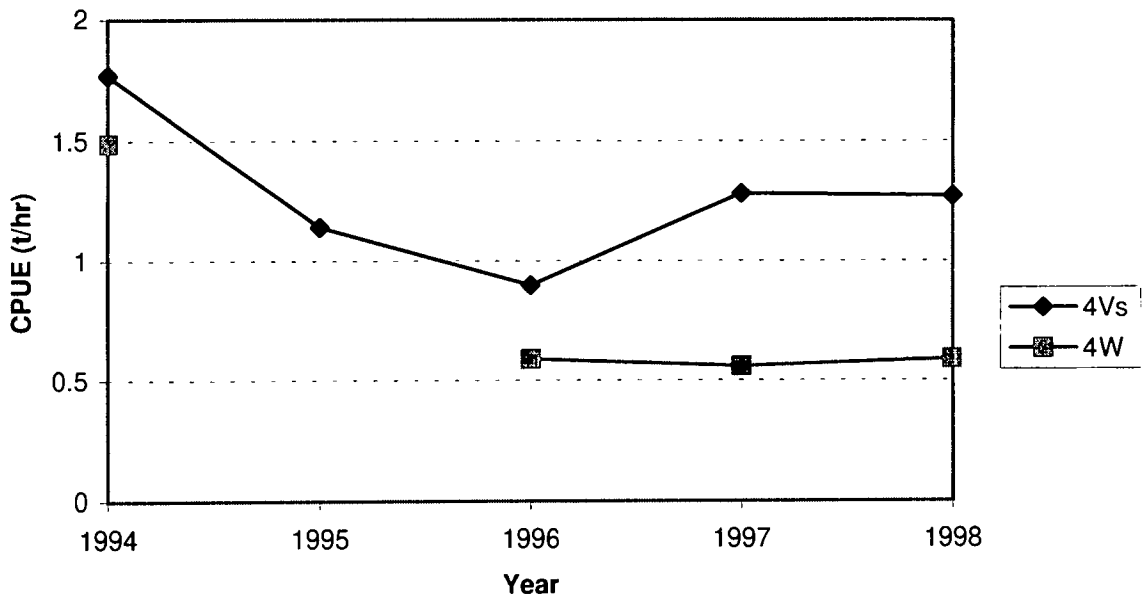
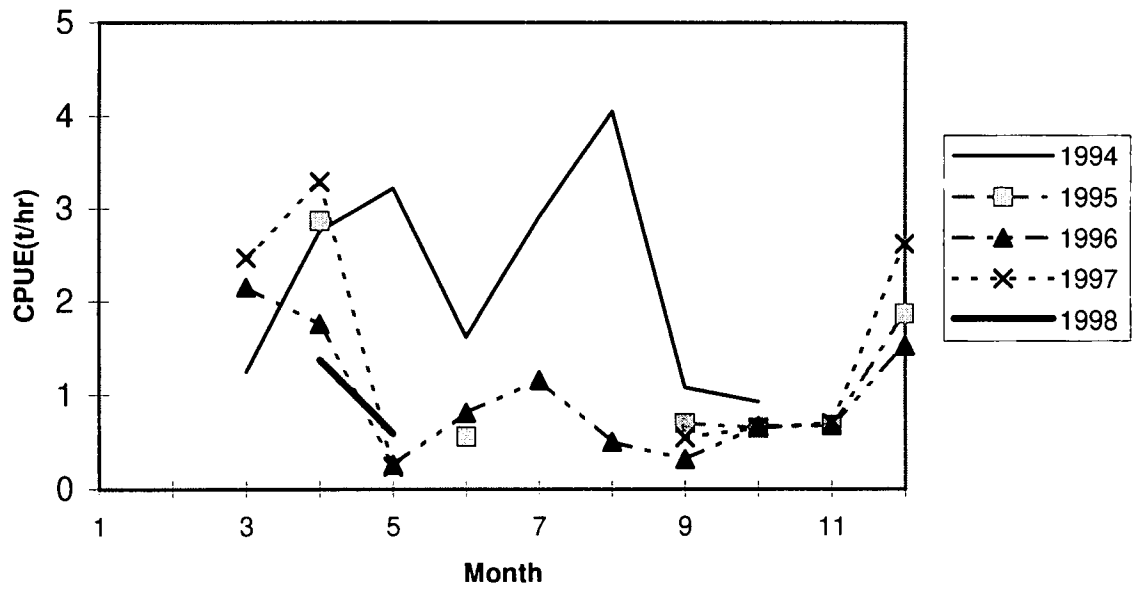


Figure 3. Commercial catch rates (t/hr) from the directed skate fishery in Div. 4VsW.

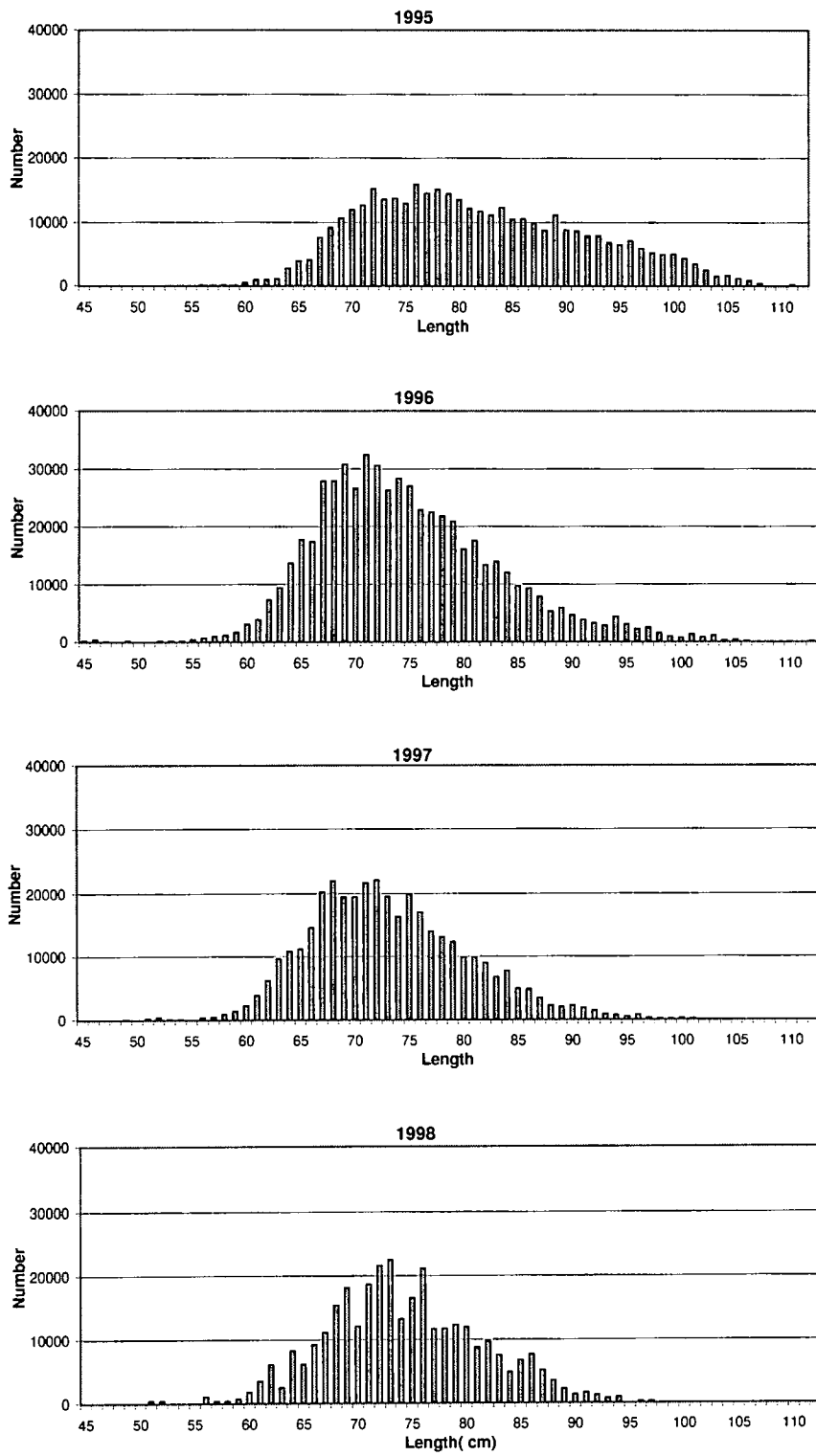


Figure 4. Removals at length from the commercial winter skate fishery in Div. 4VSW.

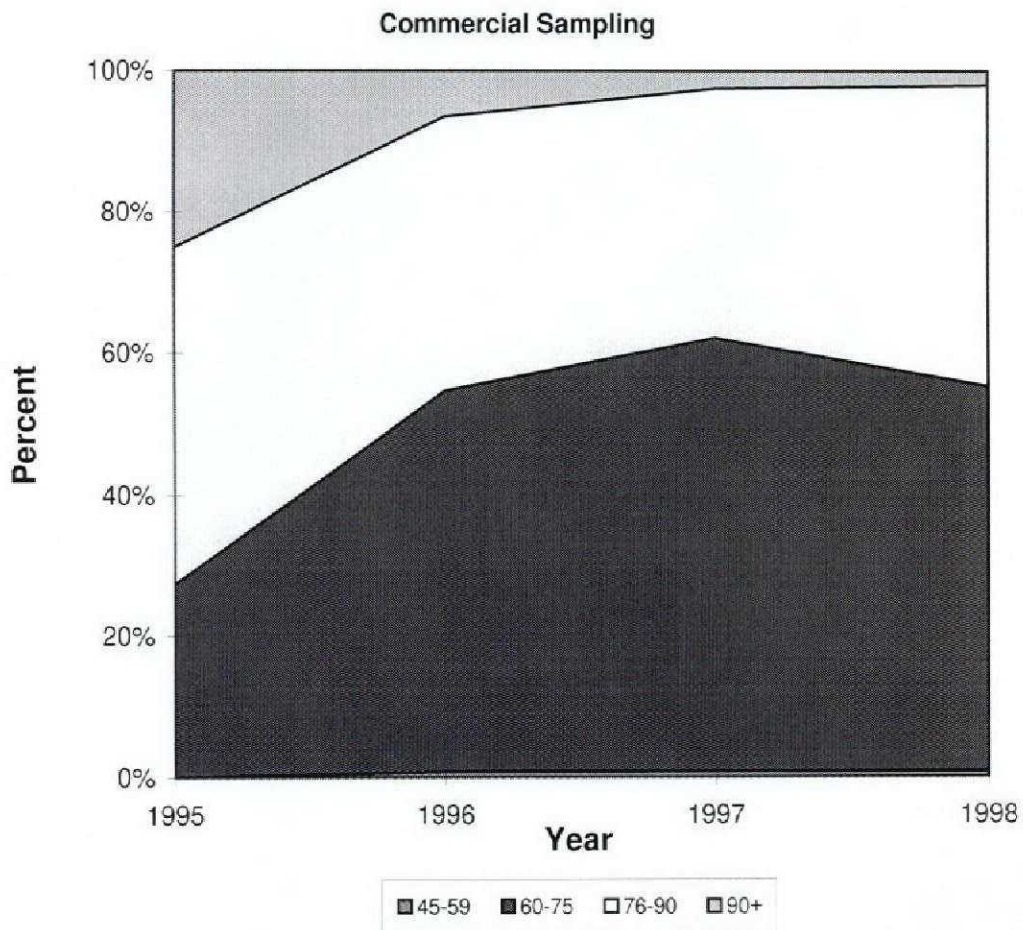


Figure 5. Percentage of winter skate by length groupings from the commercial length frequencies.

