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**Seasonal Distribution of Cod in the Northern Gulf of St.
Lawrence**

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Abstract

The spatial distribution of different sized cod in the 3Pn4RS management unit was investigated to identify possible closed areas to reduce the catch of small cod in the commercial fishery. Data from summer and winter groundfish surveys were used. The distribution of three size groups were analyzed: 0 to 29 cm- a size group rarely caught in the commercial fishery; 30 to 41 cm- a size group below the market size and which is caught and discarded; and 42+ cm- the market size group. The three size groups had similar distributions in summer, being abundant in coastal waters off northwestern Newfoundland and the north shore of the Gulf. Area closures at this time would have a major impact on the cod fishery. In winter, more spatial segregation was evident with the largest fish showing a more extensive migration into 3Pn than the other two size groups. Areas other than 3Pn account for approximately 40% of the winter fishery. The apparent differences in distribution among size groups may reflect temporal aspects of size dependent migration and the patterns should be confirmed by analysis of commercial sampling and observer data.

Resumé

La distribution spatiale de différentes tailles de morues dans les unités de gestion 3Pn4RS a été étudiée afin d'identifier quelles zones devraient être fermées à la pêche pour réduire la capture de petites morues par la pêche commerciale. Les données provenant des relevés de recherche d'été et d'hiver pour le poisson de fond ont été utilisées. Les distributions de trois groupes de taille ont été analysées: de 0 à 29 cm (un groupe rarement capturé par la pêche commerciale), de 30 à 41 cm (un groupe de taille inférieure à la taille commerciale qui est capturé et rejeté en mer) et de 42 cm et plus (le groupe de taille commerciale). Les trois groupes de tailles ont la même distribution en été, ils sont abondant dans les eaux côtières du Nord-Ouest de Terre-Neuve et de la rive Nord du Golfe. La fermeture de zones de pêche en été aurait un impact majeur sur la pêche à la morue. En hiver, une division plus nette apparaît: les gros poissons se retrouvent en plus grande proportion dans 3Pn que les poissons des deux autres groupes de tailles. Environ 40% de la pêche d'hiver a lieu en dehors de 3Pn. Les différences qui apparaissent dans la distribution des groupes de tailles en hiver sont peut-être dues à une relation entre la vitesse de migration et la taille des poissons et devraient être confirmées par l'analyse des données d'échantillonnage commercial et d'observateurs.

Introduction

The cod fishery in 3Pn4RS has declined substantially in the past 5 years. In the fall of 1990 a special committee formed by the Gulf Groundfish Advisory Committee to recommend measures to ensure the conservation and protection the stock. One of the recommendations was to analyze the spatio-temporal distributions of different size groups of cod in a effort to identify areas of high abundance of juveniles and thus provide the basic data for area closures starting in the coming season. This is the objective of our study.

There have been repeated allegations of high levels of discarding of small cod in the winter fishery in 3Pn and southern 4R. This has been confirmed by consultation with mobile gear fishermen, who have added that there is also heavy discarding in the summer fishery, especially in the area of the Esquiman Channel. Little has been said about discarding in western 4S, however, this does not mean that it does not exist.

Methods

We used the results of summer and winter abundance surveys conducted in the northern Gulf of St. Lawrence on the Lady Hammond and Gadus Atlantica to study the seasonal distribution of different sized cod. These surveys are conducted annually following the standard random stratified sampling design used on all eastern Canadian groundfish surveys (Doubleday 1981). The survey trawls are fitted with fine meshed liners to retain all but the smallest fish. The summer survey, designed primarily for redfish, sampled depths greater than 50 fathoms. A substantial portion of the summer cod fishery is prosecuted in waters less than 50 fathoms, particularly in the Strait of Belle Isle and off western Newfoundland. Thus the total area of summer cod distribution is probably not represented by these results (Fréchet et Schawb 1990). The winter survey is cod directed and covers most areas fished in this season. Sampling along the north shore of the Gulf is restricted in both surveys by very rough bottom conditions. Due to time constraints and data availability, the periods 1987-1989 summer and 1987-1990 winter were used.

Length frequencies of cod catches are taken on all sets. These were adjusted to a standard tow distance of 1.75 nm and divided into three size groups. The smallest group spans 0-29 cm. These are rarely caught in commercial gear. The mid-sized fish, 30-41 cm, are below the marketable size and are subject to the highest level of discarding. The third group includes marketable fish, 42+ cm.

The seasonal distribution of these size groups are described based upon examination of tow-by-tow plots of catch numbers, mean catch per tow by strata, and the percentage of the stock abundance in broadly defined geographic areas.

Results

Tow-by-Tow

In summer, all size groups are found in shallow waters along the north shore of the Gulf and off western Newfoundland (Figure 1). While there appears to be considerable overlap of the different size groups, relatively more older fish were taken in the northwestern Gulf, around Anticosti Island. In winter, the smaller fish were most abundant in deep water in 4S and 4R, as well as in St. Georges Bay (Figure 2) (NAFO Divisions are shown in Figure 4). The mid-sized cod were most abundant in southern 4R off St. Georges Bay, and the largest fish were most abundant in southern 4R and 3Pn.

Catch per Stratum

An index of the density of cod in different areas and size groups was taken from the mean numbers per tow by stratum (Figure 4) from the summer and winter surveys (Table 1, Figures 5 and 6). In summer, high densities of all size groups were found in 100-150 fathoms of water in most areas of the Gulf. Highest densities were observed in strata 820-824 in 4R, off western Newfoundland and around the Esquiman Channel, and strata 828-832 in 4S, around Anticosti Island and on the middle north shore. There was considerable overlap between the size groups, but the relative density of small and large fish varied with higher densities of large fish in 4S. Other strata on the north shore are not easily fished and therefore poorly sampled.

