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By-catch in the Spanish Greenland Halibut Fishery (NAFO Divisions 3LMNO): 1991–94

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Abstract

The species composition of by-catch was studied in the Spanish Greenland halibut (*Reinhardtius hippoglossoides*) fishery, developed in the NAFO Regulatory Area in Div. 3L, 3M and 3NO, for the period 1991–94. Of the 17 species occurring in the catches, two groups were identified as the more and less frequent species. The more frequent species with an annual yield of about 5 kg/hr were roughhead grenadier, roundnose grenadier, skate, American plaice, redfish, witch flounder and blue antimora. Analyzing the data on a monthly basis revealed some species such as grenadiers, skate and American plaice, particularly in Div. 3N, did not change much while other species had increased yields in recent years. The characteristic species of the demersal fisheries (skate, American plaice) showed a wide bathymetric distribution. The transfer of effort southwards to Div. 3NO in recent years, mainly in the case of small vessels, has meant variation in the composition and relative abundance of by-catch in this fleet. The proportion of each by-catch species was highly variable. Skate, American plaice, witch flounder and grenadiers were caught most frequently in both fleets. In the large vessels, however, blue antimora, redfish and roundnose grenadier were more frequent than in the small vessels. The length distribution in the discarded proportion was analyzed for the two grenadiers, skate and blue antimora. In general, the length distribution of the proportion discarded showed a wide range.

Key words: by-catch, Flemish Cap, Grand Bank, Greenland halibut, length distribution

Introduction

The Spanish deep water fishery started in 1990, as described by Junquera and Iglesias (MS 1992) and de Cárdenas *et al*. (MS 1993). The fleet targeting Greenland halibut (*Reinhardtius hippoglossoides*) since 1991 has been comprised of two types of vessels, the large and small freezer trawlers.

This fishery is conducted at a depth range of 800 m to 1 500 m. Generally the fishery avoids catching the traditionally exploited demersal species found on the continental shelf, such as cod, American plaice, yellowtail flounder, witch flounder, redfish, etc., although on occasion, some of these species have been found in unusual concentrations at these greater depths (Iglesias *et al*., 1996). On the other hand, other species considered to be bottom dwellers in deep water, such as grenadiers, have been caught in significant proportions (Paz and Iglesias, MS 1994).

The incidence of fishing activity on species other than the target species is a vitally important issue in fish management (Saila, 1983). Incidental catches and discards may comprise a considerable proportion of the biomass caught, and may constitute a major source of mortality not considered in their stock evaluations. Recently, Alverson *et al*. (1994) have reviewed the importance of this issue.

This paper describes for the first time, the presence by depth strata and NAFO Division of a group of 17 species encountered in the by-catch, and the seasonal variations of these in the period 1991–94. Analysis is also made of the possible trends in yield of these species throughout the study period.

Materials and Methods

The Spanish deep-sea fishery for Greenland halibut in NAFO Div. 3LMNO formed the basis for the sampling data. The data used for the study were derived from a directed sea sampling program initiated by the Instituto Español de Oceanografía, Vigo, Spain in 1991 (Junquera and Iglesias, MS 1992). This program involved an intense coverage of the two fleets which represented the small and large vessels. Mesh size and target species were the same in both cases.

The main problem of estimating the proportion and importance of the by-catch and discards in this deep sea fishery poses the main difficulty in sampling on board. The fact that some species are not used and are discarded directly, for example,

hinders sampling. On other occasions, it is the type of processing which makes it difficult to estimate their importance, e.g. in the production of fish sausage from two or more species (grenadiers and blue antimora) which are processed together.

In the case of this study, the coverage of sampling were very high and intensive. A total of 23 413 hauls was considered in the large vessels, in the period 1991–94, and 9 070 hauls in the small vessels between 1992 and 1994. The monthly distribution by Division of the hauls sampled in each type of vessel is shown in Table 1, and their distribution by strata, month and Division in Table 2 and 3. All performed at depths greater than 800 m. The species caught in each haul were identified. Table 4 shows a list of the main fish species accompanying the Greenland halibut catches.

The total weight of the by-catch was estimated. To estimate the live weight of the processed species, various conversion factors were

TABLE 1. Monthly distribution by Division and year of the sampled hauls in the Spanish deep sea Greenland halibut fishery, for the large vessel and small vessel fleets.

	Div. 3L				Div. 3M				Div. 3NO				Total			
Month	1991	1992	1993	1994	1991	1992	1993	1994	1991	1992	1993	1994	1991	1992	1993	1994
Large Vessels																
Jan	...	178	256	137	...	231	23	71	...	...	...	1	...	408	279	209
Feb	...	468	382	197	...	752	61	202	...	...	...	24	...	1 220	443	423
Mar	...	463	334	52	...	1 021	200	283	...	3	23	163	...	1 487	557	498
Apr	...	1 006	269	121	...	498	190	182	...	...	28	200	...	1 504	487	503
May	...	1 398	205	191	...	370	54	163	...	...	78	239	...	1 768	337	593
Jun	...	799	98	110	...	299	54	112	...	...	15	164	...	1 098	167	386
Jul	81	286	2	65	324	79	...	30	...	9	149	75	405	374	151	170
Aug	477	320	78	137	695	114	21	30	...	190	348	98	1 172	624	447	264
Sep	432	285	139	118	709	30	22	39	2	129	121	95	1 143	444	282	252
Oct	415	201	71	159	763	14	39	70	17	73	129	105	1 195	288	239	334
Nov	322	246	191	268	826	24	2	29	1	12	147	53	1 149	282	340	350
Dec	229	148	214	230	230	19	17	2	...	..	51	...	459	167	282	232
Total	1956	5 798	2 239	1 785	3 547	3 451	683	1 213	20	416	1 089	1 216	5 523	9 665	4 011	4 214
Period total				11 778				8 894				2 741				23 413
Total hours towed																123 442
Mean tow time																5 h 16 min

	Div. 3L			Div. 3M			Div. 3NO			Total		
Month	1992	1993	1994	1992	1993	1994	1992	1993	1994	1992	1993	1994
Small Vessels												
Jan	...	78	33	...	19	32	...	...	...	...	97	65
Feb	...	339	8	...	108	4	...	2	119	...	449	131
Mar	...	414	16	...	201	13	...	83	165	...	698	194
Apr	...	325	12	...	179	7	...	309	185	...	813	204
May	...	473	7	...	58	4	...	240	185	...	771	196
Jun	...	249	33	...	44	8	...	252	72	...	545	113
Jul	100	146	7	40	26	1	...	342	2	140	514	10
Aug	113	178	20	35	4	1	44	272	90	192	454	111
Sep	139	179	31	22	1	6	282	213	117	443	393	154
Oct	60	59	...	17	...	...	320	406	150	397	465	150
Nov	10	1	...	6	3	6	250	436	192	266	440	198
Dec	98	89	10	26	24	...	11	115	94	135	228	104
Total	520	2 530	177	146	667	82	907	2 670	1 371	1 573	5 867	1 630
Period total			3 227			895			4 948			9 070
Total hours towed												44 054
Mean tow time												4 h 51 min

TABLE 2. Hauls sampled in the large vessels: 1991–94. Number by stratum, month, year and Division.

Year 1991

Depth (m)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
801-900							9	175	107	13	4	30
901-1000							14	70	45	60	53	46
1001-1100							45	126	133	190	131	64
1101-1200							13	102	107	129	97	26
1201-1300								3	37	22	34	35
1301-1400								1	2	1	3	20
1401-1500												7
> 1501									1			1

Year 1992

Depth (m)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
801-900	103	126	86	223	250	186	124	92	109	45	42	62
901-1000	34	86	111	172	224	131	73	77	31	35	65	22
1001-1100	62	143	112	249	337	188	52	96	54	74	70	18
1101-1200	27	80	106	141	234	119	27	39	36	27	39	10
1201-1300	10	27	40	161	234	148	8	16	62	20	30	36
1301-1400	4	10	7	39	76	20	2		3			
1401-1500				17	33	6						
> 1501		1	1	4	10	1						

Year 1993

Depth (m)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
801-900	59	86	51	43	27	37		39	108	41	35	93
901-1000	45	70	63	55	24	14		27	19	13	36	32
1001-1100	67	68	50	58	64	18		12	8	15	37	34
1101-1200	50	59	76	69	52	17	2		2	1	31	24
1201-1300	18	47	44	38	38	12				1	50	23
1301-1400	17	41	26	6					1		2	8
1401-1500		9	12						1			
> 1501		2	12									

Year 1994

Depth (m)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
801-900	35	16	16	22	51	37	31	73	75	59	81	100
901-1000	43	46	10	14	27	21	11	38	26	18	39	50
1001-1100	43	44	9	25	29	23	10	19	13	23	52	46
1101-1200	8	31	9	30	33	6	9	5	2	27	48	21
1201-1300	4	29	7	24	37	20	4	2	3	31	38	7
1301-1400	2	20	1	5	11	2				1	6	5
1401-1500	2	9			1	1					4	1
> 1501		2										

Division 3L

Year 1991

Depth (m)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
801-900							4	14	9	4	23	42
901-1000							12	55	50	6	6	8
1001-1100							69	149	155	108	64	24
1101-1200							191	348	310	316	301	58
1201-1300							47	95	110	162	208	51
1301-1400							1	27	43	83	174	32
1401-1500								7	30	62	41	10
> 1501									2	22	9	5