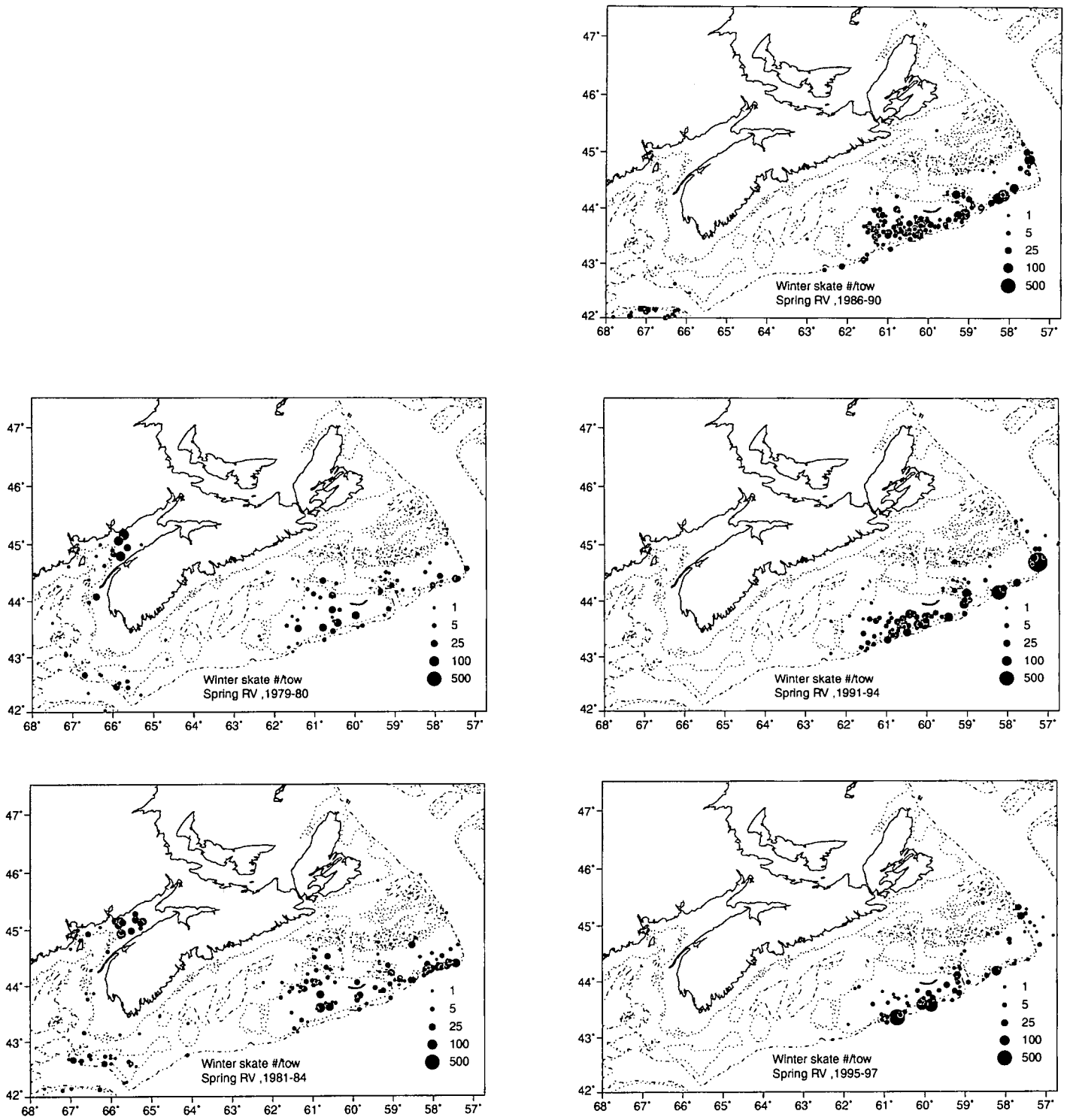


Figure 6. Distribution of winter skate (#/tow) on the Scotian Shelf from the spring rv survey. Note that only positive sets are plotted, that there were no surveys on the western half of the shelf after 1985 and there were incomplete surveys in 1985 and 1996.

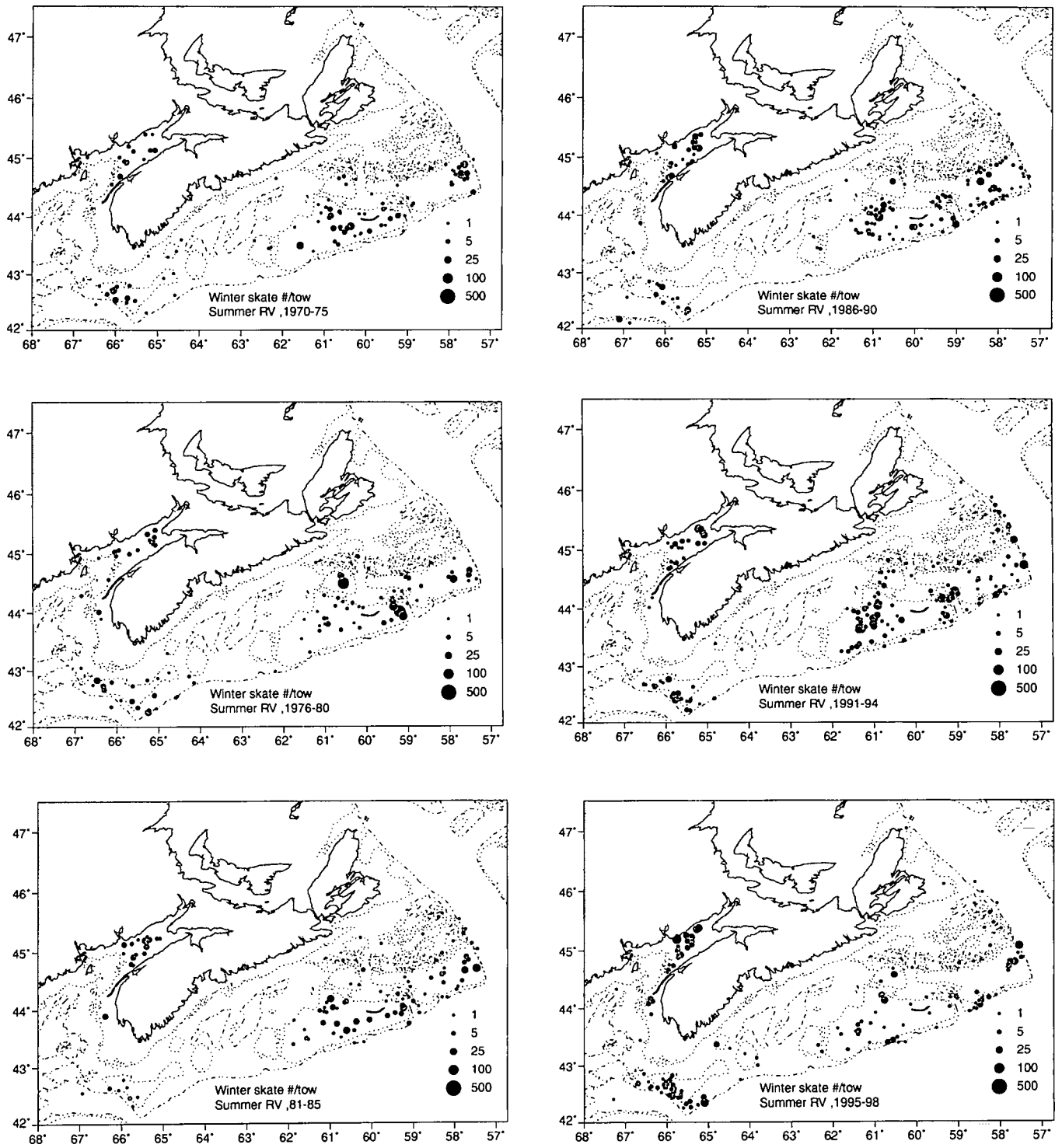


Figure 7. Distribution of winter skate (#/tow) on the Scotian Shelf from the summer groundfish research vessel survey. Note that only positive sets are plotted.

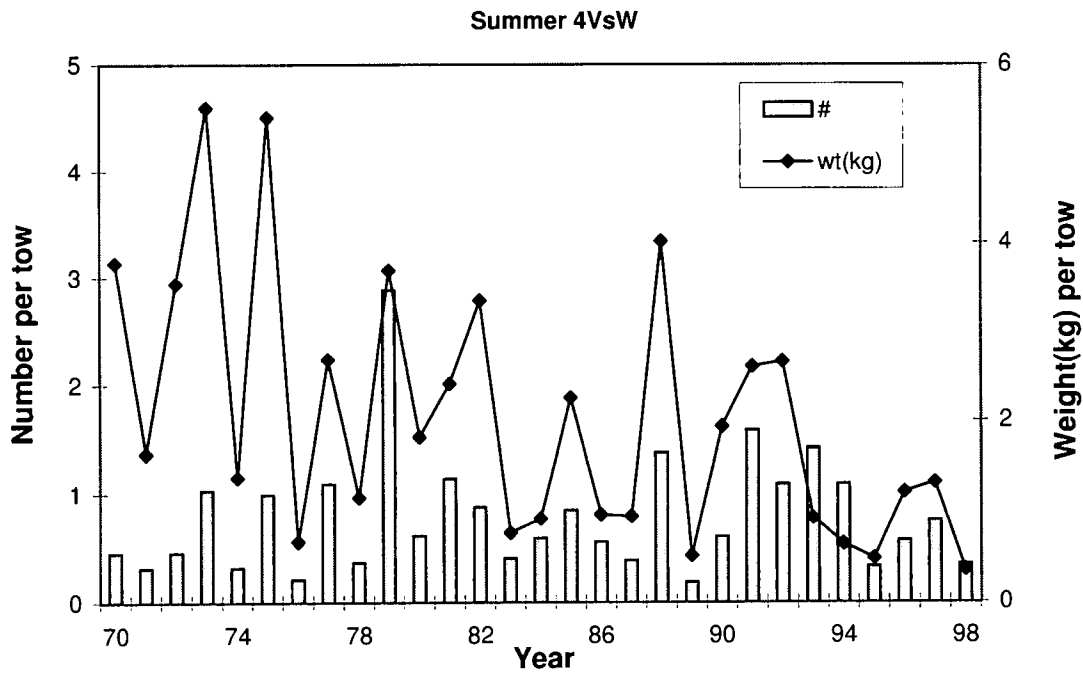
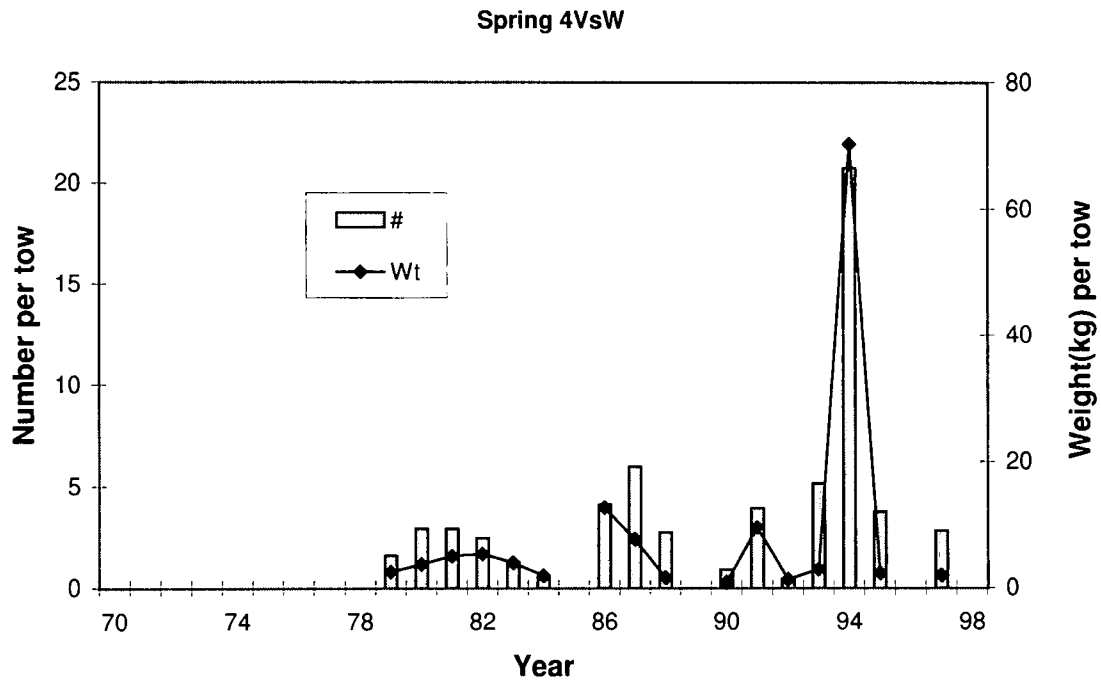


Figure 8. Mean number and weight per tow from the spring and summer groundfish rv surveys.