In winter, the different size groups were more segregated. The smallest fish occupied deeper waters in the central Gulf and southern 4R. The highest densities of 30-41 cm cod were in southern 4R, while for the largest fish they were found off southwestern Newfoundland including 3Pn.

Percent Abundance by Area

The survey strata are defined by depth and are not necessarily convenient for defining areas that could be closed to fishing to protect concentrations of small fish. Thus, the strata were combined into sub-

areas of contiguous strata containing similar densities of the different sized cod. These areas also corresponded to statistical unit areas to allow the estimation of fishing activity from commercial catch and effort statistics. The sub-areas are defined below.

Area	Strata
4S	803-808, 814-819, 827-833
4R1, northern 4R	801, 812, 813, 822, 823, 824, 836
4R2, middle 4R	809, 811 north, 821, 835
4R3, southern 4R	802, 810, 811 south, 820
3Pn	302-305

The abundance of the different size groups in each sub-area was calculated by summing the products of the strata mean catch per tow and the strata areas, according to standard stratified random survey procedures. The percent distribution of total abundance among sub-areas in summer and winter is given in Figures 7 and 8. During the summer, observations were made in 3Pn only in 1987 when catches were very small.

Less size segregation is evident in summer than in winter. In summer, the highest percentage abundance was found in 4S for all size groups. This was followed by northern 4R, the area including the Esquiman Channel. As noted above, the largest fish were relatively more abundant in 4S than the smaller fish. The distribution in winter was very different. The middle size group had a much reduced presence in 4S and the highest abundance in middle and southern 4R. The largest cod were most abundant in southern 4R and 3Pn. The smallest cod showed little change in distribution among these broadly defined areas.

Discussion

Tagging studies have shown that the 3Pn4RS cod stock highly migratory, being concentrated at the entrance on the Gulf in winter and distributed throughout the northern Gulf in summer (Templeman 1979, Gascon, *et al.* 1990). The seasonal changes in distribution that are evident from the research survey are consistent with that of the commercial fishery. The latter is intense in 3Pn and 4Rd in winter and concentrated in the northern Gulf (4Rab, 4S) in summer. An appreciation of the relative importance of different statistical unit areas in the Gulf in terms of cod

catch by mobile gears is given in Figure 9. Unit area 4Rd corresponds roughly with area 4R3 used in the analysis of survey results.

The results of this study indicate size-dependent differences in the migration and distribution of the stock. There was considerable overlap in the distribution of the three size groups in summer, however the larger fish were relatively more abundant in 4S than the smallest fish. The smallest size group showed the least amount of seasonal migration, the distribution shifting from the shallow coastal areas in summer to deeper water in the central Gulf in winter. The mid-sized group exhibited a more pronounced migration in having a high abundance in western 4S in summer and then a shift to the southern parts of 4R in winter. The migration of the largest fish was the most extensive in being almost exclusively concentrated in 4S in summer and then in southern 4R and in 3Pn in winter.

Cod in the 30-41 cm range are subject to discarding at sea. The objective of this analysis was to identify areas of high abundance of these fish that could be closed to reduce their catch. These results indicate that in summer, fish of this size are distributed in waters of 100-150 fathoms with highest concentrations around the Esquiman Channel (unit area 4Rab, 4Svw), the middle north shore (unit area 4Sy), and east of Anticosti Island (unit area 4Ssx). About 60% of the summer, mobile gear fishery occurs in the area of the Esquiman Channel, and another 25% in the other areas mentioned above. Thus, closure of these areas in summer would virtually eliminate the summer, mobile fishery. In winter the 30-41 cm fish were concentrated in southern 4R (unit area 4Rd) and they were rarely caught in 3Pn. Approximately 40% of the winter fishery catch from 1985-89 was taken in this area.

The persistence and extent of these size-dependent differences in migration and distribution are difficult to determine. The surveys do not cover the whole area of known cod distribution. We hope to address this by adding inshore stations to the summer survey beginning in 1991. A second difficulty stems from the timing of the surveys. The summer survey occurs in August-September. It is likely that the fish have attained their summer distribution by this time as indicated by the timing of commercial catches (A. Sinclair, unpublished data). However, the winter survey occurs at the beginning of the winter fishery and it is not clear whether all size groups have reached their over-wintering grounds by that time. Size dependent differences in swimming velocities may result in apparent differences in distribution. This could be resolved by analysis of commercial sampling and observer data from the winter

fishery. Nevertheless, the data indicate age-dependent differences in migration and distribution and the ecological significance of this warrants further investigation.

Acknowledgements

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Table 1: Mean catch per tow (numbers) for three size groups of 3Pn 4RS cod from the winter and summer groundfish surveys. Zeros indicate no catch and blanks indicate no fishing.