Year 1992

Depth (m)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
801-900		6	41	2	6	4	1	2	1		4	7
901-1000	18	86	93	36	48	35	16	21	1	1	7	
1001-1100	110	214	245	122	88	59	36	52	4	2	8	6
1101-1200	110	316	385	214	116	114	20	38	13	4	5	5
1201-1300	14	121	187	78	64	53	6	1	8	2		1
1301-1400	2	17	45	35	38	33			3	4		
1401-1500		7	24	11	9	1				1		
> 1501	1		1		1							

Year 1993

Depth (m)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
801-900	1		10	16				2	4	1		
901-1000	10	17	13	39	1	3		9	8	1	1	1
1001-1100	9	20	81	72	3	5		6	7	6		9
1101-1200	3	21	72	54	16	22		3	3	14	1	7
1201-1300		3	21	4	15	18		1		15		
1301-1400			3	5	16	6						
1401-1500					3					1		
> 1501										1		

Year 1994

Depth (m)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
801-900	4	3	1	2	1	1		3	2	4	1	
901-1000	15	20	30	32	14	6	7	9	11	7	7	2
1001-1100	22	72	64	75	61	31	8	13	14	14	11	
1101-1200	21	86	127	50	38	44	9	4	8	16	8	
1201-1300	6	20	47	14	38	27	6	1	4	21	1	
1301-1400	2	2	14	8	10	3				4		
1401-1500	1			1	1					4	1	
> 1501												

Division 3M

Year 1991

Depth (m)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
801-900									1	2		
901-1000										9		
1001-1100									1	3	1	
1101-1200										2		
1201-1300										1		
1301-1400												
1401-1500												
> 1501												

Year 1992

Depth (m)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
801-900			1				2	64	52	13	2	
901-1000			1				4	70	32	20	2	
1001-1100							1	39	28	27	4	
1101-1200			1				1	12	16	8	3	
1201-1300							1	5	1			
1301-1400										2		
1401-1500										2		
> 1501										1	1	

Year 1993

Depth (m)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
801-900			3	5	4	4	46	126	53	57	30	2
901-1000			9	4	25	7	39	32	26	28	45	3
1001-1100			10	7	22	2	31	47	25	19	29	5
1101-1200			1	12	27	1	17	41	9	17	24	10
1201-1300						1	9	63	3	7	13	16
1301-1400							6	31	5	1	4	13
1401-1500							1	4			2	1
> 1501								5				1

Year 1994

Depth (m)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
801-900		8	43	65	34	68	13	31	70	55	17	
901-1000	1	8	44	30	28	41	12	33	20	19	8	
1001-1100		3	39	38	35	23	21	20	3	9	11	
1101-1200		3	19	34	49	15	19	5	3	5	11	
1201-1300		2	11	30	55	13	9	3	1	8	4	
1301-1400			5	1	32	2	1			3	2	
1401-1500			2	1	5	2						
> 1501				1	1					6		

Division 3NO

TABLE 3. Hauls sampled in the small vessels: 1992–94. Number by stratum, month, year and Divisions.

Division 3L

Year 1992

Depth (m)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
801-900							15	25	67	22	5	72
901-1000							48	25	39	10		17
1001-1100							31	30	8	10	1	4
1101-1200							6	30	23	16	1	1
1201-1300								3	1	2	3	4
1301-1400												
1401-1500												
> 1501												

Year 1993

Depth (m)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
801-900	56	109	135	55	101	47	22	34	17			39
901-1000	39	126	121	84	113	53	46	60	54	14		29
1001-1100	19	87	123	81	105	92	55	73	60	33		17
1101-1200	13	25	29	64	87	44	13	9	38	7	1	3
1201-1300		2	6	41	67	13	10	2	9	5		1
1301-1400												
1401-1500												
> 1501												

Year 1994

Depth (m)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
801-900	14		11	6		3		14	1			4
901-1000	14	1		2		2	5	2	14			1
1001-1100	5	2	3	3	2	4		1	14			2
1101-1200		2	2	1	1	5	2	2	2			2
1201-1300		3			4	18		1				1
1301-1400												
1401-1500												
> 1501						1						

Division 3M

Year 1992

Depth (m)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
801-900								5	1	3	2	2
901-1000								7	1	9	4	20
1001-1100								15	11	1	4	2	4
1101-1200								13	22	8	7	4	
1201-1300										1			
1301-1400													
1401-1500													
> 1501													

Year 1993

Depth (m)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
801-900	4	8	24	26	10		2		1		1	11
901-1000	15	38	54	38	13	10	6	1				7
1001-1100	9	49	78	68	20	18	6	3			1	3
1101-1200	4	25	44	47	15	16	11					3
1201-1300	1	2	1				1					
1301-1400											1	
1401-1500												
> 1501												

Year 1994

Depth (m)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
801-900	3		1					1				
901-1000	12		3	3		1			2		1	
1001-1100	14	2	6	4		5	1		2		2	
1101-1200	3	2	3			1			2			
1201-1300					3	1					3	
1301-1400					1							
1401-1500												
> 1501												

Division 3NO

Year 1992

Depth (m)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
801-900								28	70	87	152	2
901-1000								7	118	101	82	5
1001-1100								9	61	90	94	4
1101-1200									28	68	39	
1201-1300									5	9	5	
1301-1400												
1401-1500												
> 1501												

Year 1993

Depth (m)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
801-900			16	74	29	91	99	46	43	53	46	3
901-1000			38	131	100	51	113	61	46	69	47	2
1001-1100		2	20	62	79	53	70	82	47	99	61	13
1101-1200			9	30	29	30	49	57	46	93	91	36
1201-1300				10	3	6	11	24	24	70	152	42
1301-1400				1		1		2	6	16	29	16
1401-1500				1						5	1	1
> 1501									1	1	3	1

Year 1994

Depth (m)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
801-900		7	27	17	13	12		15	26	57	7	23
901-1000		32	37	35	38	27		16	39	25	19	27
1001-1100		39	13	51	35	13	2	16	20	22	38	10
1101-1200		21	38	30	33	8		9	22	19	50	8
1201-1300		12	32	30	33	4		15	8	23	41	13
1301-1400		5	16	20	20	1		19	1	2	27	8
1401-1500		3	1	1	10	7					9	2
> 1501			1	1	3				1	2	1	3

Division 3NO

TABLE 4. Main by-catch fish species caught in Spanish deep sea Greenland halibut fishery in NAFO Regulatory Area, 1991–94.

Families	Scientific name	Common name
Anarhichididae	*Anarhichas* sp.	Wolffish
Chimaeridae	*Chimaera* sp.	Chimera
Escorpenidae	*Sebastes* sp.	Redfish
Gadidae	*Gaiodropsarus ensis* *Urophycis* sp.	Rockling White hake
Macrouridae	*Coryphaenoides rupestris* *Macrourus berglax* *Nezumia bairdi*	Roundnose grenadier Roughhead grenadier Common grenadier
Moridae	*Antimora rostrata*	Blue antimora
Notacanthidae	*Notacanthus nasus*	Spiny eel
Pleuronectidae	*Glyptocephalus cynoglossus* *Hippoglossoides platessoides* *Hippoglossus hippoglossus*	Witch flounder American plaice Atlantic halibut
Rajidae	*Raja* sp.	Skate
Squalidae	*Centroscyllium fabricii* *Somniosus microcephalus*	Black dogfish Boreal shark
Zoarcidae	*Lycodes* sp.	Eelpout

periodically calculated for each of the species in their different types of processing. For this purpose, 20 different sized individuals were separated out and were weighed prior to and following processing. The conversion factor was then calculated as the quotient of both weight values. With the conversion factor values, catches-per-haul were estimated based on the weight of each species retained and processed. Table 5 shows the estimated average values and their standard deviation in each type of processing (dressing).

When the catch of accompanying species was not large, the total catch of each species was weighed before being discarded or used. Weight estimate of the hauls of the relatively abundant yet unused accompanying species was less precise. The estimation procedure was as follows: the time taken to fill, from the discard conveyor belt, one or more boxes of known average weight, then in order to obtain the total discarded weight, this was multiplied by the total operational time of the belt. Additionally, the proportion of the discarded species in each box was obtained, based on a sample, generally 3 or 4 boxes weighing 40 kg each, and then the total weight of discards was shared out between them. In this manner, an estimate of the weight caught of each species not used in each haul was obtained. The weights of each species were used to calculate yield (kg/hr) which is the index used.

Length distribution in the discarded proportion of four species was analyzed: two grenadiers, skate and blue antimora (Table 6). In this sampling pre-anal fin length to nearest 0.5 cm for grenadiers and total length to nearest cm in other species was taken. Table 6 shows the number of samples and individuals sampled in each fleet by species, Division and year in the period considered.

A depth strata analysis was performed, establishing 8 strata of 100 m in a range between 801 m and greater than 1 500 m (Table 7). The presence or absence of each species caught in each stratum per month, Division, each year and each fleet were considered.

In the seasonality study, those species with a monthly yield no greater than 5 kg/hr were not considered. Sampling data for cod were not available, and this species was not included in the analysis.