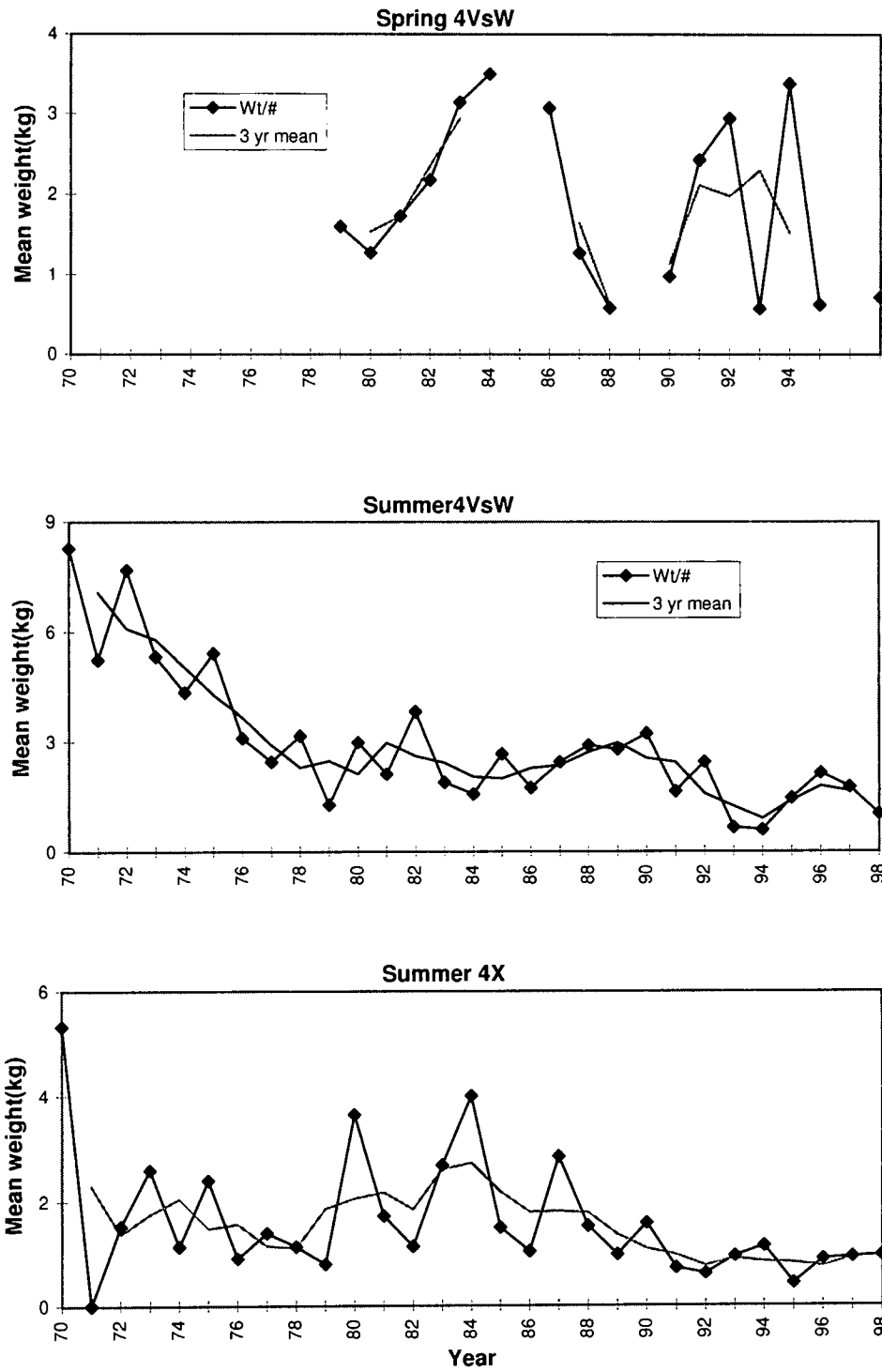


Figure 9. Comparison of the mean weight of an individual winter skate from the spring and summer RV surveys in Div. 4VsW and the summer RV survey in Div. 4X.



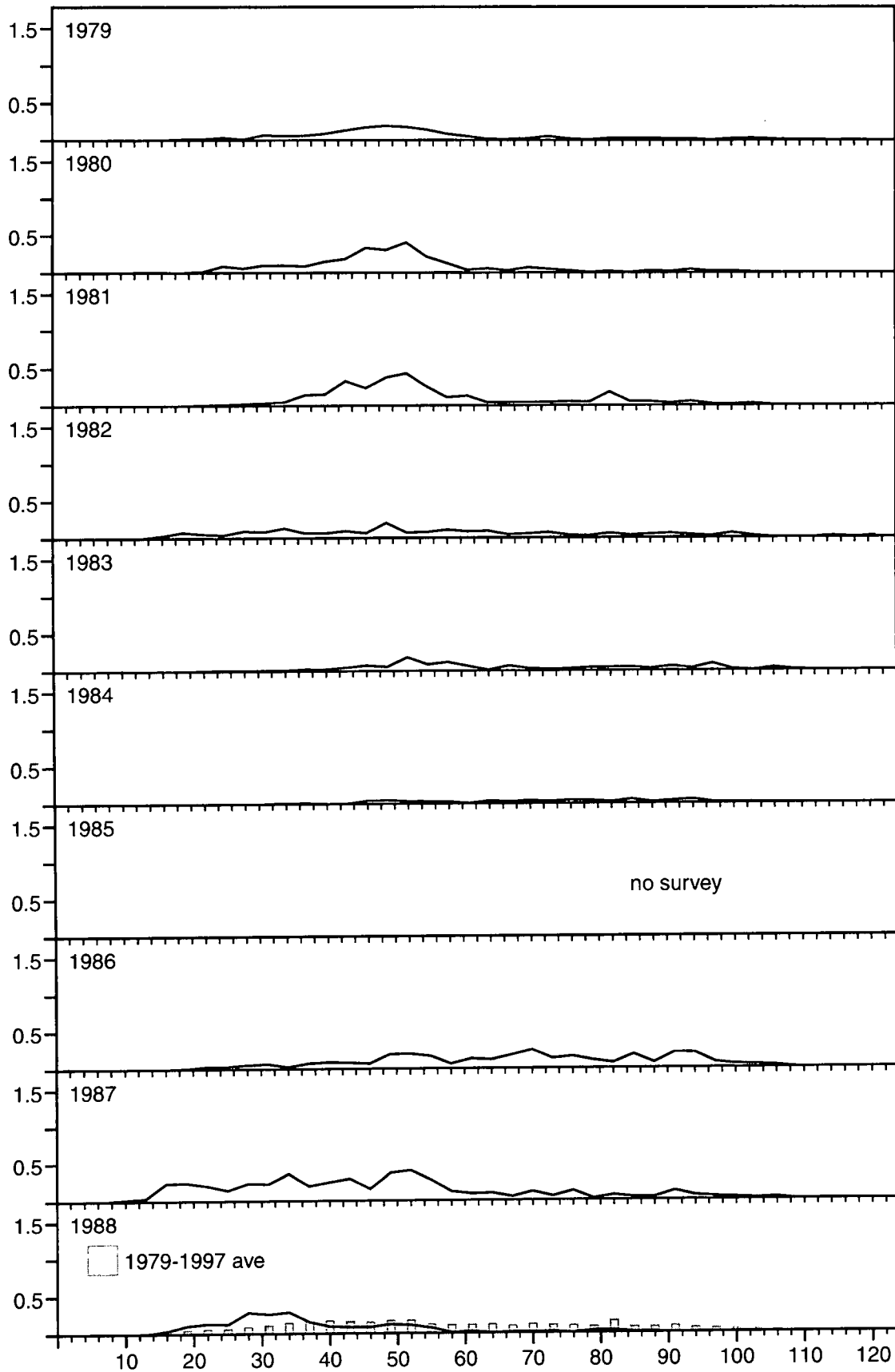


Figure 10. Div.4VsW Winter Skate mean numbers-at-length per tow from the spring research vessel surveys 1970-1997 (bars represent the long term mean).

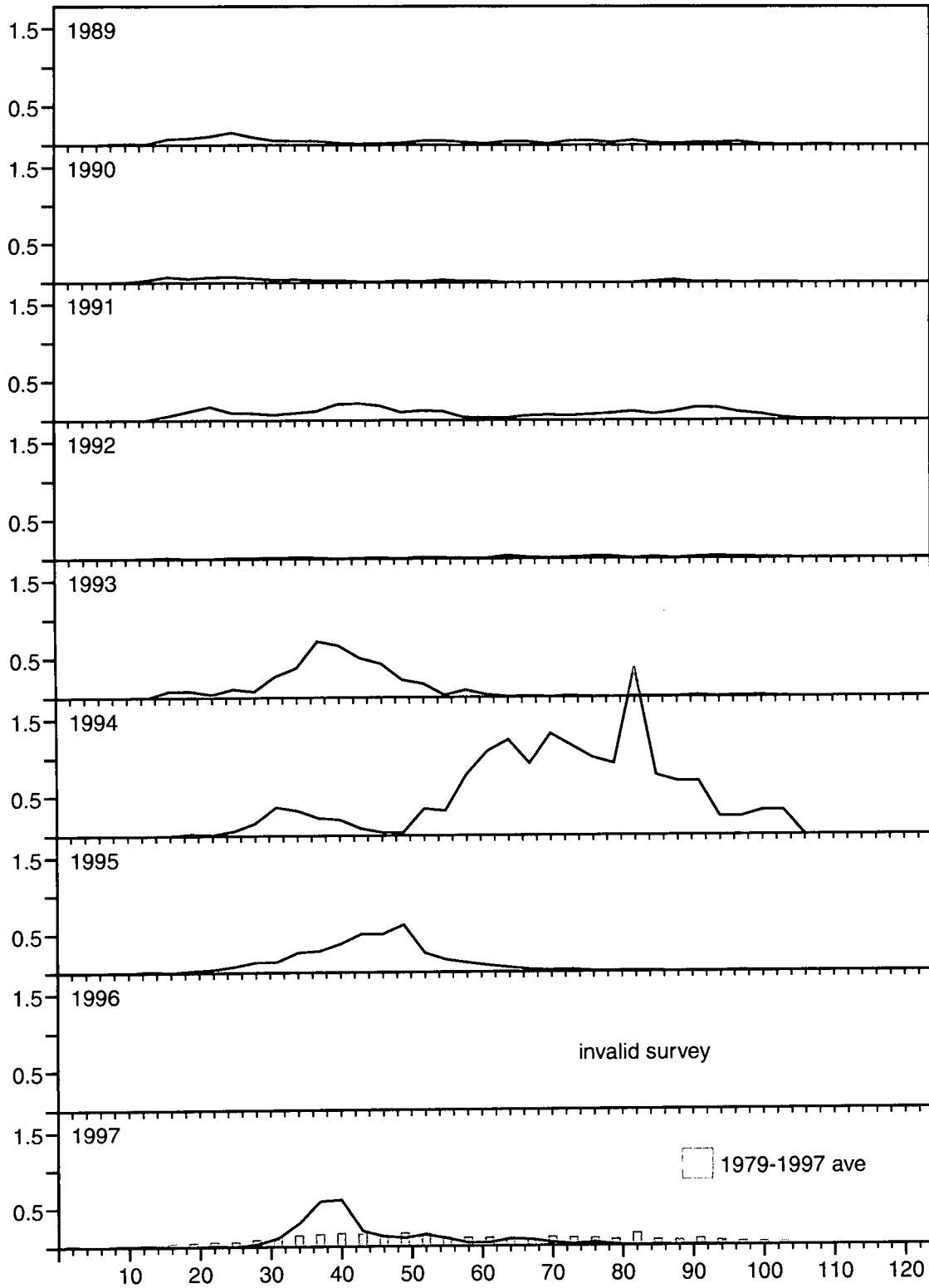


Figure 10 (cont.). Div.4VsW Winter Skate mean numbers-at-length per tow from the spring research vessel surveys 1970-1997 (bars represent the long term mean).