0 to 29 cm		Mean Number per Tow						
Division	Stratum	Summer			Winter			
		87	88	89	87	88	89	90
3Pn	302	1			2	2	0	1
	303	1			0	1	0	1
	304	0			0	0	0	0
	305	0			0	1	0	0
4R	801	0	0	0	0	1		
	802	0	0	0	0	0	0	4
	809	0	0	0	2	6	17	37
	810	0	0	0	1	4	0	45
	811	0	0	0	10	25	28	76
	812	0	0	0	4	9	15	21
	813	0	2	1	23	16	15	2
	820	4	48	37	2	13	78	4
	821	4	5	41	2	3	284	6
	822	5	4	16	1	2	14	0
	823	75	52	34		0	6	1
	824	29	75	36		12		
	835					9	1	2
	836					6		
	4S	803	0	0	0	0	0	0
804		0	0	0	1		0	
805		0	0	0				
806		0	0	0				
807		0	1	0	1	11	0	15
808		0	0	0	2	4	4	20
814		0	3	0	2	8		
815		0	0	0	4	9	19	28
816		0	1	0		20	16	
817		1	0	0				
818		0	0	0				
819		0	0	0	10	3	14	27
827		0	79			2	5	
828		8	12	1				
829		5	20	12	3	4	2	
830	33	7	59	1	1	9	2	
831	2	5	6					
832	1	2	6					
833	0	32	1		1	0		

Table 1: Continued

30 to 41 cm		Mean Number per Tow						
Division	Stratum	Summer			Winter			
		87	88	89	87	88	89	90
3Pn	302	3			5	6	2	0
	303	1			2	18	11	1
	304	0			0	4	2	12
	305	0			0	1	1	4
4R	801	0	0	0	1	2		
	802	0	0	0	1	1	1	227
	809	0	0	0	26	9	25	21
	810	0	0	0	244	22	10	134
	811	0	0	0	68	109	9	13
	812	1	0	0	3	2	4	3
	813	3	2	12	5	2	2	0
	820	9	12	25	4	4	29	1
	821	23	32	32	10	1	167	1
	822	29	8	23	0	0	1	0
	823	65	52	25		0	0	0
	824	47	48	63		0		
	835					0	1	1
	836					0		
	4S	803	0	0	0	2	7	4
804		0	0	0	13		0	
805		0	0	0				
806		0	0	0				
807		0	0	0	2	14	0	4
808		0	0	0	7	4	18	10
814		1	0	0	0	1		
815		0	0	1	14	3	4	5
816		3	3	1		5	5	
817		1	0	1				
818		3	0	0				
819		2	0	1	4	3	2	9
827		10	7			0	0	
828		198	44	12				
829		5	35	114	1	0	0	
830	100	22	17	0	0	0	0	
831	19	40	20					
832	29	28	21					
833	8	6	4		0	0		

Table 1: Continued

42 + cm		Mean Number per Tow						
Division	Stratum	Summer			Winter			
		87	88	89	87	88	89	90
3Pn	302	5			249	89	15	0
	303	1			49	792	131	8
	304	1			20	130	14	114
	305	0			9	98	35	115
4R	801	0	0	1	2	1		
	802	0	0	0	18	107	446	363
	809	1	0	0	35	1	0	1
	810	0	1	0	266	15	68	434
	811	1	1	4	142	10	1	1
	812	8	0	0	1	0	0	0
	813	8	6	26	1	0	0	0
	820	52	39	50	23	2	44	1
	821	51	76	39	42	0	100	0
	822	37	31	37	0	0		0
	823	53	81	19		0	0	0
	824	111	87	99		0		
	835					0	1	0
	836					0		
	4S	803	0	0	0	8	18	12
804		0	0	0	10		0	
805		0	0	0				
806		0	0	0				
807		1	1	0	3	1	0	0
808		1	0	0	9	1	14	1
814		16	2	1	0	0		
815		1	7	2	4	1	1	0
816		21	18	12		3	2	
817		27	3	2				
818		6	1	3				
819		2	2	4	1	0	0	1
827		64	49			0	0	
828		583	104	53				
829		2	45	187	0	1	0	
830		99	79	28	0	0	0	1
831		76	164	104				
832	175	128	184					
833	27	21	14		0	0		

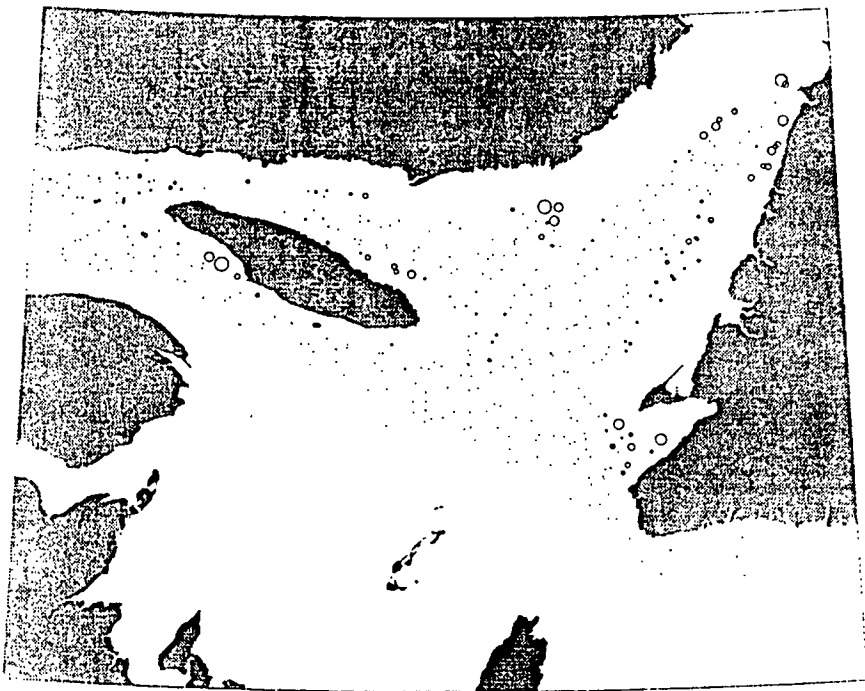


Figure 1: Catches of 3 size groups of cod during summer groundfish surveys, 1987-1989. Clockwise from top left, 0-29 cm, 30-41 cm, 42+ cm.