TABLE 5. Average values of the conversion factors estimated on board for the various types of dressing. n = number of observations. (Codes of Dressing Types: A. Head off, gutted, tail off, unskinned; B. Head off, gutted, tail off, skinned; C. Head off, gutted, with tail, unskinned; D. Fillet by hand, skinned; E. Fish sausage; F. Wings, skinned.)

	Dressing types					
Species	A	B	C	D	E	F
Roughhead grenadier					3.7 ± 0.52 n = 34	
Roundnose grenadier					3.14 ± 0.15 n = 7	
Skate						3.59 ± 0.42 n = 24
American plaice	1.4 ± 0.07 n = 36	1.53 ± 0.08 n = 22				
Redfish			1.96 ± 0.10 n = 24			
Witch flounder	1.39 ± 1.10 n = 24	1.43 ± 0.15 n = 19	1.31 ± 0.04 n = 6			
Blue antimora					2.98 ± 0.54 n = 9	
White hake	1.66 ± 0.04 n = 4		1.39 ± 0.05 n = 3			
Wolffish	1.61 ± 0.13 n = 6			3.43 ± 0.38 n = 6		
Rockling	1.55 ± 0.11 n = 5					

Results and Discussion

Annual yield of the by-catch species in the study period showed a wide range of variation (Fig. 1). Two groups of species were distinguished, according to their annual yield using the criterion that the most abundant were with a yield value above 5 kg/hr, and the least abundant species were with a yield below 5 kg/hr.

Roundnose grenadier, roughhead grenadier and skate were the most important by-catch species in both fleets during the study periods . A marked increase of skate was apparent in 1993 and 1994 of the small vessel fleet, while in the large vessel fleet the importance increased progressively from 1991 to 1994. American plaice also showed increase in yield in the two fleets, particularly in 1994.

Comparing the yields for the two fleets, some differences appeared in the yield values of the species in the catch composition. Although there was a general similarity in the level of importance of the by-catch species in the two fleets, roundnose grenadier and redfish were more important in the large vessels. Roundnose grenadier was the most important species in the large vessels but its presence decreased through the study period with lowest values in the last two years. Probably, the greater yield of roundnose grenadier for year 1991 and partially 1992, would be due to identification problems. Both roundnose grenadier and witch flounder yields were higher in the small vessels in comparison to the large vessels.

Pattern by month and stratum

The effort pattern was different in both fleets (Tables 2 and 3). In the small vessels, the depth range was minor, in Div. 3L and 3M, with hauls mainly ranging up to 1 300 m. The effort was more intensive and deeper in Div. 3NO, with few hauls carried out at depths ranging to >1 500 m particularly in 1993 and 1994.

Table 7 shows the occurrence range of each species, by month and Division throughout the study period for both fleets. Sixteen species appeared

TABLE 6. Number length distribution samples and individuals sampled for discards by species, year and Division. (I = individuals, S = samples.)

		Large Vessels					Small vessels			
		1991	1992	1993	1994	Total	1992	1993	1994	Total
Roughhead grenadier										
Div. 3L	I	147	85 101	2 380	7 751	95 379	3 027	9 257	682	12 966
	S	1	498	18	47	564	30	67	4	101
Div. 3M	I	296	21 094	975	6 898	29 263	1 038	3 674	181	4 893
	S	2	142	6	46	196	44	76	17	137
Div. 3NO	I		1 509	985	6 744	9 238	5 038	8 548	2 575	16 161
	S		8	10	40	58	44	76	17	137
Total	I	443	107 704	4 340	21 393	133 880	9 103	21 479	3 438	34 020
	S	3	648	34	133	818	84	164	22	270
Roundnose grenadier										
Div. 3L	I	440	54 159	6 224	224	61047	2 244	15 705	843	18 792
	S	3	311	41	2	357	14	84	4	102
Div. 3M	I		97 534	4 229	5 158	106 21	1 304	4 933	117	6 354
	S		555	24	32	611	8	26	1	35
Div. 3NO	I			4 636	1 863	6 499	2 894	7 912	7 677	18 483
	S			51	16	67	23	55	41	119
Total	I	440	151 693	15 089	7 245	174467	6 442	28 550	8 637	43 629
	S	3	866	116	50	1 035	45	165	46	256
Skate										
Div. 3L	I				233	233		1 059		1 059
	S				5	5		10		10
Div. 3M	I							339		339
	S							5		5
Div. 3NO	I				3 040	3 040		2 776		2 776
	S				21	21		19		19
Total	I				3 273	3 273		4 174		4 174
	S				26	26		34		34
Blue antimora										
Div. 3L	I		5882	1 245	643	7 770		976	169	1 145
	S		48	18	7	73		7	1	8
Div. 3M	I		3 401	1 716	1 888	7 005		693	87	780
	S		23	12	14	49		5	1	6
Div. 3NO	I		748	1 943	3 127	5 818	512	2 886		3 398
	S		5	50	21	76	9	28		37
Total	I		10 031	4 904	5 658	20 593	512	4 555	256	5 323
	S		76	80	42	198	9	40	2	51

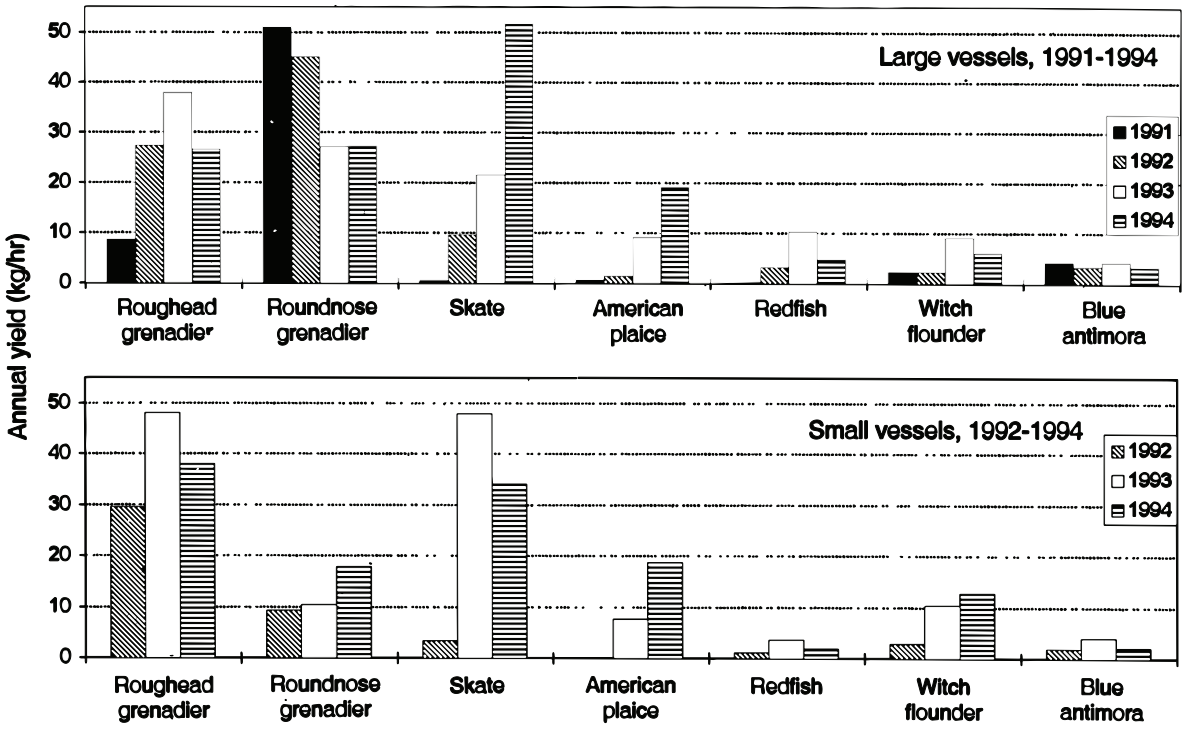

Fig. 1. Annual yield (kg/h) for main by-catch species in the large vessels, 1991–94, and small vessels, 1992–94.

TABLE 7. Depth range (m) of the main by–catch species by fleet and Division. The range 800 m to greater than 1 500 m is denoted by +.