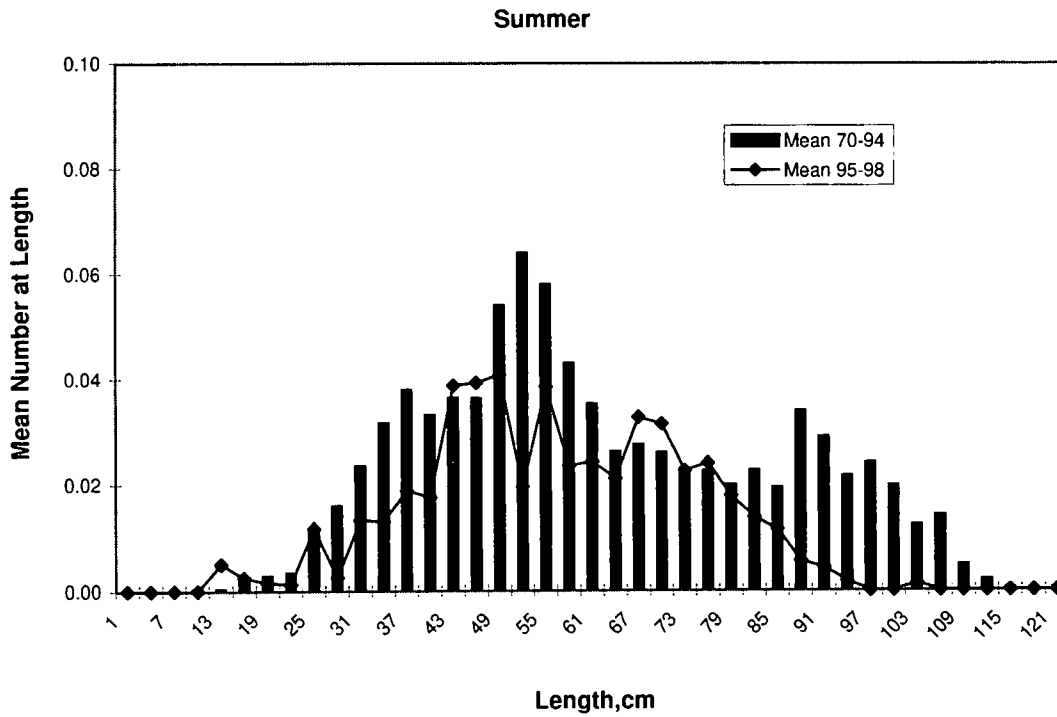
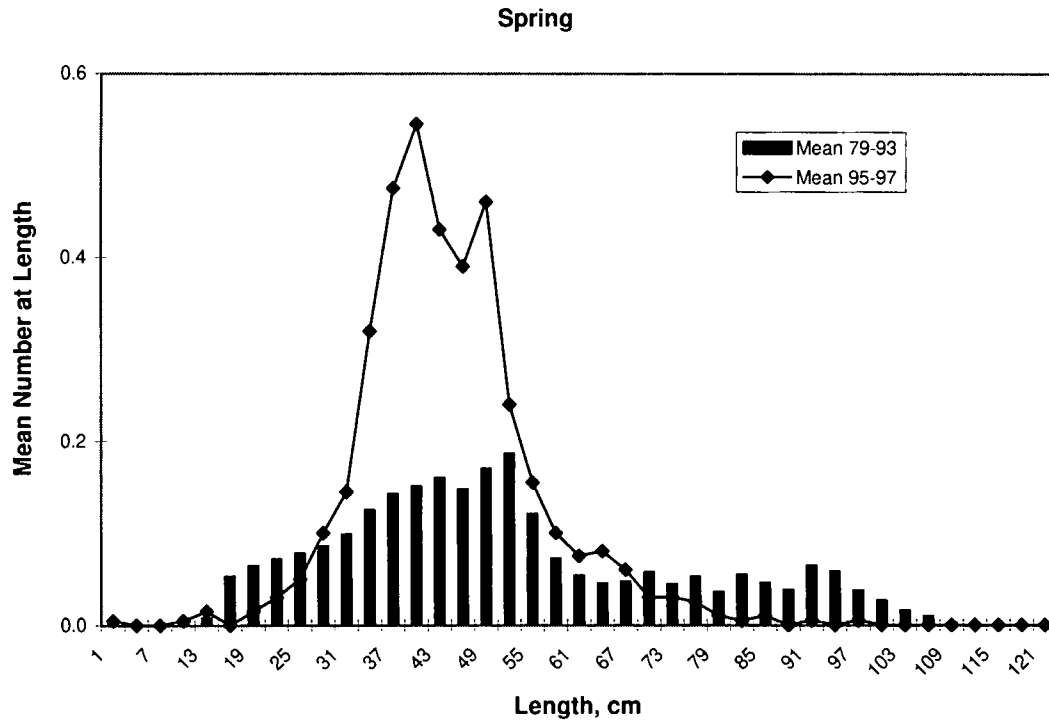


Figure 11. Comparison of the spring and summer catch numbers at length of winter skate from the research vessel groundfish surveys in Div. 4VSW.

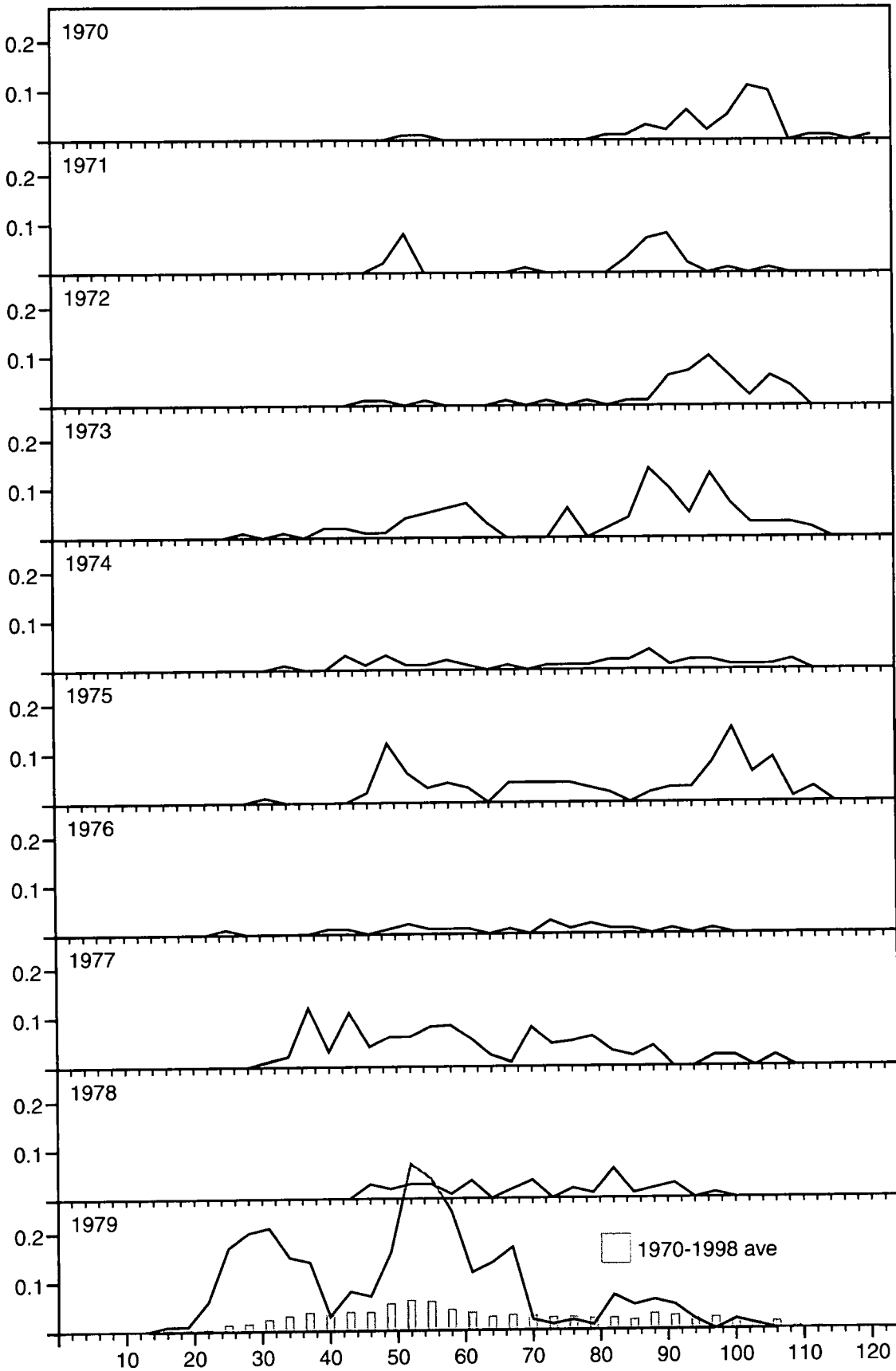


Figure 12. Div.4VsW Winter Skate mean numbers-at-length per tow from the summer research vessel surveys 1970-1998 (bars represent the long term mean).

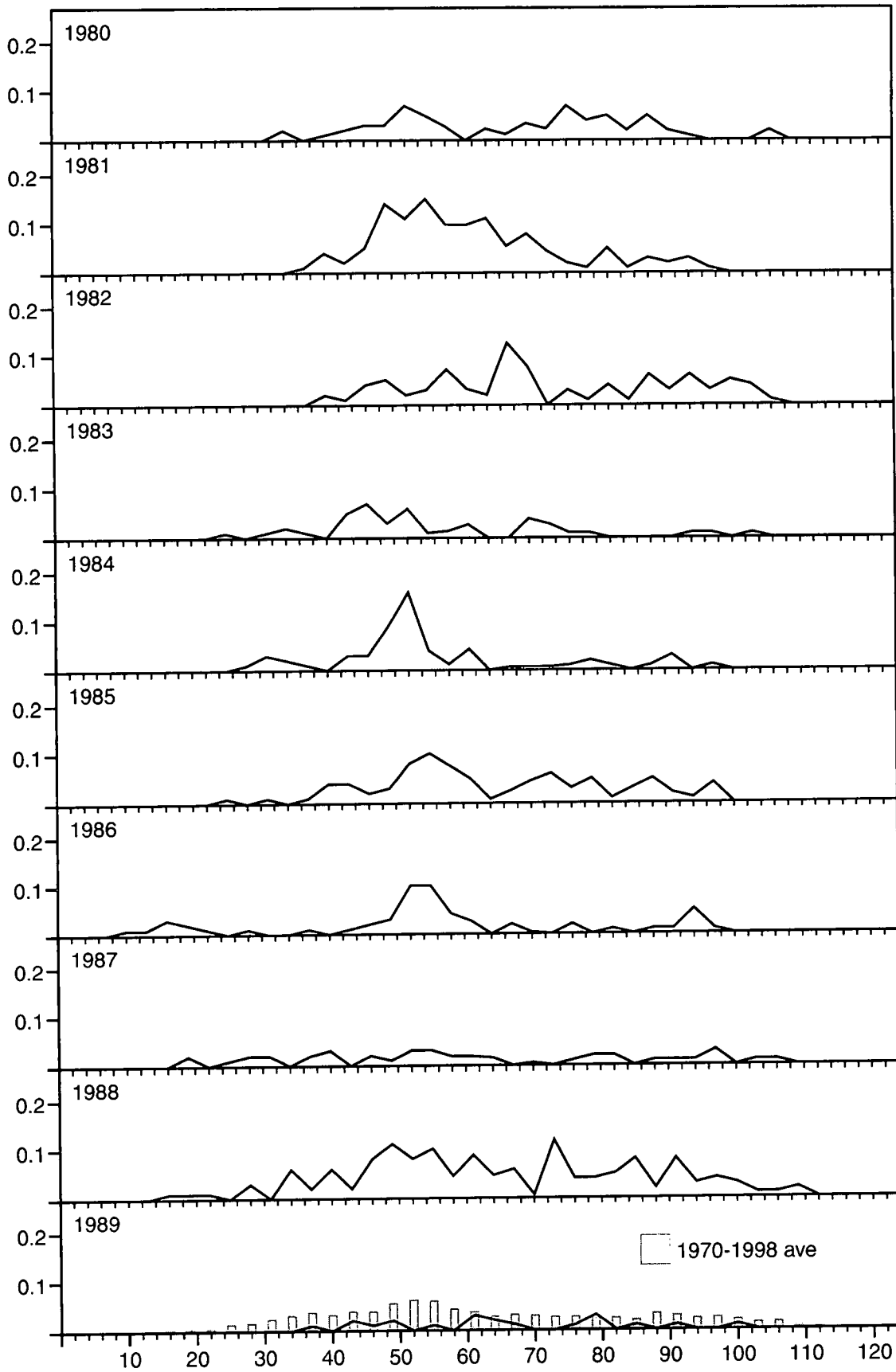


Figure 12 (cont.). Div.4VsW Winter Skate mean numbers-at-length per tow from the summer research vessel surveys 1970-1998 (bars represent the long term mean).