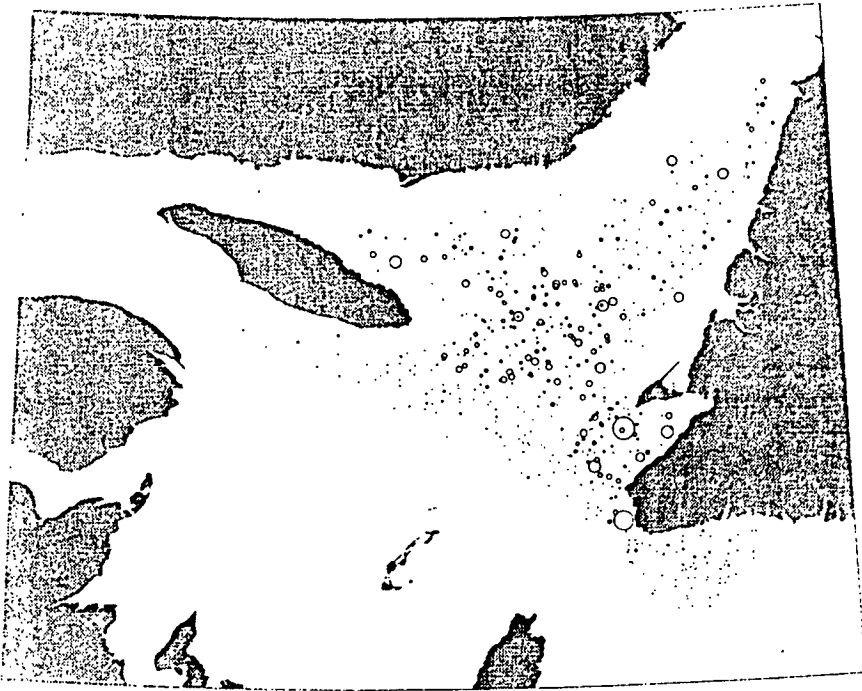


Figure 2: Catches of 3 size groups of cod during winter groundfish surveys, 1987-1989. Clockwise from top left, 0-29 cm 30-41 cm, 42+ cm.

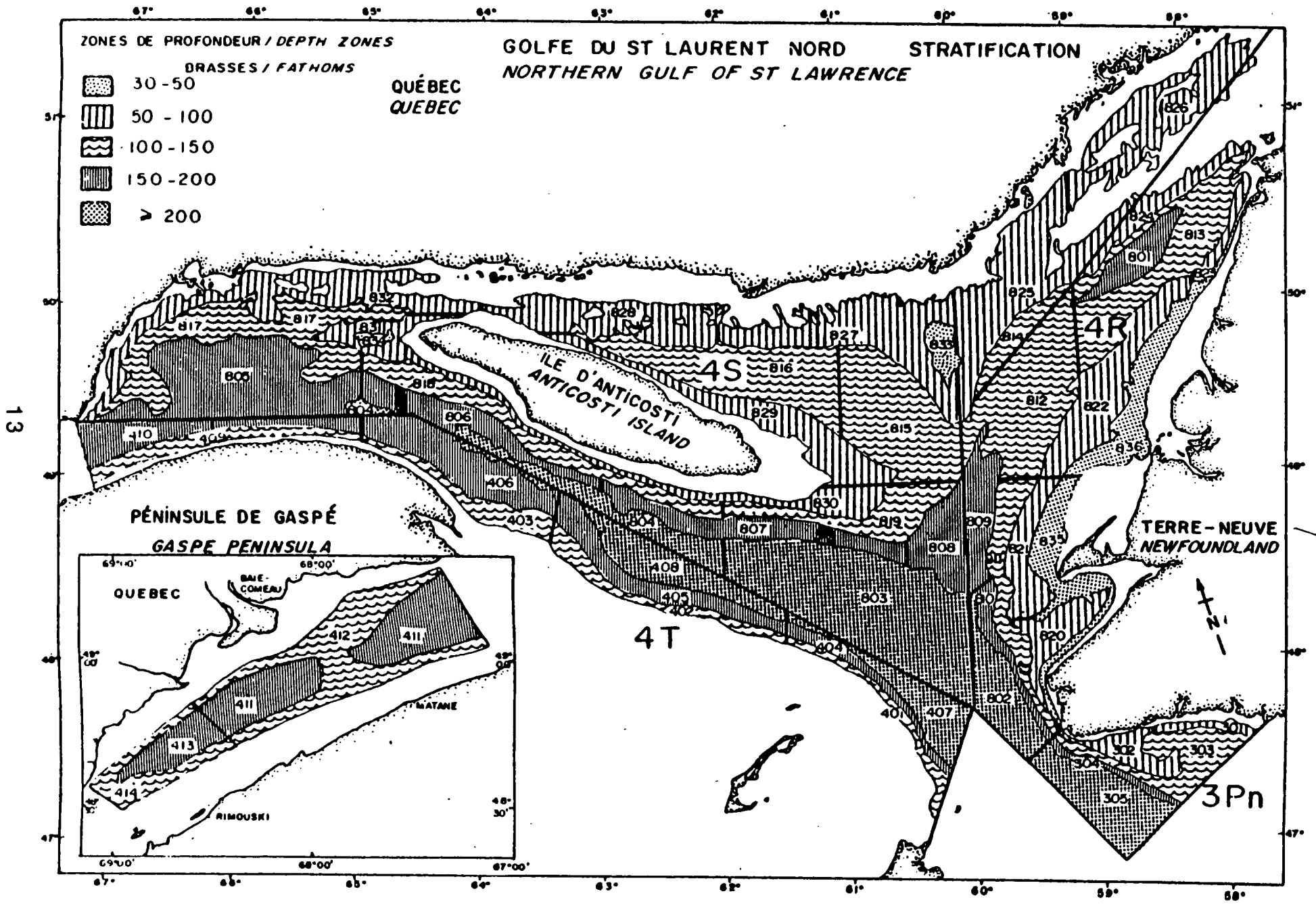


Figure 3: Groundfish survey strata in the northern Gulf of St. Lawrence.