	Large Vessels (1991–94)			Small Vessels (1992–94)		
Species	3L	3M	3NO	3L	3M	3NO
Roughhead grenadier	+	+	+	+	800–1 400	+
Roundnose grenadier	+	+	+	+	800–1 400	+
Common grenadier	+	+	+	+	800–1 400	+
Skate	+	+	+	+	+	+
American plaice	+	+	+	800–1 300	800–1 300	+
Redfish	+	+	+	800–1 300	800–1 300	+
Witch flounder	+	+	+	800–1 300	800–1 300	+
Blue antimora	+	+	+	+	+	+
White hake	+	+	+	+	800–1 300	+
Wolffish	+	+	+	+	800–1 300	+
Eelpout	+	+	+	800–1 300	800–1 300	+
Boreal shark	+	+	+	+	+	+
Black dogfish	+	+	+	800–1 300	800–1 400	+
Atlantic halibut	800–1 300	800–1 300	+	800–1 200	800–1 300	+
Chimaera	+	+	+	800–1 200	800–1 200	+
Rockling	+	+	+	800–1 300	800–1 300	+
Spiny eel	+	+	+	+	800–1 200	+

distributed from 800 to over 1 500 m depths. Only Atlantic halibut showed a shallower depth range in its bathymetric distribution in the large vessel hauls in Div. 3L and 3M. Generally, almost all the species were caught within a very wide range, reaching great depths (1 500 m). The species which are typical of the demersal fisheries (e.g. American plaice, wolffish, skate) appeared outside the limits considered as typical in each study (Scott and Scott, 1988; UNESCO, 1984; Pitt,1970; Templeman,

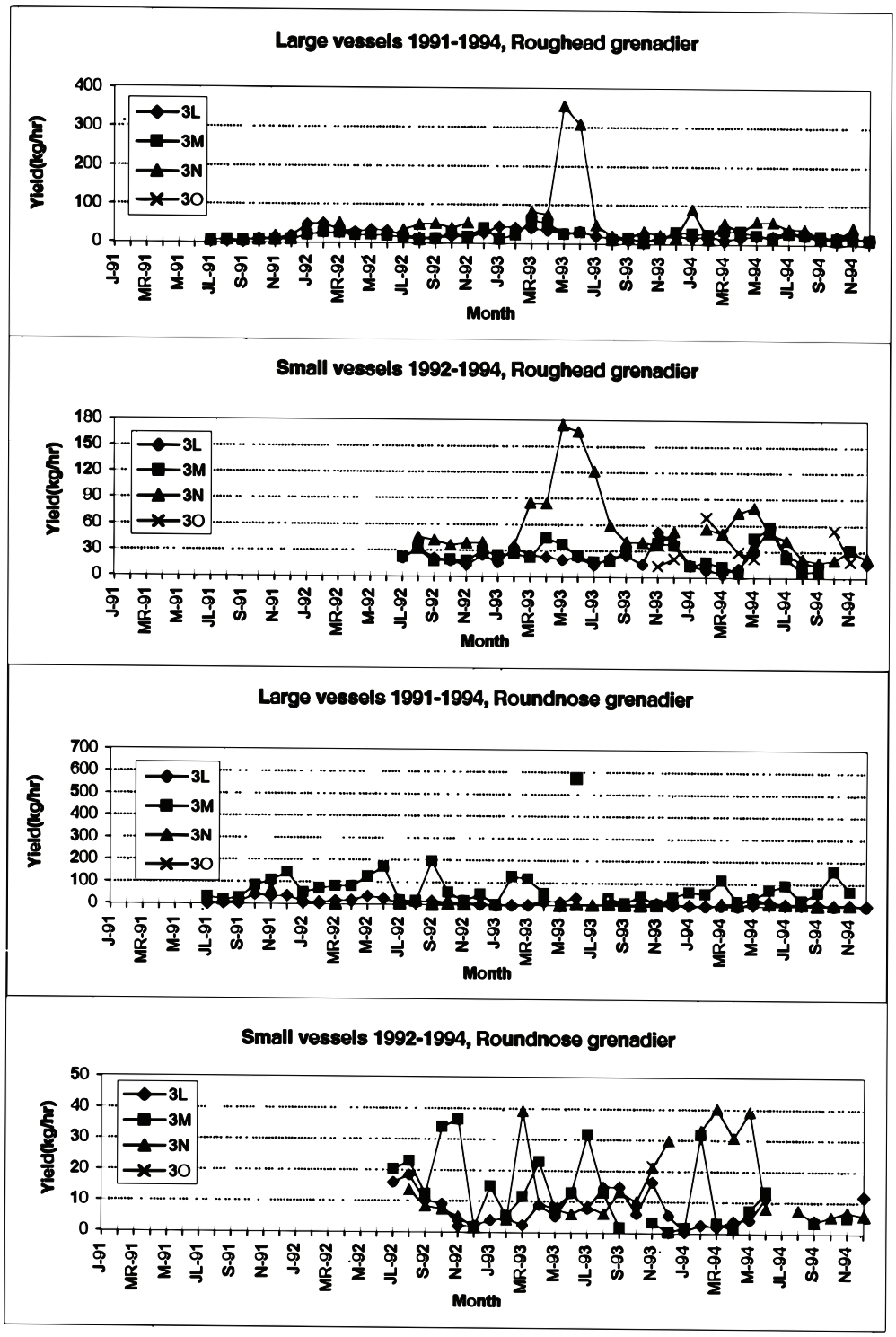

Fig. 2. Roughhead grenadier and roundnose grenadier yield (kg/h) by month and Division.

1986a and 1986b, Walsh, 1994). No clear differences were seen between the occurrence range of the species considered to be typical of deep-water and those typically demersal species. However, some species such as white hake and eelpout appeared on more occasions in the northern areas in Div. 3L and 3M. Others such as black dogfish, chimaera and witch flounder were more abundant in the south (Div. 3NO). Since the present study considered only the occurrence of by-catch

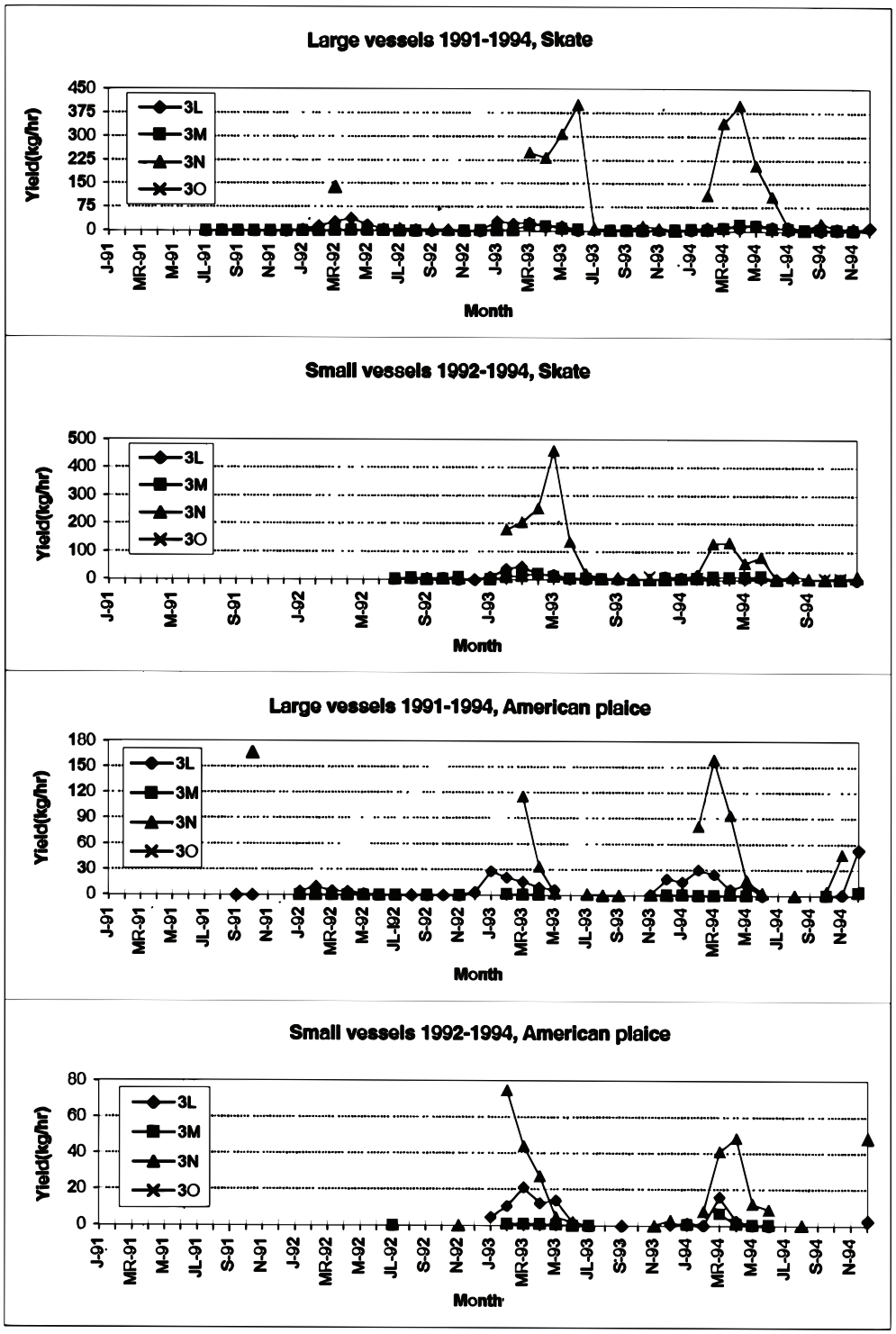

Fig. 3. Skate and American plaice yield (kg/h) by month and Division.

species in the haul, no on-going seasonal behaviour was detected in the hauls over the period of the study.