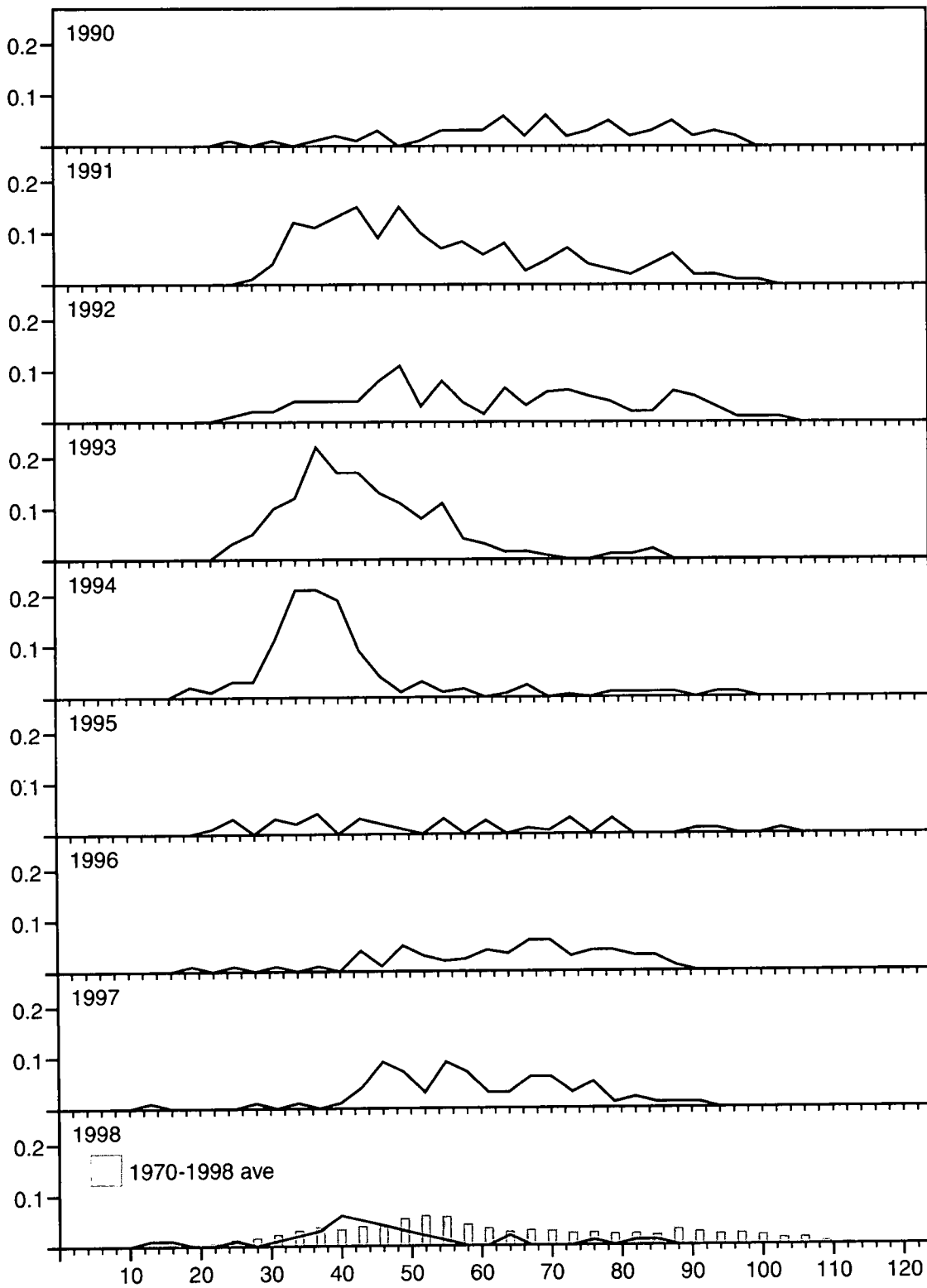


Figure 12 (cont.). Div.4VsW Winter Skate mean numbers-at-length per tow from the summer research vessel surveys 1970-1998 (bars represent the long term mean).

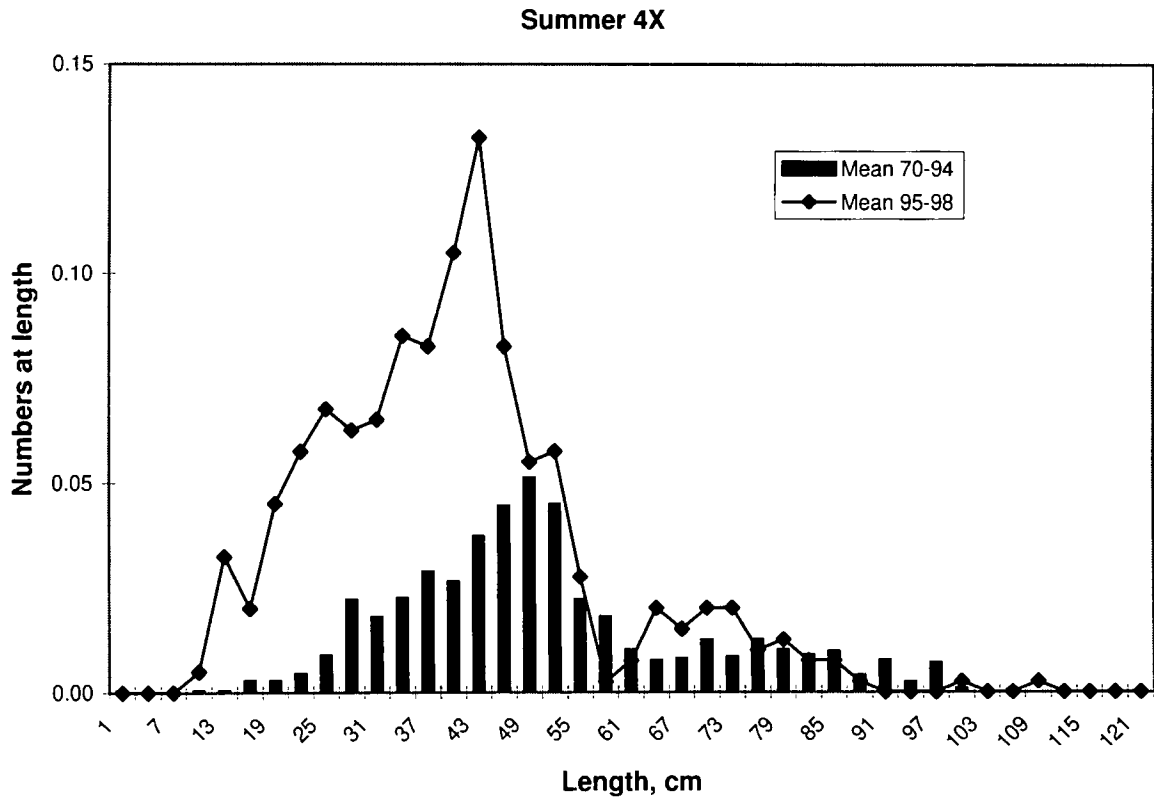


Figure 13. Mean catch numbers at length of winter skate in Div. 4X from the summer rv survey.

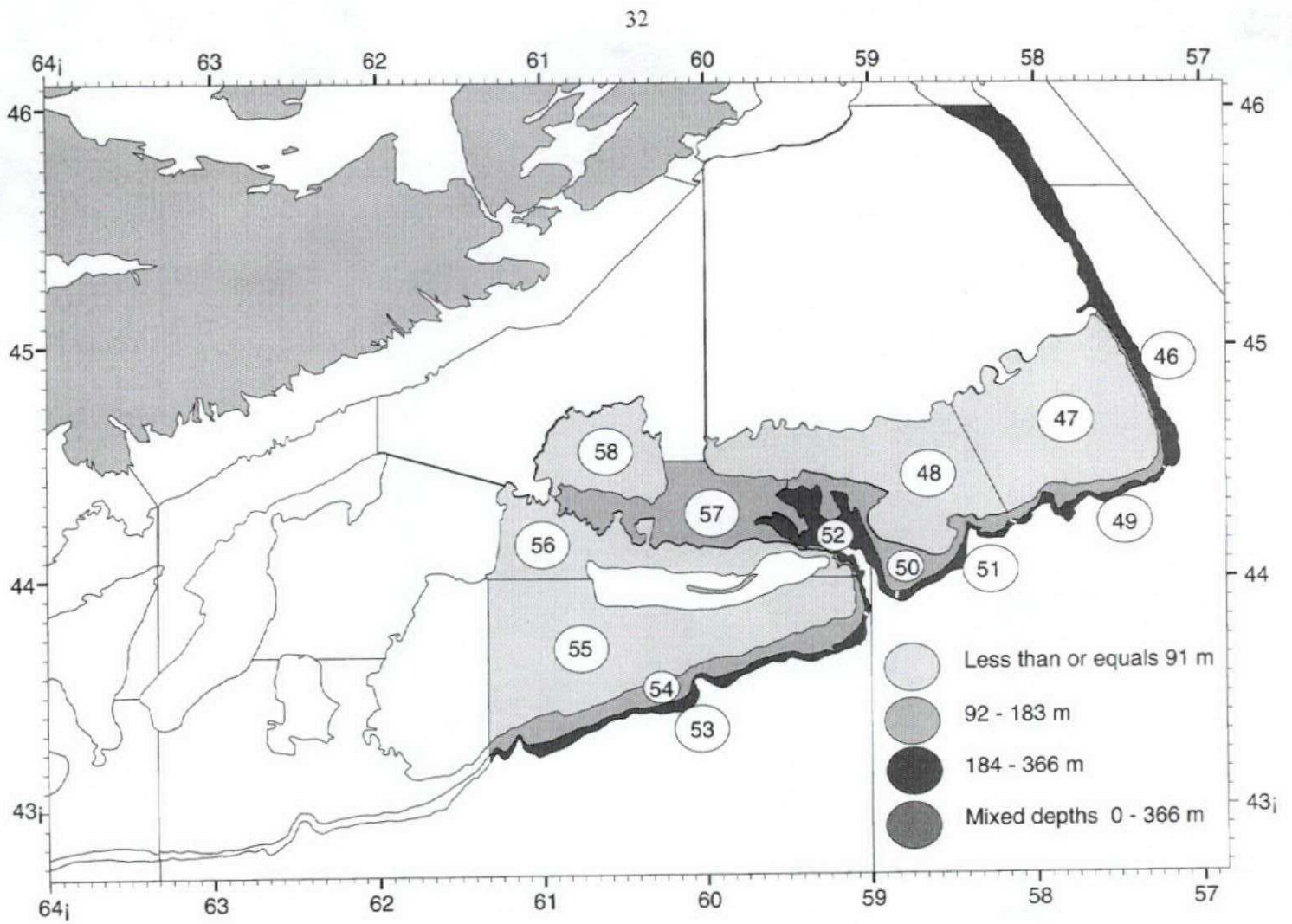


Figure 14. Summer research vessel groundfish strata surveyed during the joint industry/science skate survey.