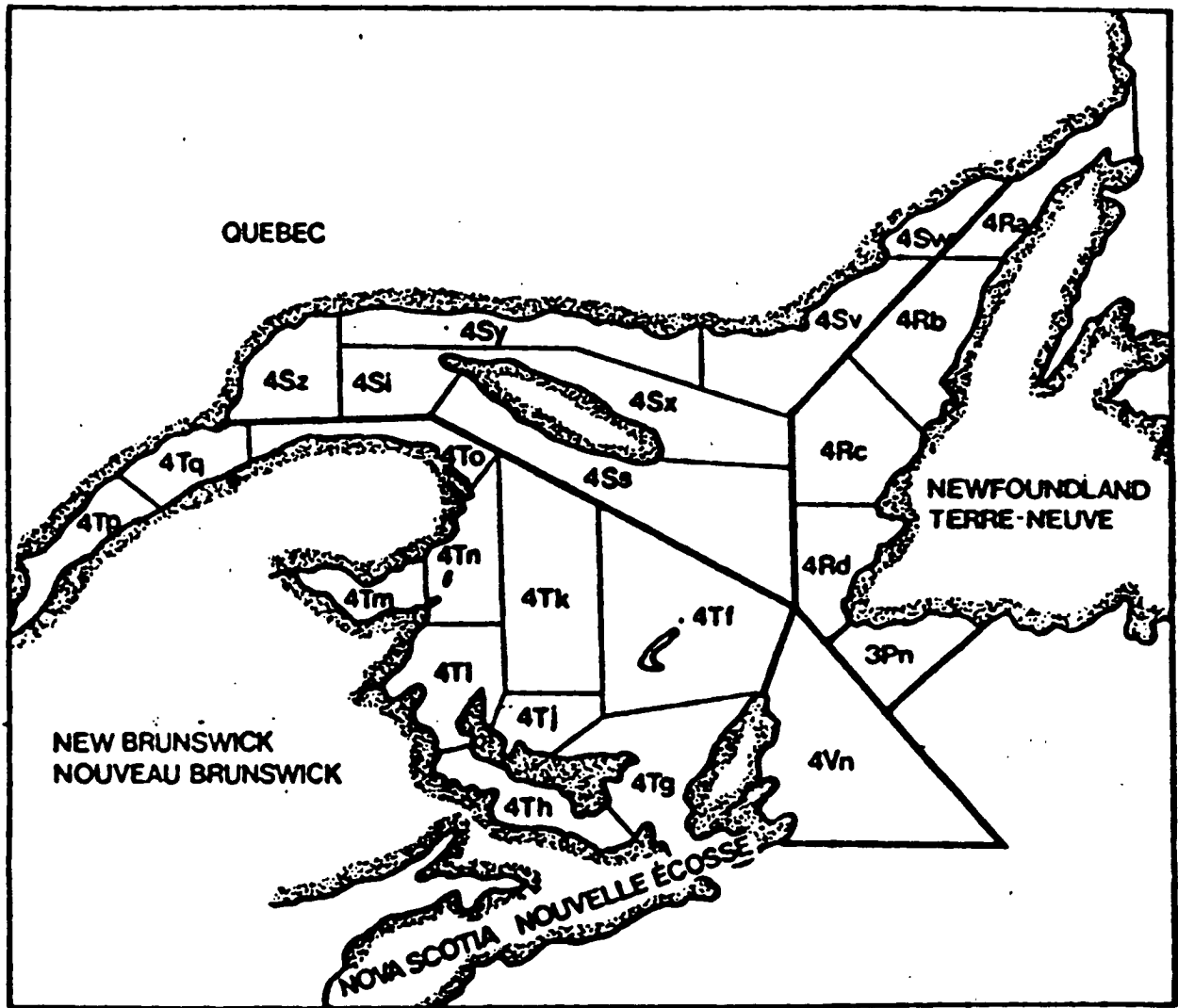


Figure 4: Statistical unit areas in the Gulf of St. Lawrence.