Yield variations in the period

The monthly yield of by-catch are shown by Division in Fig. 2 to 8 through the study period for

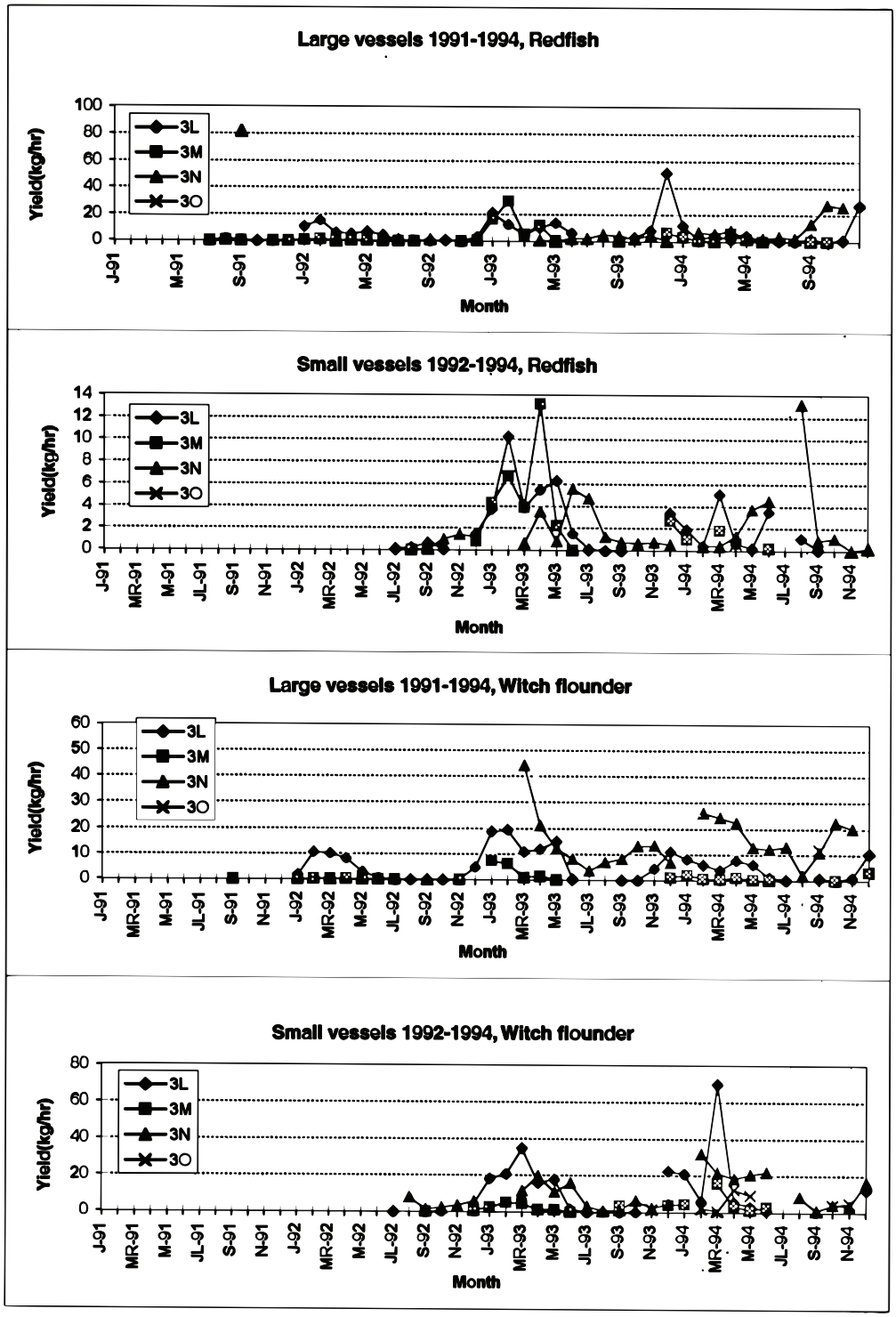

Fig. 4. Redfish and witch flounder yield (kg/h) by month and Division.

the main species considered in the two types of vessels. This made it possible to observe the possible seasonal fluctuations of availability and distribution of each species in each Division.

Roughhead grenadier showed maximum yield in May–June, 1993, in both fleets, and in Div. 3N. In the small vessels, a maximum also appeared in the same months in 1994. Roundnose grenadier

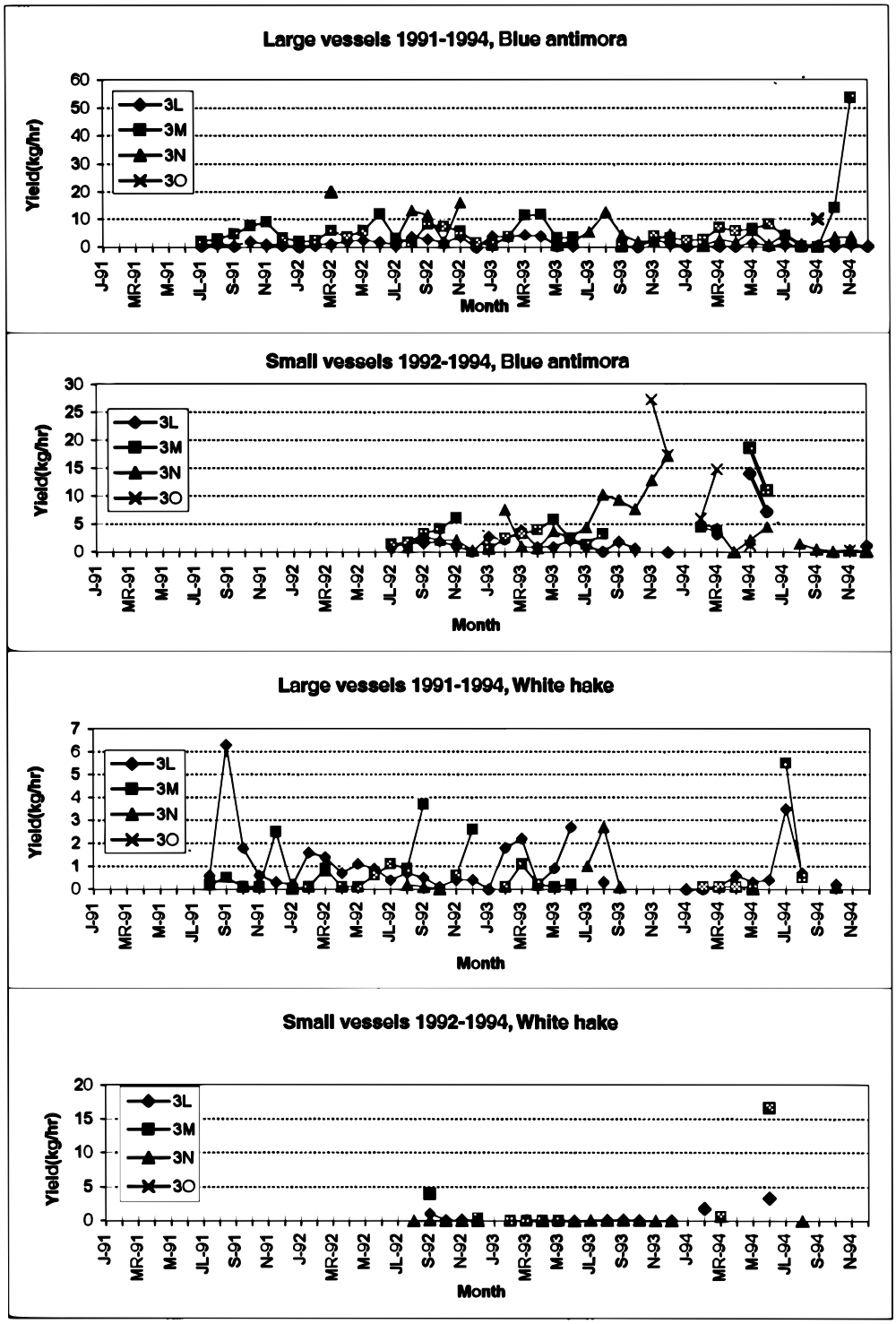

Fig. 5. Blue antimora and white hake yield (kg/h) by month and Division.

reached a maximum in the same season, but in Div. 3M in the large vessels it attained a high yield (Fig. 2). Skate had its maximum at the end of spring (April–June), while American plaice had its