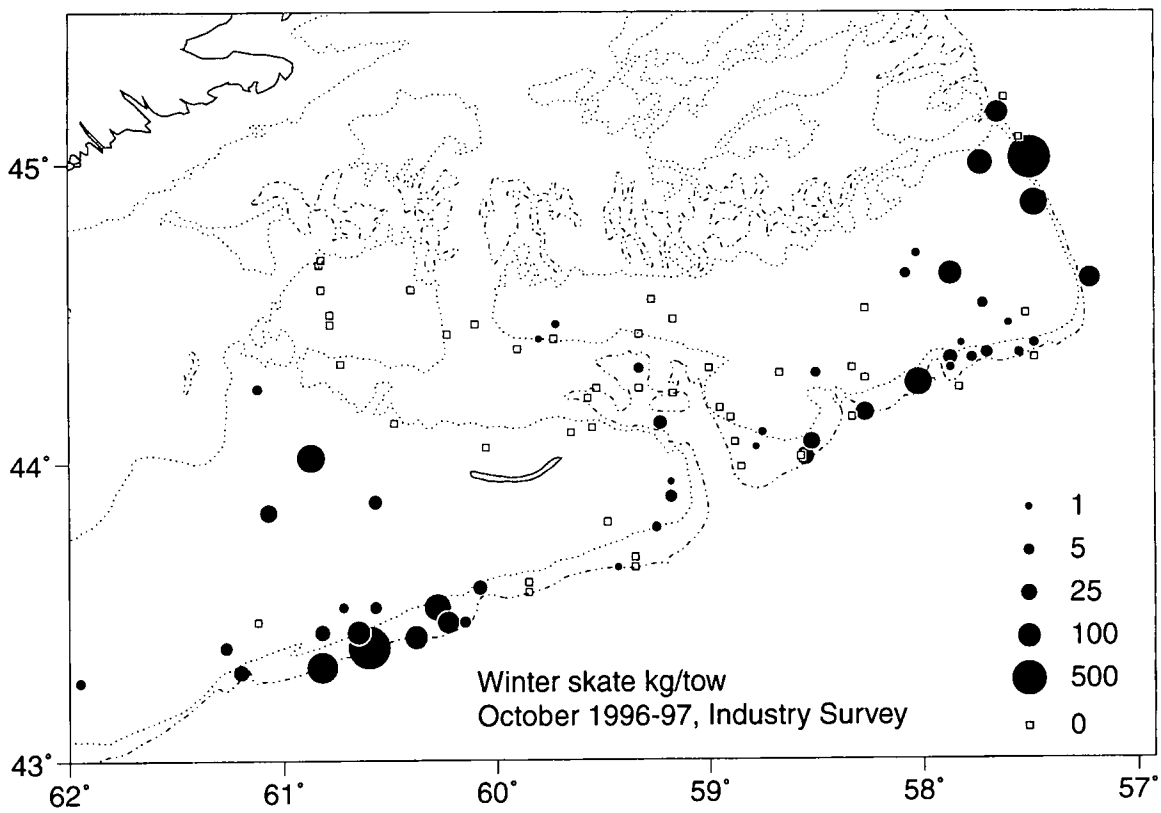
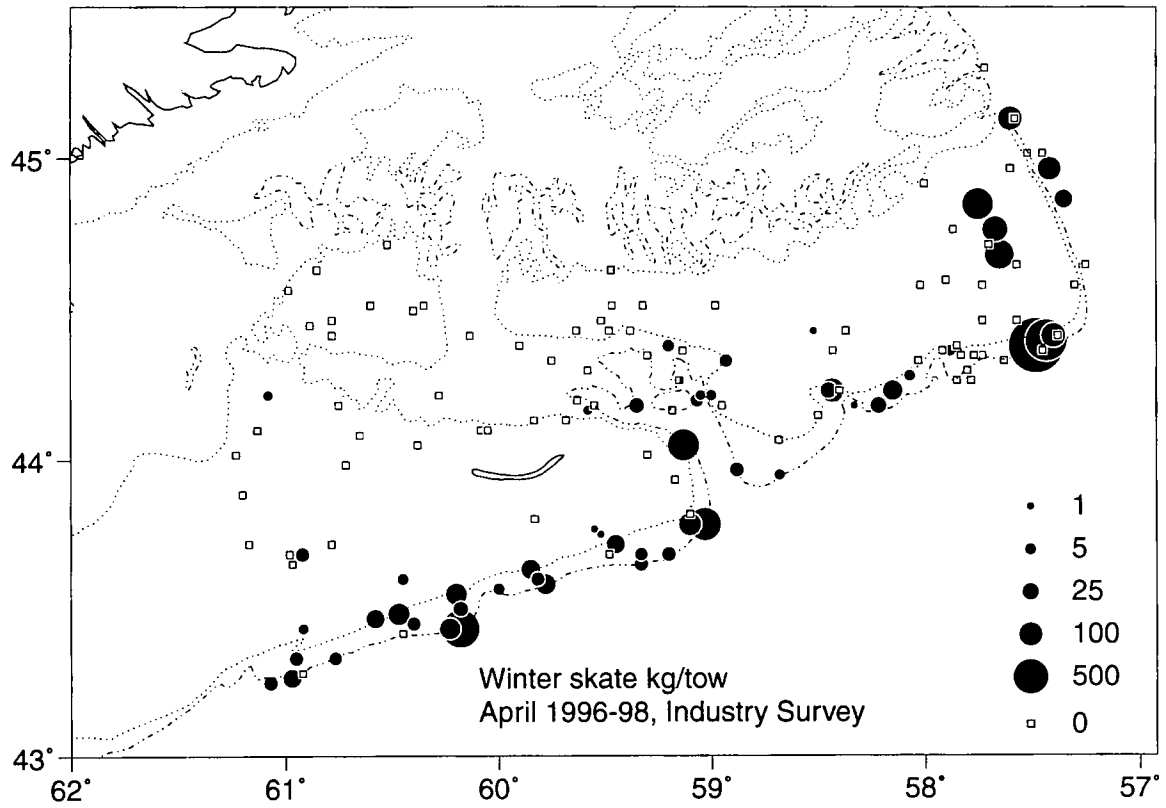


Figure 15. Combined results from the industry/science winter skate surveys in 1996, 1997 and 1998.

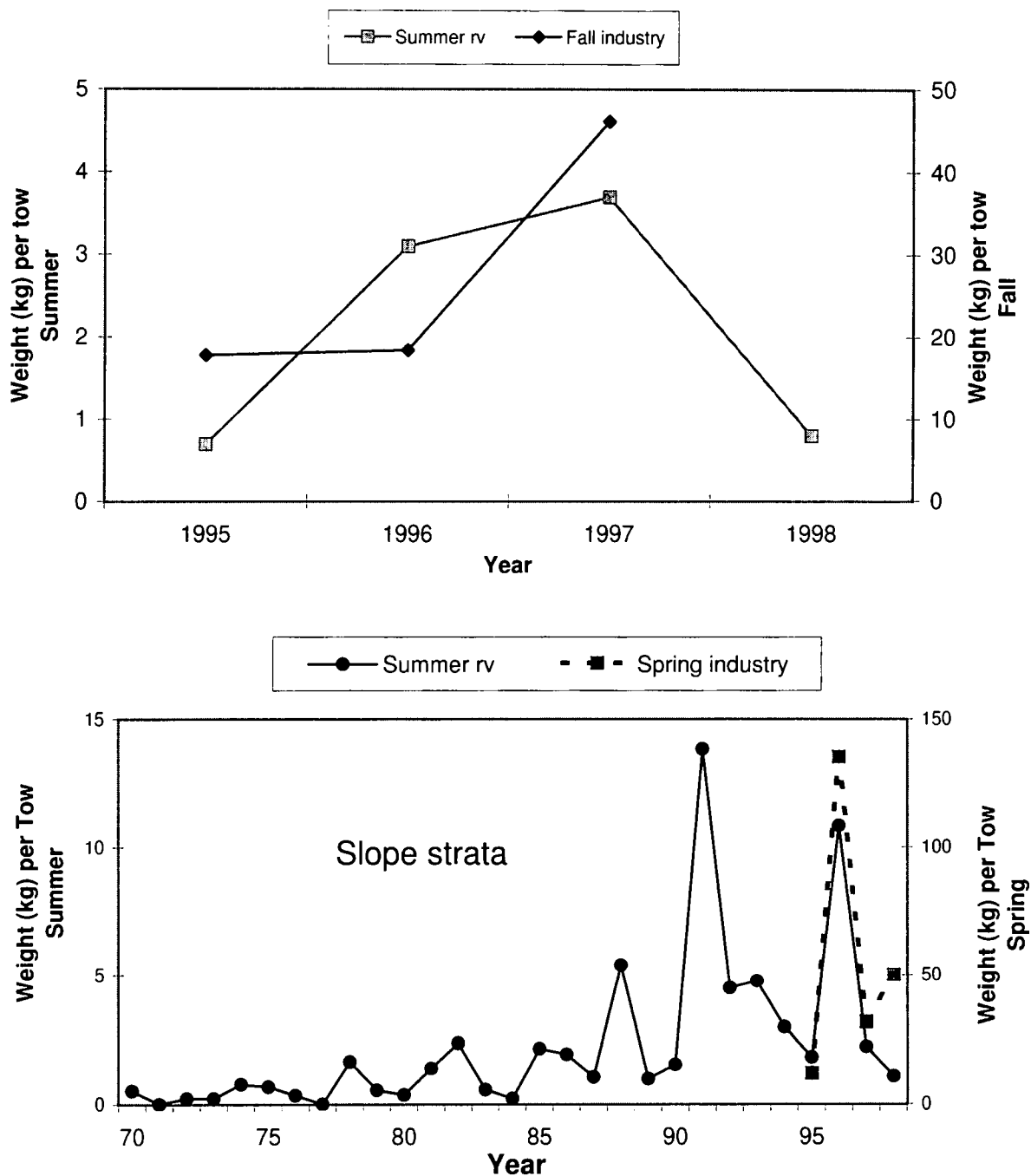
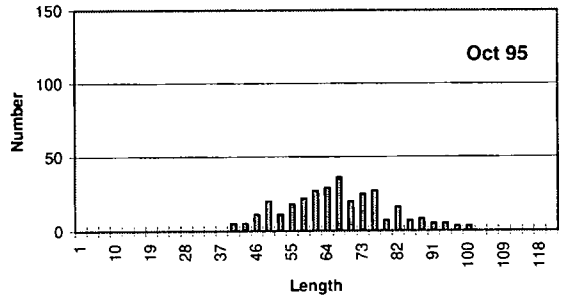
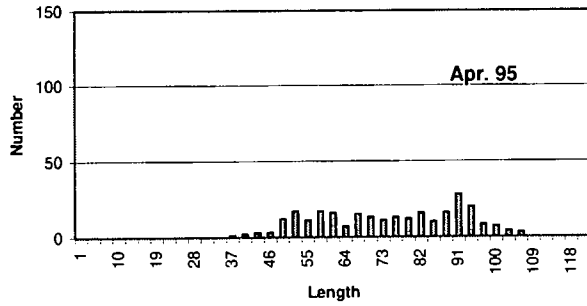
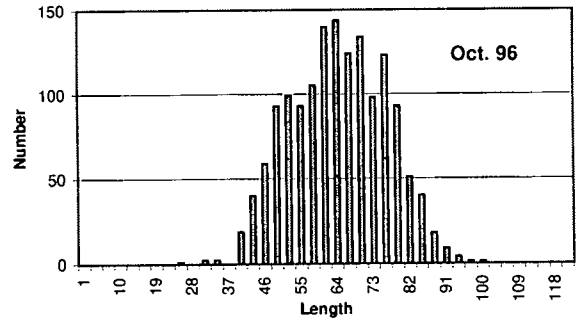
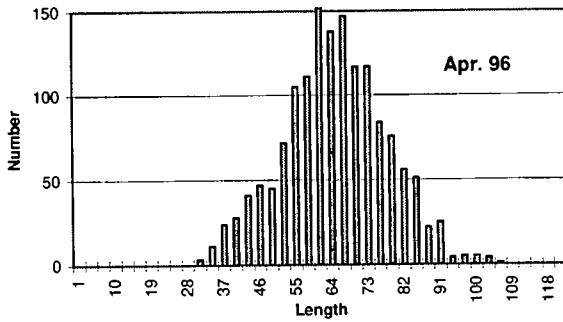


Figure 16. Comparison of catch rates in the summer research vessel and fall industry surveys based on the summer rv survey strata( 46-58)(upper panel). The lower panel compares the catch rates in the spring industry surveys and the summer RV using the slope strata only (46,49,50,51,52,53,54). The depth range for these strata is 92 to 366 m.