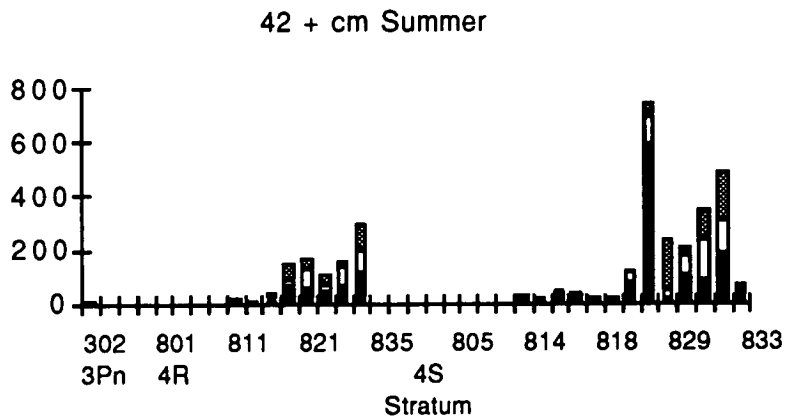
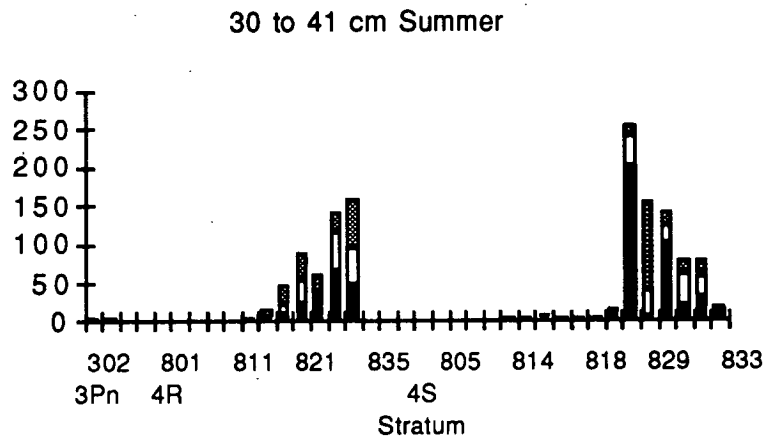
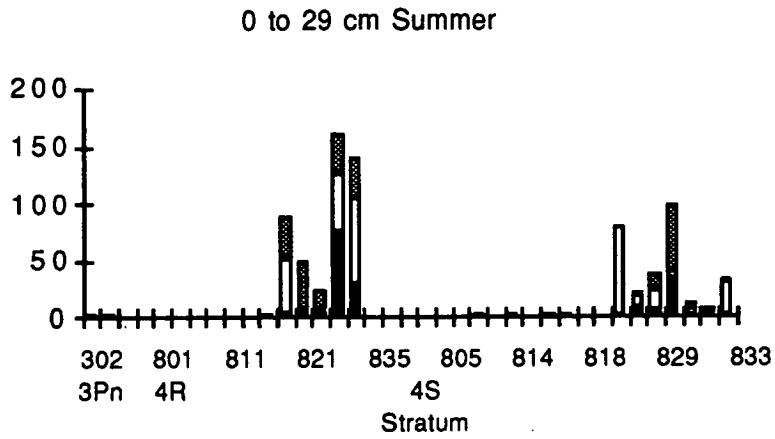


Figure 5: Mean catch per tow for three size groups of cod from summer surveys in the northern Gulf of St. Lawrence. One in four strata are labeled on the x axis, the bar is aligned with the first digit in the strata number, and the order of the strata corresponds to that in Table 1. The stacked histograms represent the years 1987-1989.

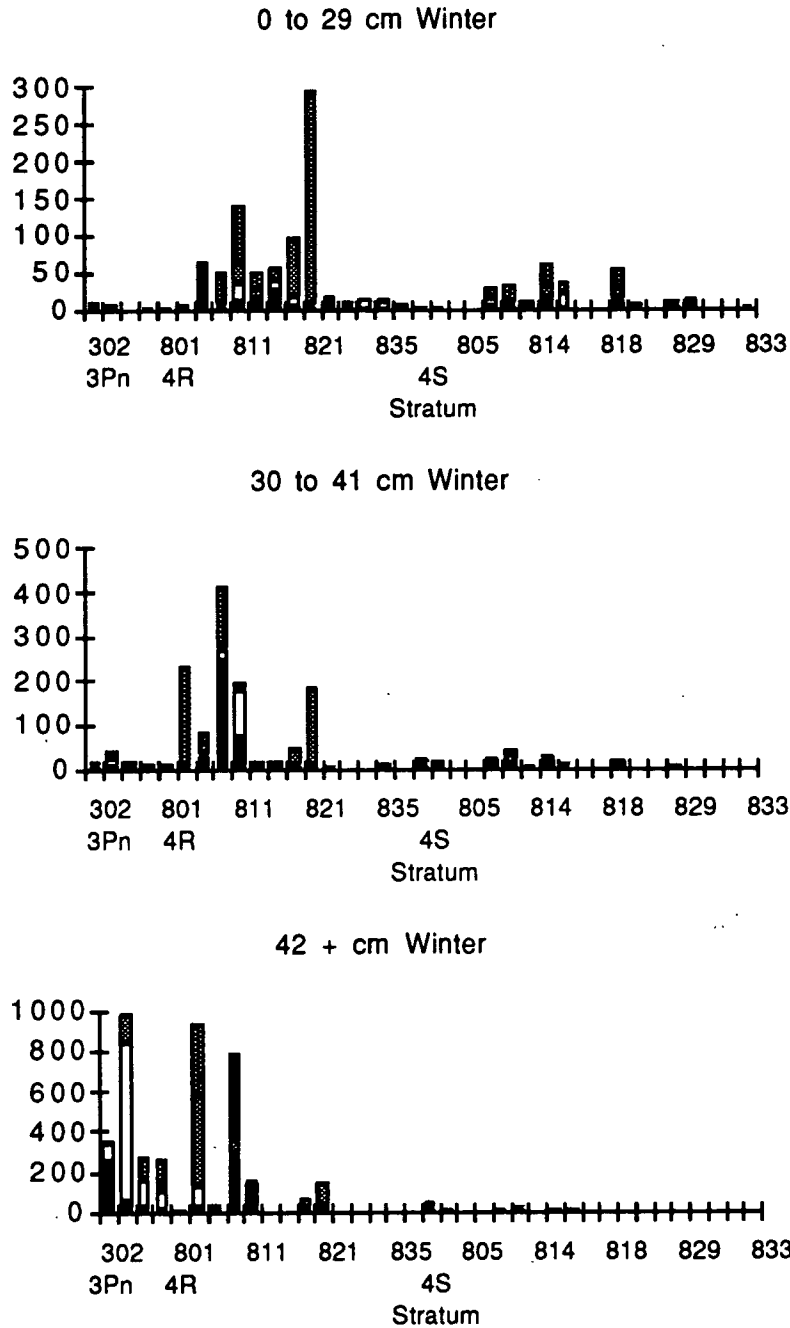


Figure 6: Mean catch per tow for three size groups of cod from winter surveys in the northern Gulf of St. Lawrence. One in four strata are labeled on the x axis, the bar is aligned with the first digit in the strata number, and the order of the strata corresponds to that in Table 1. The stacked histograms represent the years 1987-1990.