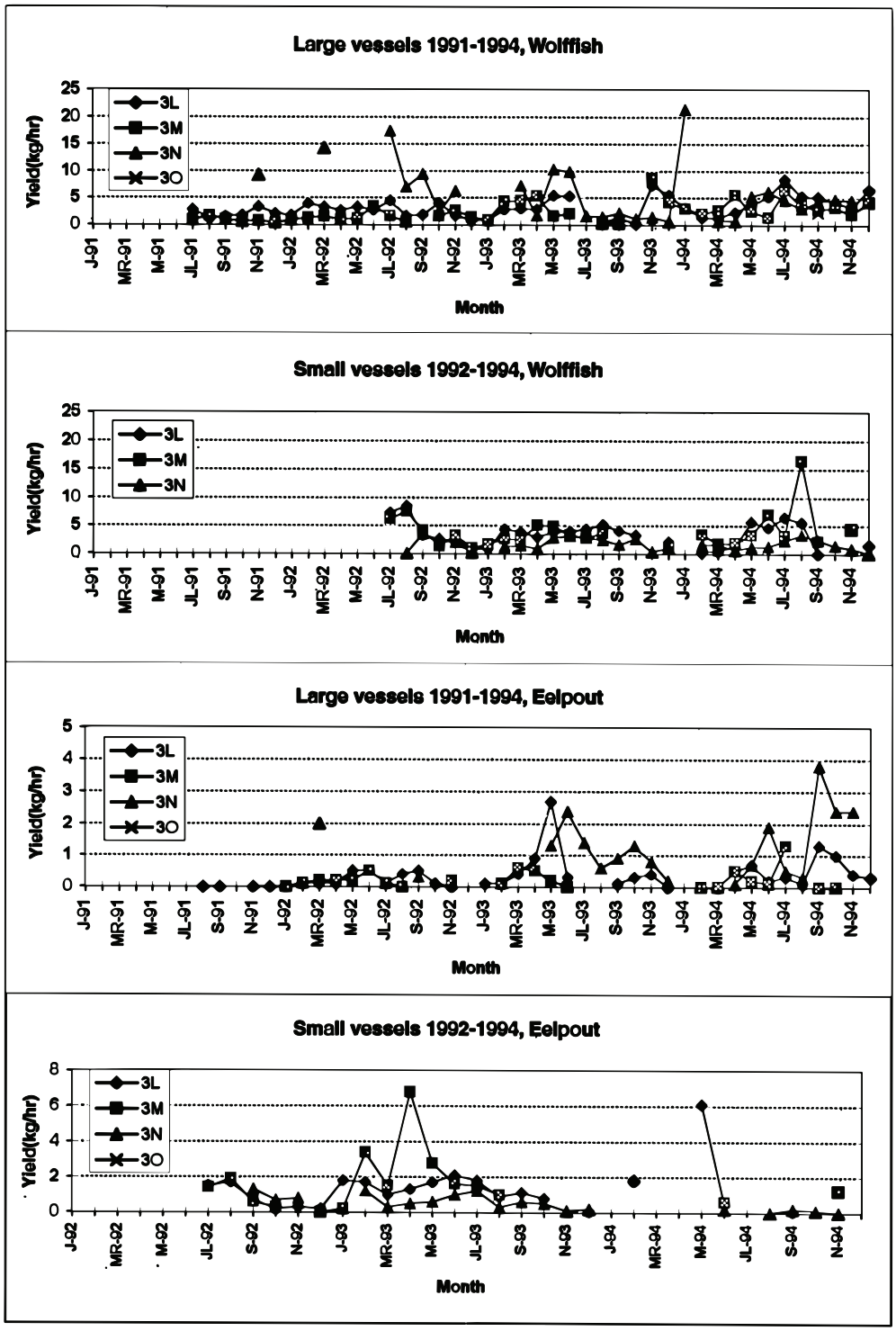

Fig. 6. Wolffish and eelpout yield (kg/h) by month and Division.

maximum in March. Both species reached their maximum yields in 1993 and 1994 in Div. 3N (Fig. 3). In these four species, the large vessels obtained absolute maximum yields.

The maximum yield for redfish occurred in winter in Div. 3L and 3M in the large vessels, while the witch flounder reached maximum yields in spring in both fleets (Fig. 4). Blue antimora had two

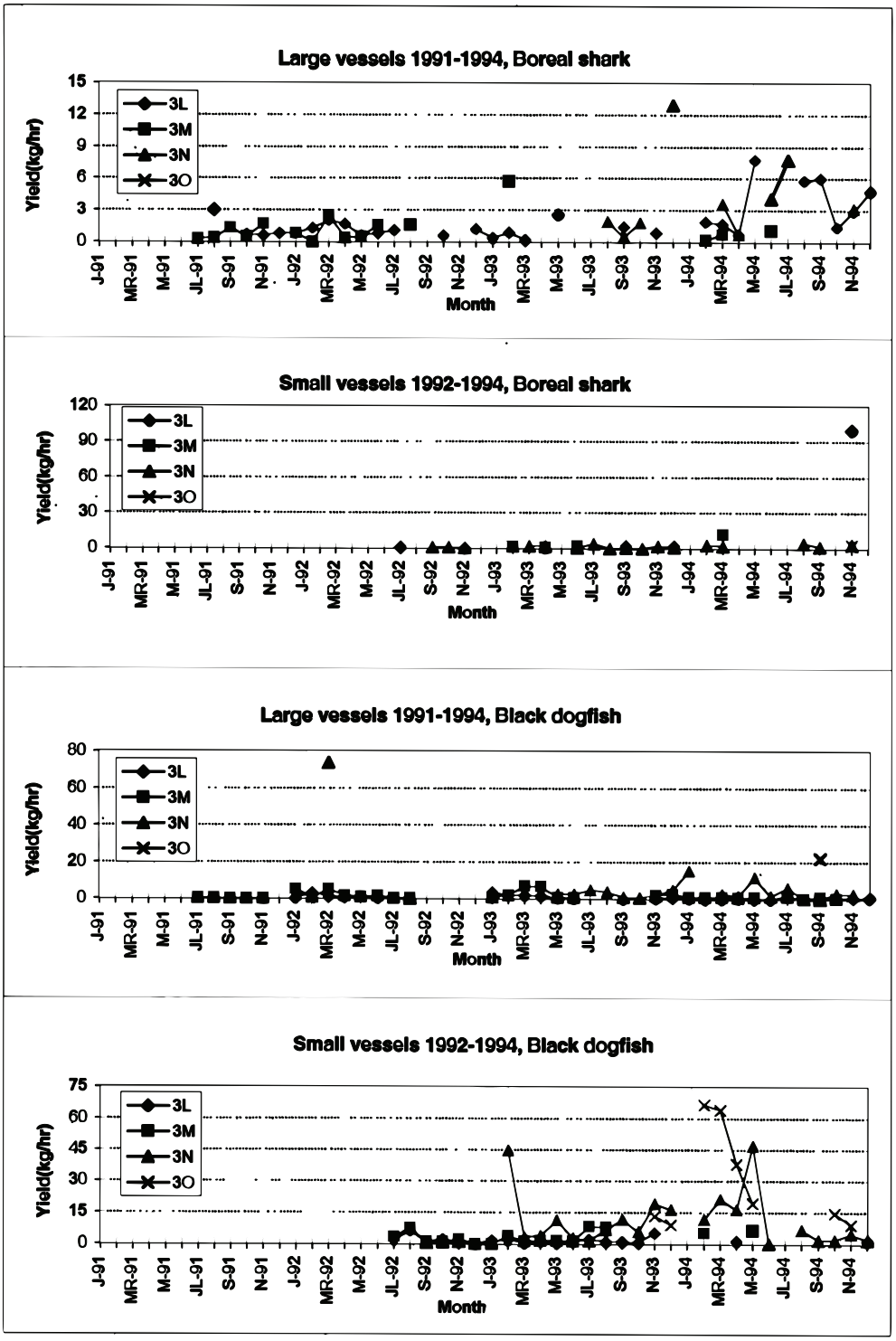

Fig. 7. Boreal shark and black dogfish yield (kg/h) by month and Division.

peaks, one in the large vessels in Div. 3M in 1994 and the other in the small vessels in Div. 3O in 1993, both in November. The maximum for white hake occurred in September in Div. 3L, in the large vessels (Fig. 5). Wolffish on the other hand was caught more in autumn in Div. 3N in large vessels (Fig. 6), while in the small vessels the maximum corresponded to Div. 3M. The eel pout maximum yield occurred in spring for the large vessels in Div. 3L and 3N and for the small vessels in Div. 3L and 3M (Fig. 6). The other main by-catch species was shark. Sharks were more abundant in the catches of the small vessels (Fig. 7) and the maximum yield occurred in Div. 3NO for the two shark species encountered.

Atlantic halibut yield was very small. The maximum was 8 kg/hr in Div. 3N in 1994 (Fig. 8).

Discards

Discards (kg/hr) by fleet, Division and year were estimated for the seven principal by-catch species (Fig. 9). In general, discards increased in two fleets in 1993 and decreased in 1994. Large vessels showed more interannual variability in discards. Roundnose grenadier and roughhead grenadier were the most important species discarded.

Figure 10 shows the retained proportion relative to the total catch for the seven principal by-catch species. The roundnose and roughhead grenadiers, the redfish and the blue antimora, were proportionally the most retained species in the large vessels. Roundnose grenadier was discarded more than roughhead grenadier in the two fleets during the sampling period. The proportion of American plaice and witch flounder retained was greater in the small vessels.

Length distribution

American plaice length distribution in this fishery has been studied in a previous paper (Iglesias *et al.*, 1996). The present paper presents the length distributions for four of the other principal by-catch species: roughhead grenadier, roundnose grenadier, skate and blue antimora.

The roughhead grenadier in the small vessels showed a tendency for the greater length distributions to be discarded (Fig. 11 and 12). The smaller lengths of the roundnose grenadier retained in the small vessels in 1994 indicated a better use of this species in this fleet. In Div. 3M, the lengths of two discarded grenadier species was larger than in the other Divisions. The skate discarded in the small vessels had a wide length distribution range although there was a greater proportion of larger individuals. The blue antimora length distribution on the other hand showed a higher proportion of shorter individuals in the large vessels but not in the small vessels.