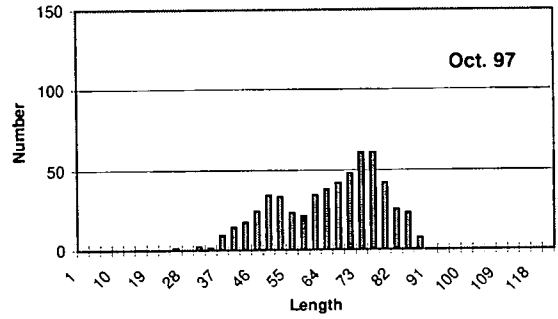
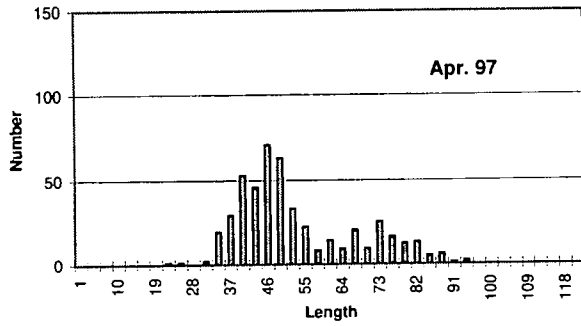
255mm



155mm



155mm



155mm

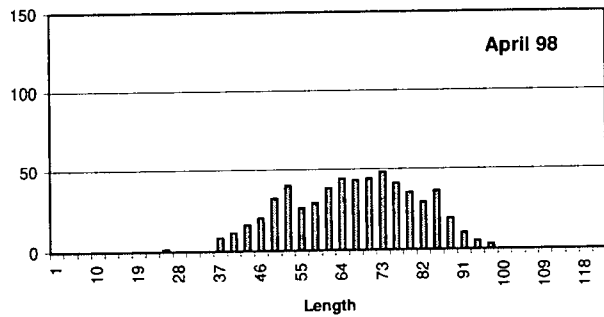


Figure 17. Length frequencies of winter skate taken during the survey sets of the industry/science surveys in 1995,1996,1997 and 1998.

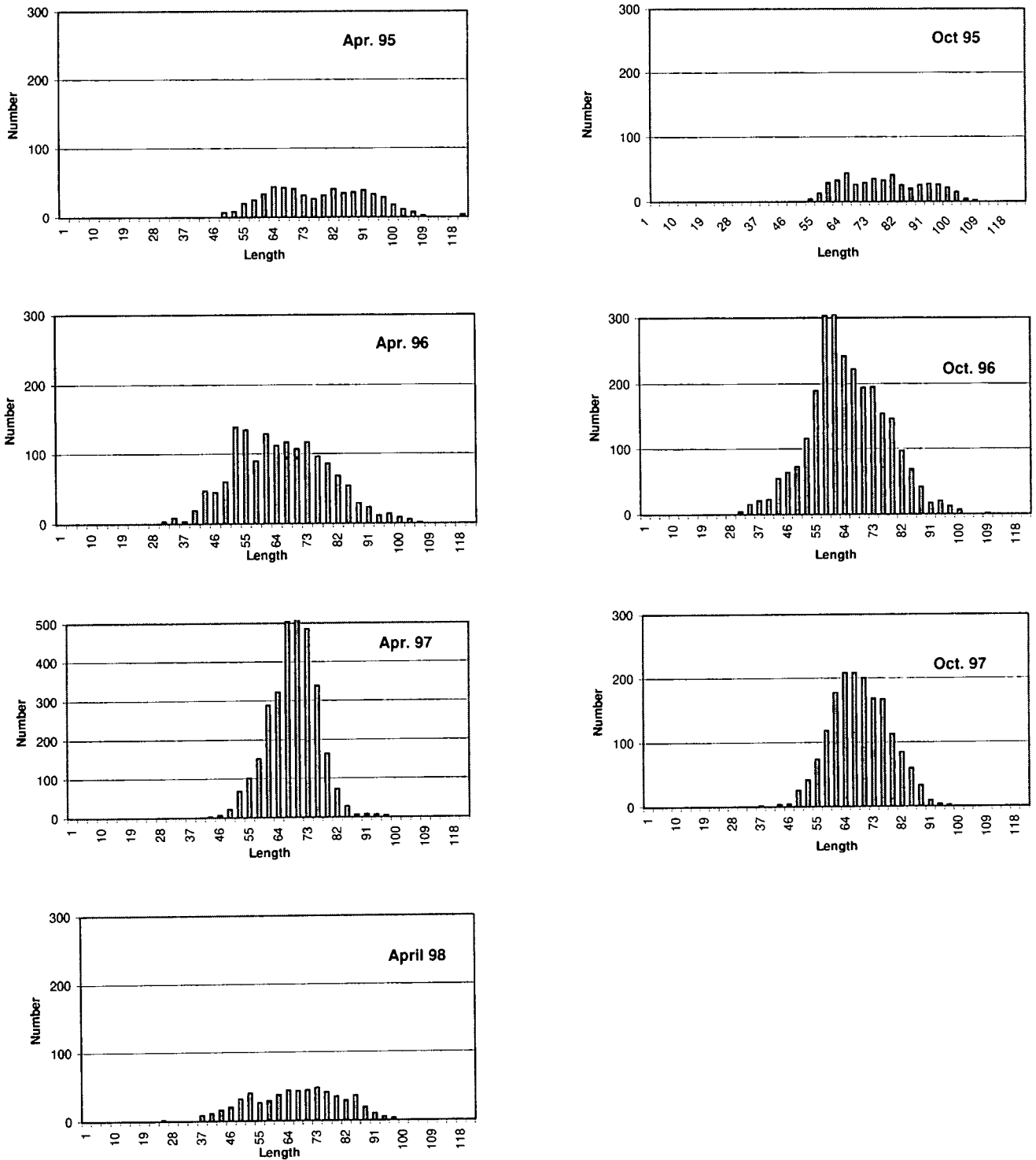


Figure 18. Length frequencies of winter skate taken during the fishing sets of the industry/science surveys in 1995, 1996, 1997 and 1998.

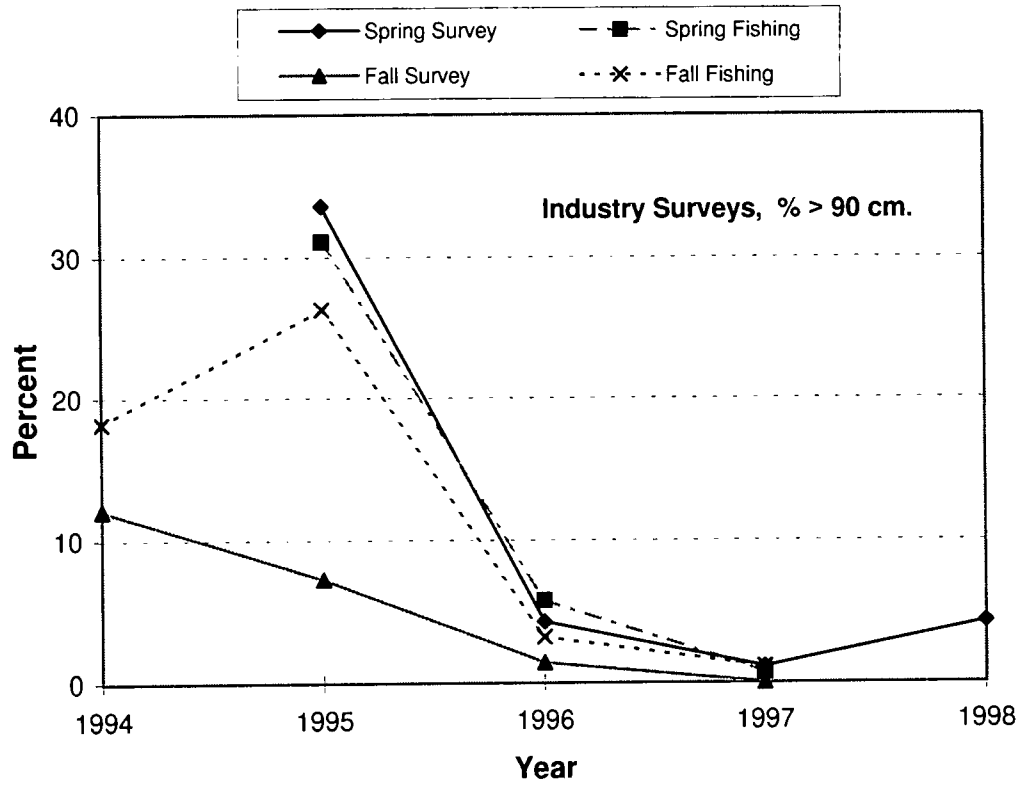
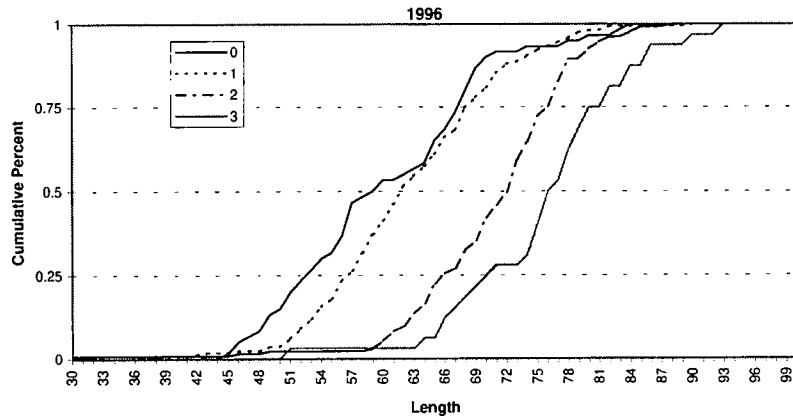
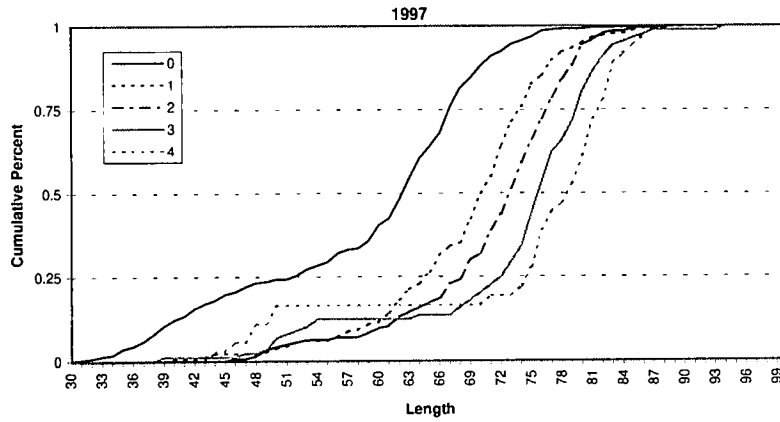


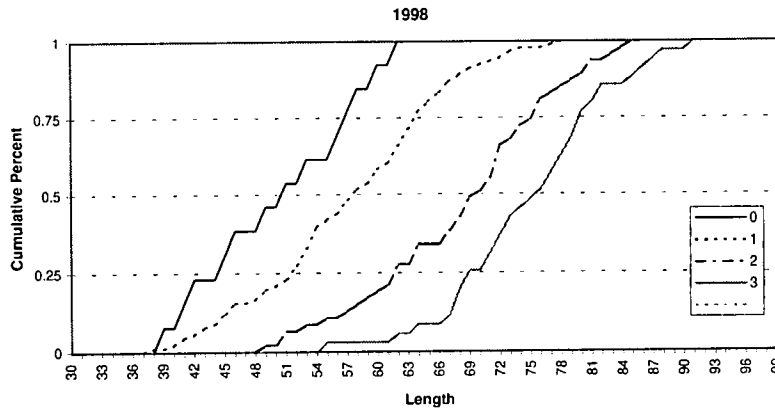
Figure 19. Percentage of winter skate > 90cm in the spring and fall industry/science surveys.



n=393



n=725



n=186

Figure 20. Comparison of maturity staging of female winter skates from three years of observer data. Staging is based on a maturity key developed by M. Cox with modifications by DFO.