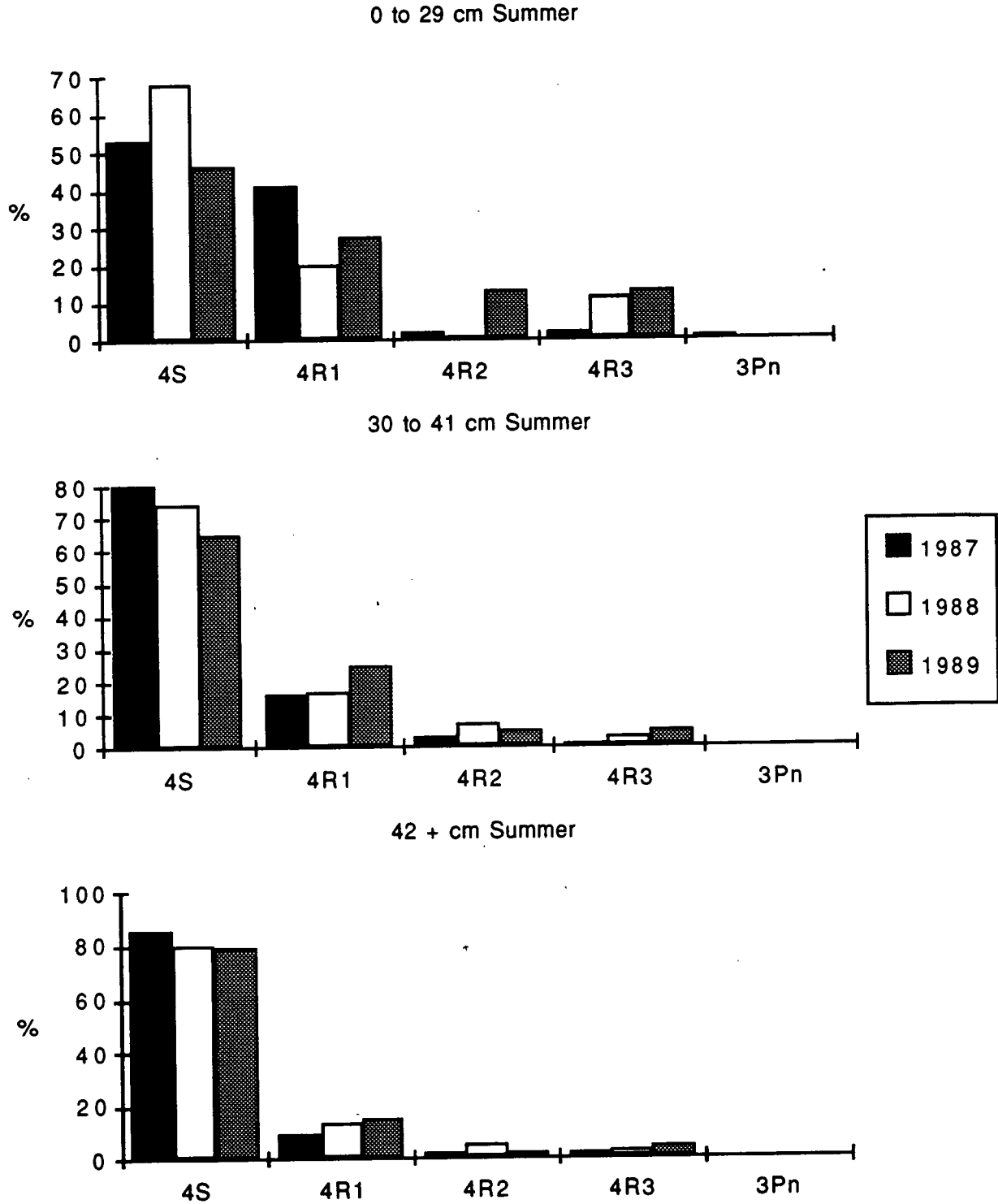


Figure 7: Percentage (numbers) distribution of 3Pn4RS cod among 5 broadly defined areas. Results of summer surveys.