Conclusions

At depths of between 800 and 1 500 m, the by-catch in the Spanish Greenland halibut fishery was basically comprised of the deep living species, roundnose and roughhead grenadiers and skate. Only 7 species were found to be of yields over 5 kg/hr annually: roughhead grenadier, roundnose grenadier, skate, American plaice, redfish, witch flounder and blue antimora.

American plaice was the only demersal species which showed a relationship to the characteristics of the platform. This by-catch species increased its yield significantly in both fleets in 1994 which may indicate a change in the distribution of this species. Redfish also increased in its yield, particularly in the small vessels. Witch flounder and the black dogfish shark yields have risen to 5 kg/hr in recent years only in small vessels, although the development of catch throughout this period was highly variable.

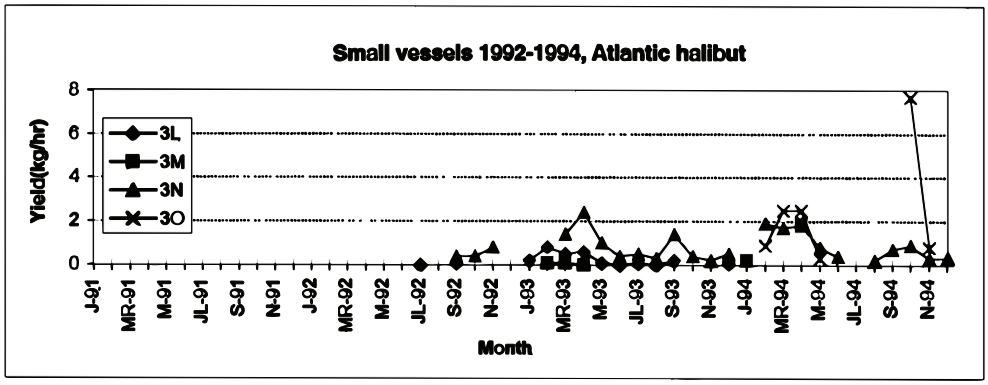

Fig. 8. Atlantic halibut yield (kg/h) by month and Division.

The differences in catch composition of the hauls from both fleets may, at least partially, be explained by the difference in effort made by each of these in each Division. It appears that the small vessels intensified their fishing activity in the deep strata of the more southern area (Div. 3NO) in the year 1994.

This study showed there was a degree of seasonality in the various by-catch. In general, the

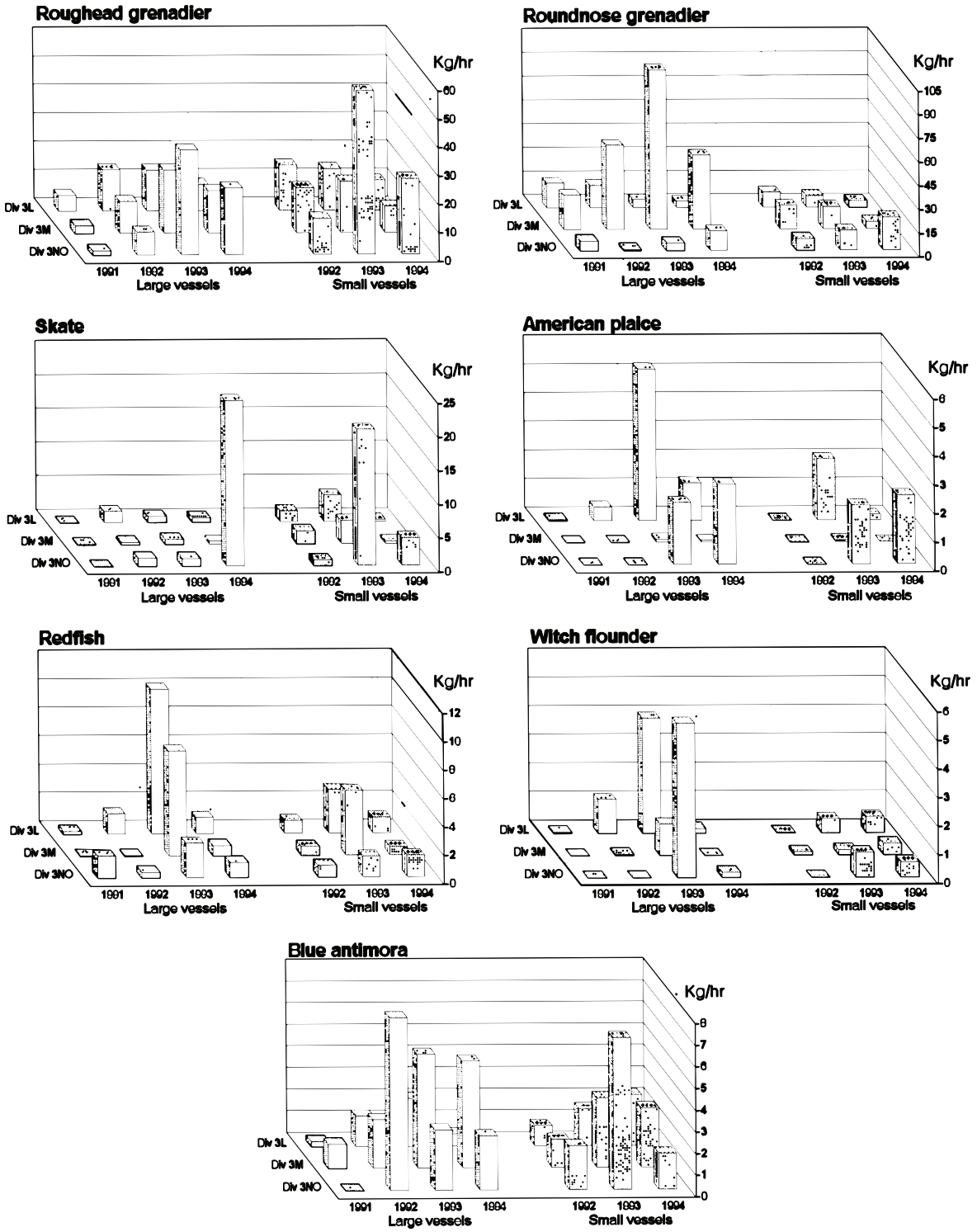

Fig. 9. Discard (kg/h) for main by-catch species, by year and Division.

yield of the more important species increased in spring, particularly in Div. 3NO, except in the case of grenadiers which were more abundant in autumn.

The relative importance of the by-catch in the fishery was also observed. Roundnose grenadier showed a higher discard rate than roughhead

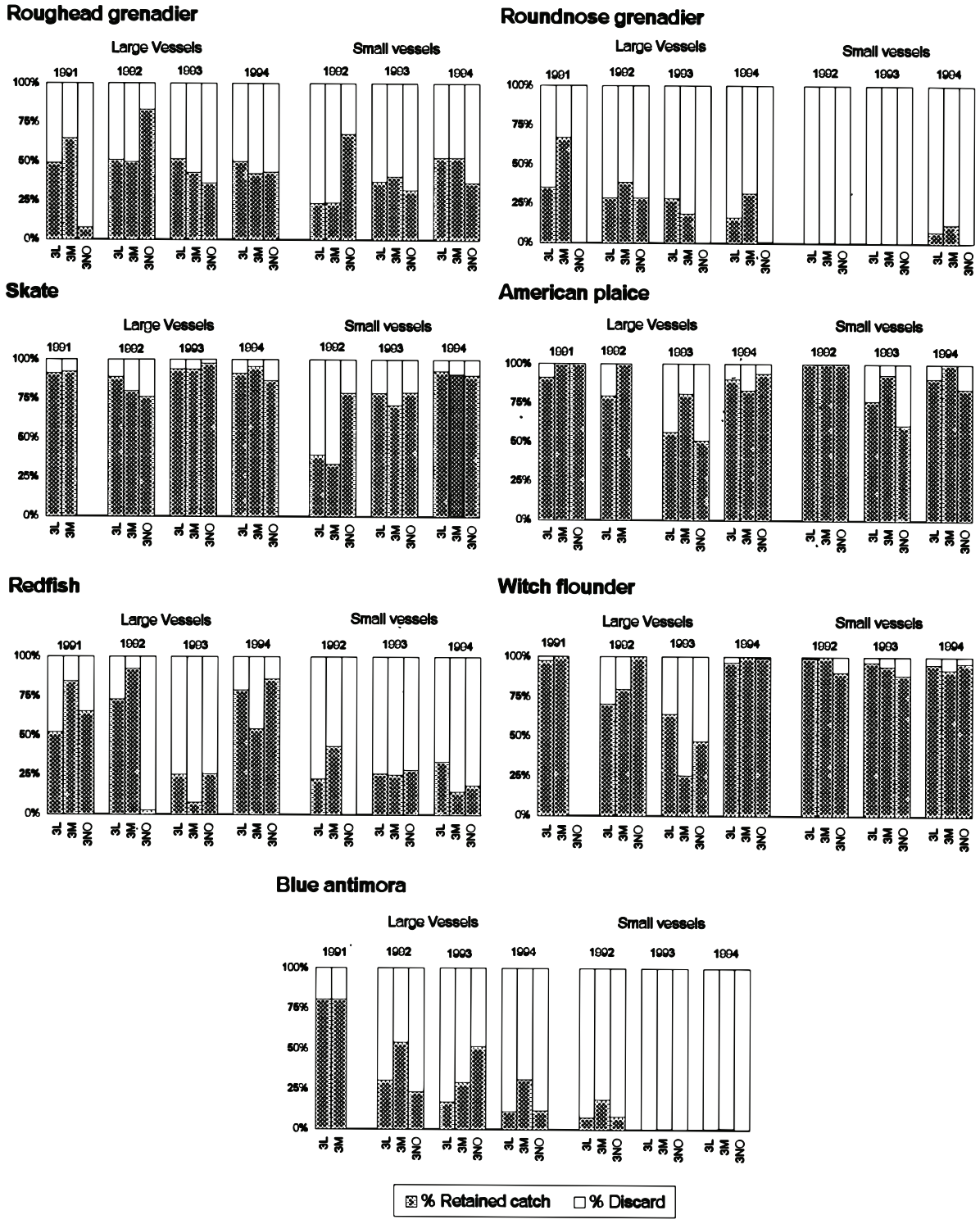

Fig. 10. Retained catch and discard ratio (%) for main by-catch species, by year and Division.

grenadier. Roughhead and roundnose grenadiers, redfish and blue antimora were processed in greater proportion in large vessels, and American plaice and witch flounder in the small vessels.