- Stage 0 = no development evident
- Stage 1 = R1, clear eggs up to 2mm
- Stage 2 = R2 eggs 2-5mm, cream coloured
- Stage 3 = Ripe eggs 5-20mm, yolks creamy yellow
- Stage 4 = Spawning, yolk in fallopian tubes, purses may be evident

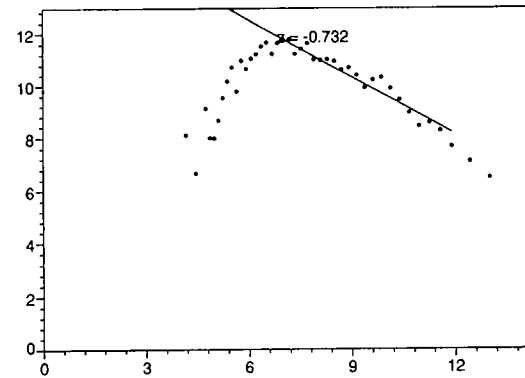
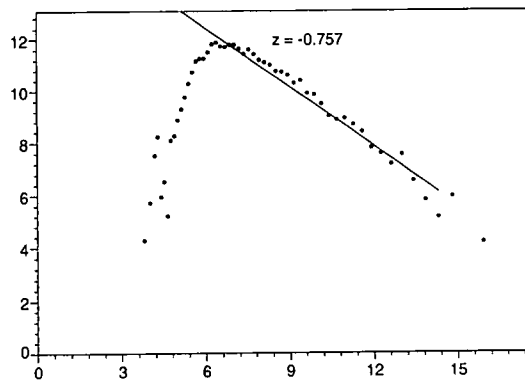
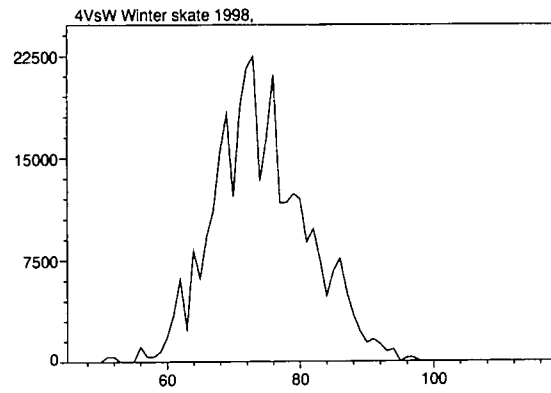
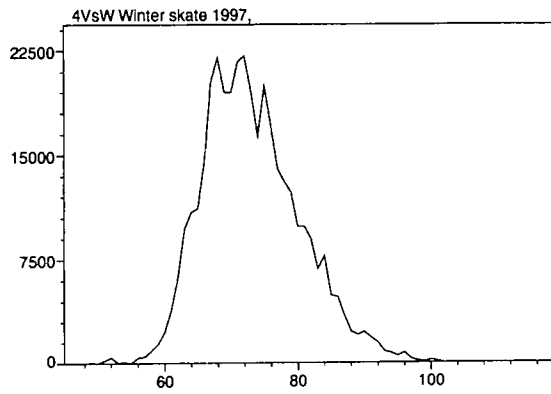
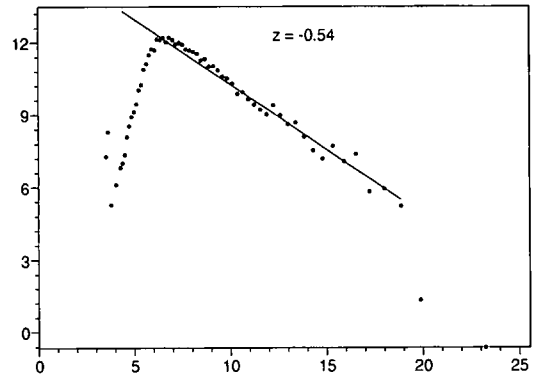
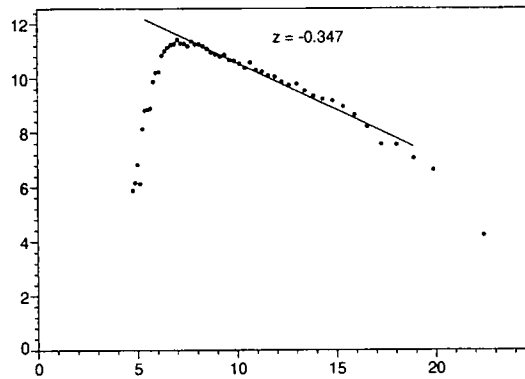
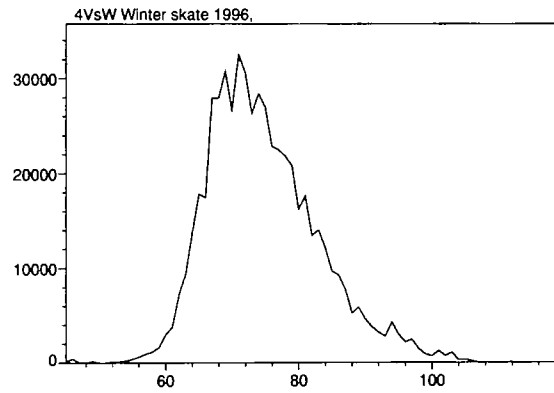
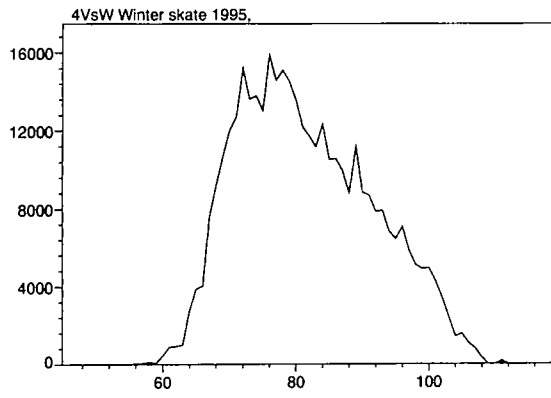


Figure 21. Estimates of total mortality( $Z$ ) as derived from commercial catches of winter skate using a growth model of winter skate on the Scotian Shelf.

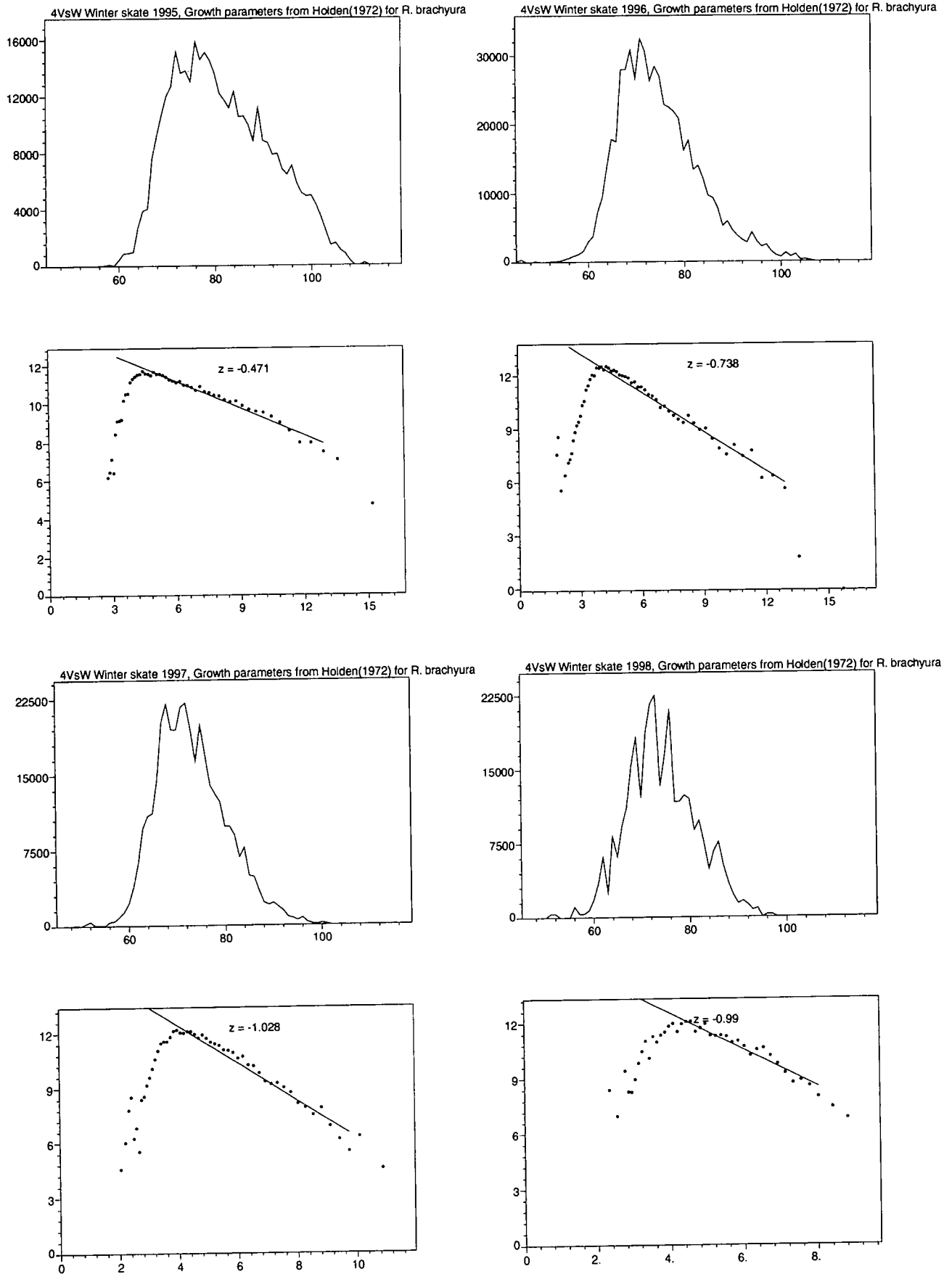


Figure 22. Estimates of total mortality ( $Z$ ) as derived from commercial catches of winter skate using a growth model from a North Sea skate (*R. brachyura*).



## Appendix A

### Maturity Stages of Skates

#### Stage 0 IMMATURE

Surface of ovaries undeformed and smooth. No eggs visible on the dorsal or ventral surface. Ovary thinner than stage 2.

#### Stage 1 RIPENING 1

Clear eggs up to 2 millimeters in diameter are visible in the top surface (dorsal) of the ovaries. Surface of ovaries smooth and undeformed. Caution: When observing from the ventral surface the ovary must be flipped over.

#### Stage 2 RIPENING 2

Eggs grow in size (2-5 mm) and are cream coloured. Texture and content resemble small chicken yolks except for colour. Dorsal surface of ovary irregular. Ventral surface of ovary may still be smooth in early stage but slicing ovary with knife immediately reveals eggs.

#### Stage 3 RIPE

Eggs grow in size (5-20 mm) and turn chicken yolk creamy yellow in colour and texture. Ovaries swollen and deformed on all surfaces. Blood vessels appear on yolk surface in later stage. Yolk may be seen in the fallopian tubes.

#### Stage 4 SPAWNING

Yolk in fallopian tubes beginning to be enveloped by purse. This begins at the rear and continues until entire yolk is surrounded by purse. The number of purses should be noted in comments. When complete the purse is discharged.

by Mike Cox and Jim Simon  
21/02/97