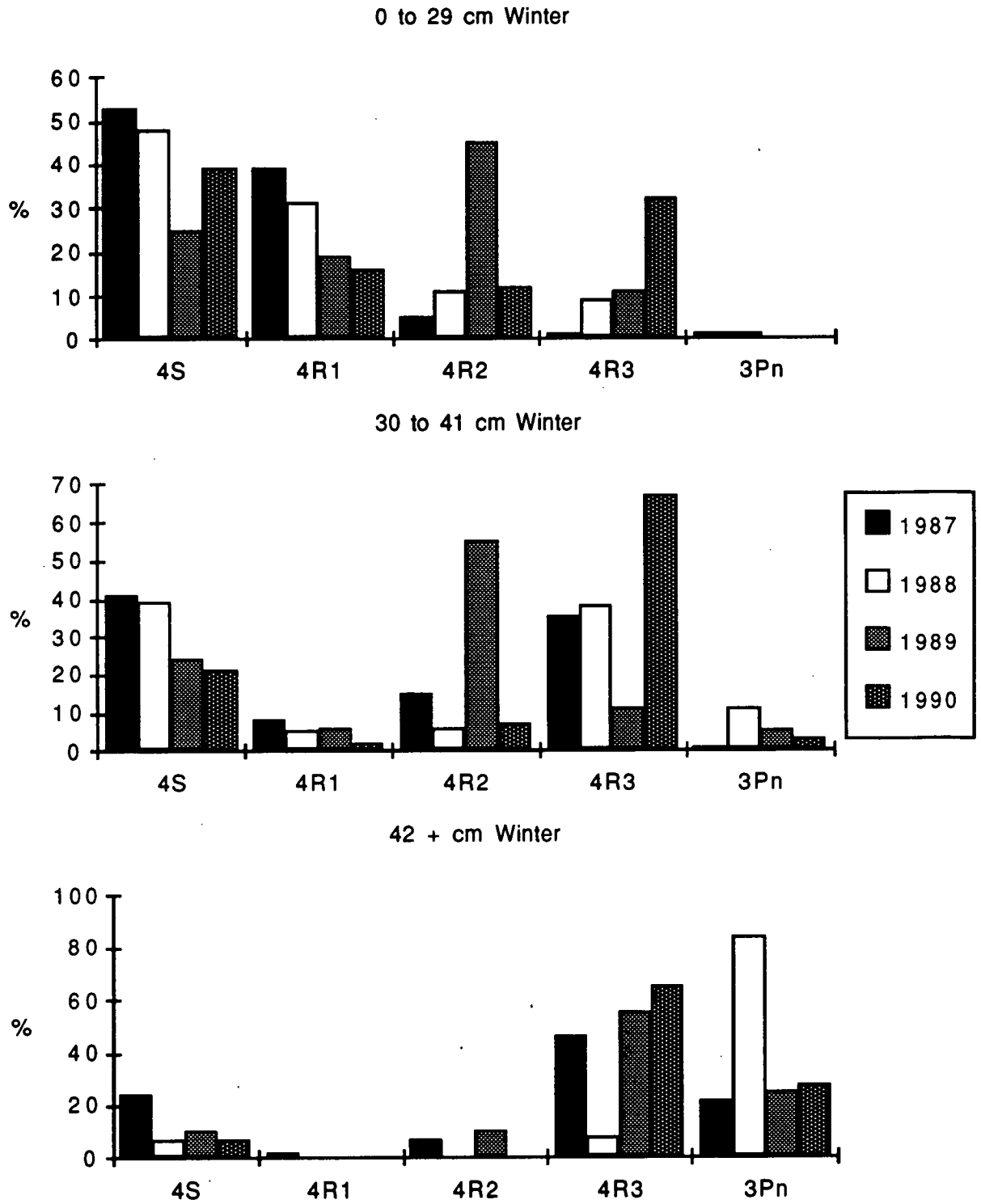


Figure 8: Percentage (numbers) distribution of 3Pn4RS cod among 5 broadly defined areas. Results of winter Surveys.

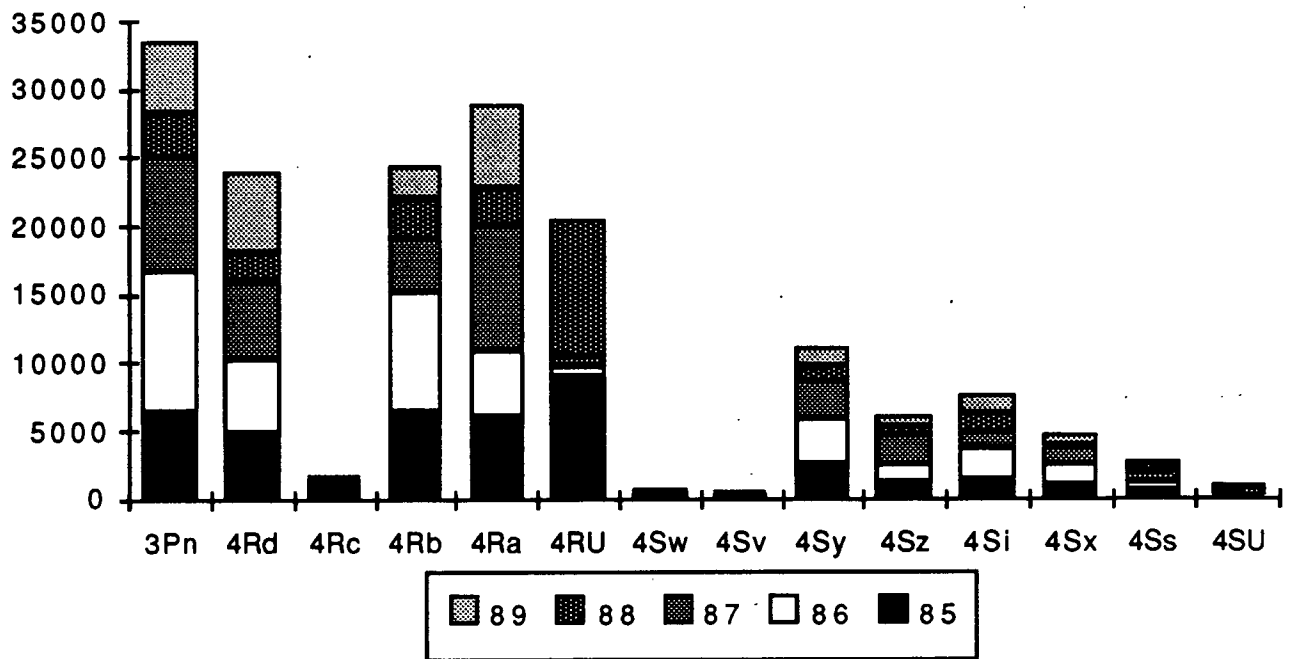


Figure 9: Catch of 3Pn4RS cod by mobile gears by statistical unit area between 1985-1989.