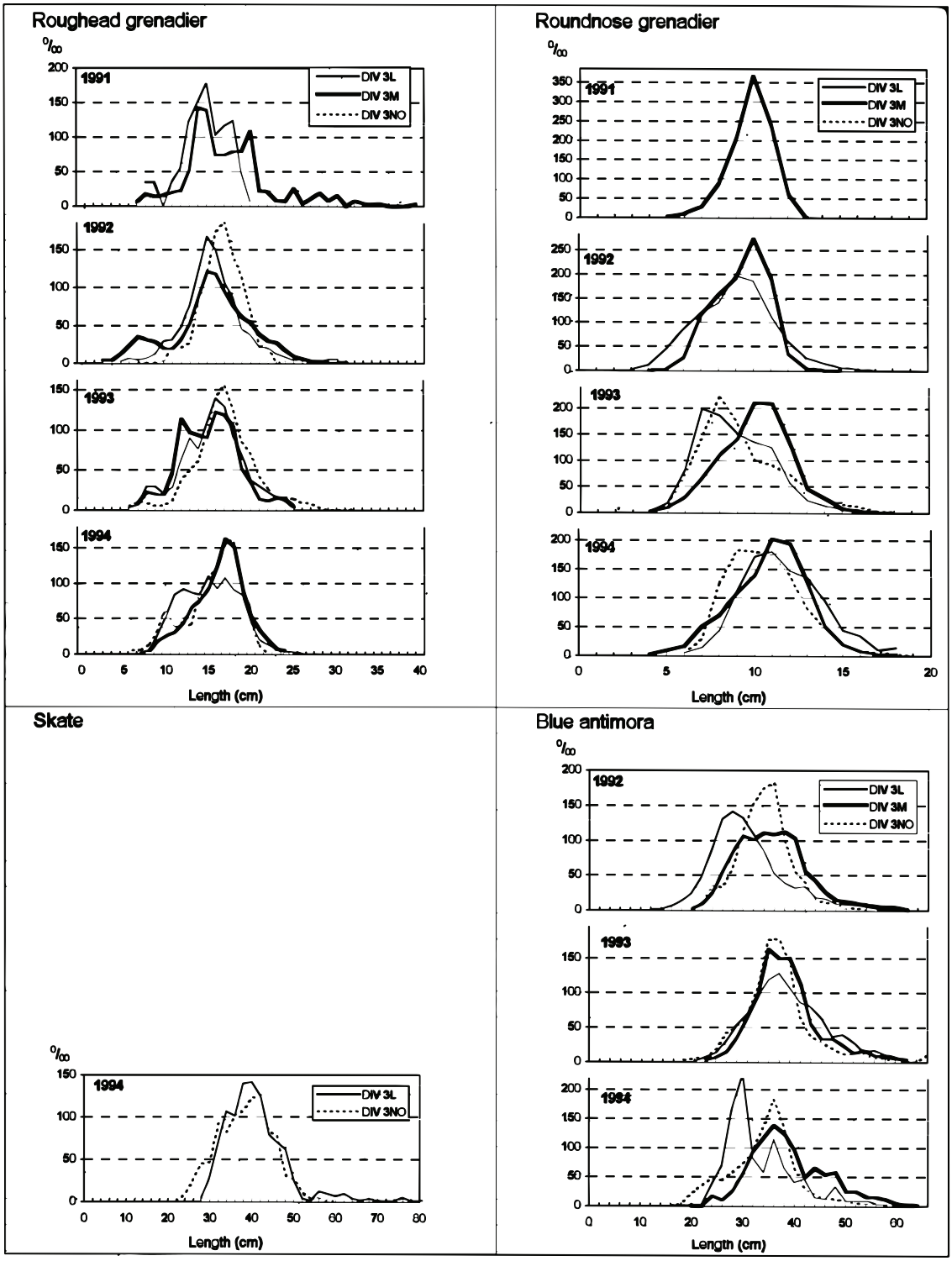

Fig. 11. Length distribution of the species discarded: roughhead and roundnose grenadier (anal-fin length), skate and blue antimora (total length). Large vessels, 1991–94.

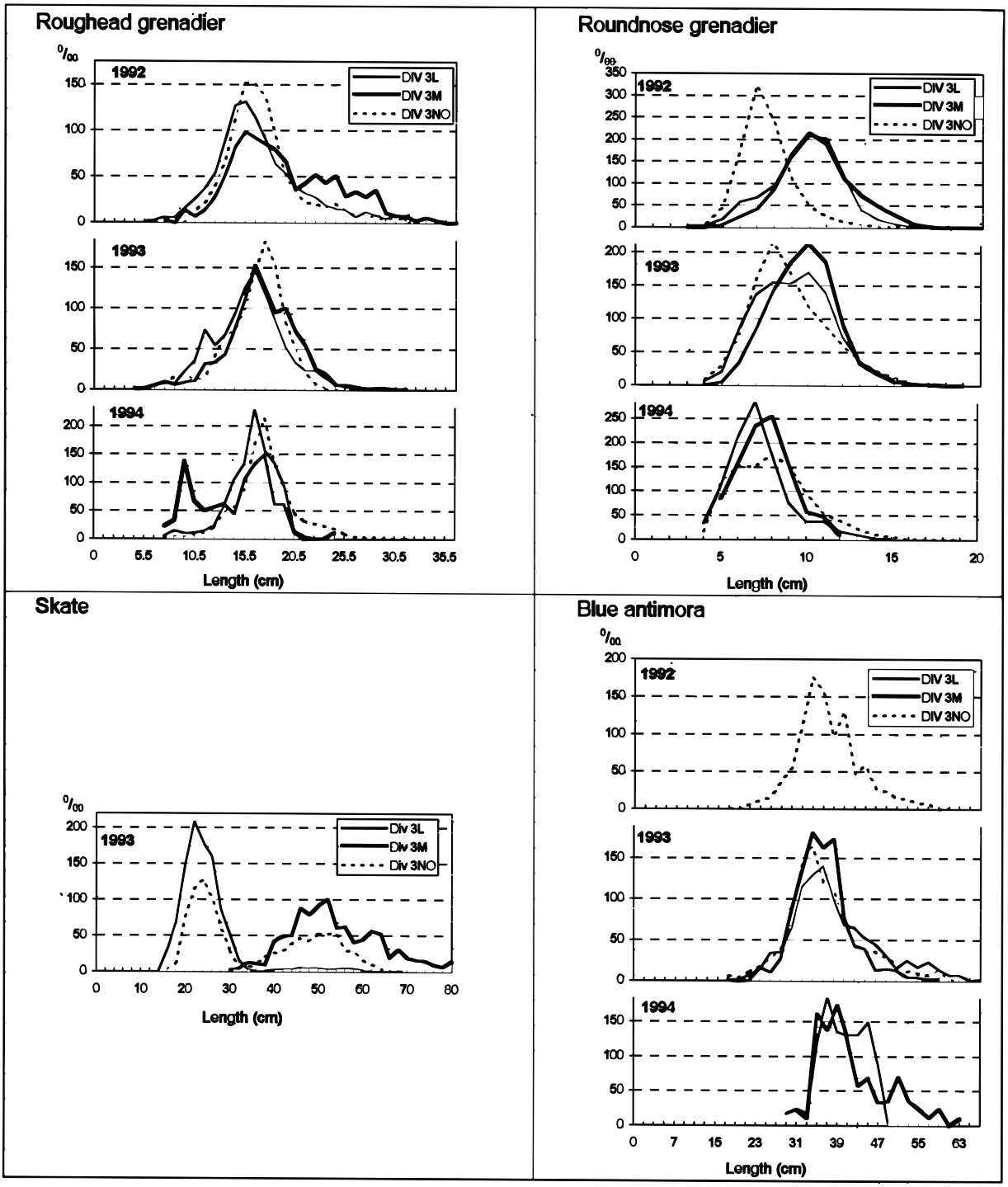

Fig. 12. Length distribution of the species discarded: roughhead and roundnose grenadier (anal-fin length), skate and blue antimora (total length). Small vessels, 1992–94.

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