Witch Flounder (*Gyptocephalus cynoglossus*) in the Spanish Deep-sea Fishery (NAFO Divisions 3LMNO), 1991–94

P. Durán and X. Paz

Instituto Español de Oceanografía, Centro Oceanográfico de Vigo
P. O. Box. 1552, Vigo, Spain

Abstract

The by-catch of witch flounder (*Glyptocephalus cynoglossus*) was studied in the Spanish deep-sea fishery for Greenland halibut, which developed in the NAFO Regulatory Area in Div. 3LMNO over the period 1991–94. A total of 32 483 hauls were sampled. Some data from the Div. 3NO Spanish bottom trawl survey in 1995 and 1996 were also included in this study. Witch flounder yield was estimated for this period. The yield showed an annual seasonality where yield was greater in spring. Through the period 1992–96, the overall annual yield showed a general increase.

The length frequency and the length/weight relationship were obtained from samplings performed at depths ranging from 800 m to 1500 m. The length range of the individuals was 26–60 cm in males and 22–72 cm in females. The mean length decreased throughout the period analyzed, and was higher in the large vessel catches. The individuals were also larger in Div. 3M. The sex ratio showed seasonal variation in the large vessel catches, while no clear trend appeared in the small vessels.

In addition to Greenland halibut, which was the target species, the main fish species accompanying the witch flounder catches were redfish, grenadiers, skate and American plaice as incidental catch.

Keywords: Flemish Cap, Grand Bank, length distribution, length-weight relationship, Witch flounder, yield

Introduction

Witch flounder (*Glyptocephalus cynoglossus*) populations in NAFO Div. 2J3KL and 3NO have declined in recent years (Bowering, MS 1995; Bowering, MS 1996). There is no NAFO recommendation for the management of the Div. 2J3KL stock. Very little stock information is available due to the recent moratorium on directed fishing in all NAFO Divisions. Moreover, the published data from research trawl surveys refer to limited depth range, not greater than 850 m, which does not include all distribution areas of this species (Gorchinsky *et al*., MS 1995; Paz and Casas, 1996; Durán *et al*., 1997). Bowering (1987) published a comprehensive resume of the distribution and the changes in some biological parameters after 20 years of exploitation, although this only referred to a depth range of less than 900 m.

The present study analyzes the witch flounder by-catch data derived from the Spanish direct sea sampling program established for the Spanish Greenland halibut deep-sea fishery in NAFO Div. 3LMNO for the period 1991–94. The fishery (Junquera *et al*., MS 1992), has comprised two types of vessels, the large and the small freezer trawlers. Witch flounder is a by-catch species in this fishery and is caught by both fleets all year round in varying amounts, and occasionally at depths as great as 1 500 m (Durán *et al*, 1997). This study provides information on the deeper distribution of the population, and makes it possible to estimate some biological parameters of the stock. Stock discrimination studies suggest that breeding populations are present in each of the Divisions (Fairbain, 1981; Bowering and Misra, 1982), therefore this analysis considers data for each Division separately.

Materials and Methods

In this study, sampling of the commercial catches covered the period 1991–94 and covered a depth range from 800 m to 1 500 m. In order to analyze the occurrence of witch flounder, a total of 23 413 hauls were considered in the large vessels and 9 070 in the small vessels (Durán *et al*., 1997).

The distribution by Division and year of the total sampled hauls for this period and the number of sampled hauls with witch flounder present are shown in Table 1 indicating the mean depth. The locations of the sampled hauls with witch flounder present are shown in Fig. 1. The witch flounder yield by Division and months were estimated for both fleets (Fig. 2).

TABLE 1. Mean catches (kg) of the main species in the sampled hauls with witch flounder present, by year and Division in the Spanish deep–sea Greenland halibut fishery, for the large vessel and small vessel fleets.

	1991			1992			1993			1994		
	3L	3M	3NO	3L	3M	3NO	3L	3M	3NO	3L	3M	3NO
Large Vessel												
Total sampled hauls	1 956	3 547	20	5 798	3 451	416	2 239	683	1 089	1 785	1 213	1 216
No. of sampled hauls with witch flounder present	34	–	–	1245	226	–	1 021	79	446	661	88	829
Percentage of total hauls sampled	2	–	–	21	7	–	46	12	41	37	7	68
Mean depth (m)	816	–	–	971	1076	–	1 037	980	999	951	1 017	967
Greenland halibut	1 011	–	–	1 907	1 796	–	1 856	1 647	1 036	1 437	1 384	1 308
Skate	13	–	–	228	24	–	122	17	289	63	38	874
American plaice	141	–	–	52	2	–	118	7	36	161	10	204
Roughhead grenadier	301	–	–	152	102	–	193	102	296	106	86	187
Redfish	102	–	–	99	19	–	131	224	33	68	20	66
Wolffish	1	–	–	23	22	–	21	23	14	32	20	26
Witch flounder	476	–	–	94	15	–	127	68	97	66	41	153
Roundnose grenadier	48	–	–	26	472	–	14	35	11	5	49	22
Boreal shark	–	–	–	5	9	–	4	25	3	31	–	467
Rockling	–	–	–	2	14	–	2	2	2	315	11	–
Black dogfish	–	–	–	7	20	–	10	7	7	2	5	61
Comm. grenadier	–	–	–	16	17	–	8	11	24	20	30	36
Blue antimora	–	–	–	3	31	–	16	3	11	2	2	32

|	1992			1993			1994		
	3L	3M	3NO	3L	3M	3NO	3L	3M	3NO
Small Vessels									
Total sampled hauls	520	146	907	2 530	667	2 670	177	82	1 371
No. of sampled hauls with witch flounder present	88	–	–	808	–	–	75	22	848
Percentage of total hauls sampled	17	–	–	32	–	–	42	27	62
Mean depth (m)	894	–	–	962	–	–	973	1034	955
Greenland halibut	1 334	–	–	917	–	–	1 382	1 259	1 682
Skate	12	–	–	158	–	–	56	22	439
American plaice	–	–	–	92	–	–	30	31	742
Roughhead grenadier	79	–	–	131	–	–	127	119	304
Redfish	28	–	–	43	–	–	35	13	186
Wolffish	4	–	–	25	–	–	14	10	10
Witch flounder	129	–	–	160	–	–	180	113	233
Roundnose grenadier	13	–	–	26	–	–	21	18	185
Black dogfish	2	–	–	4	–	–	2	–	153
Comm. grenadier	10	–	–	32	–	–	8	5	52
Blue antimora	2	–	–	15	–	–	19	29	8
Red hake	–	–	–	–	–	–	–	18	–
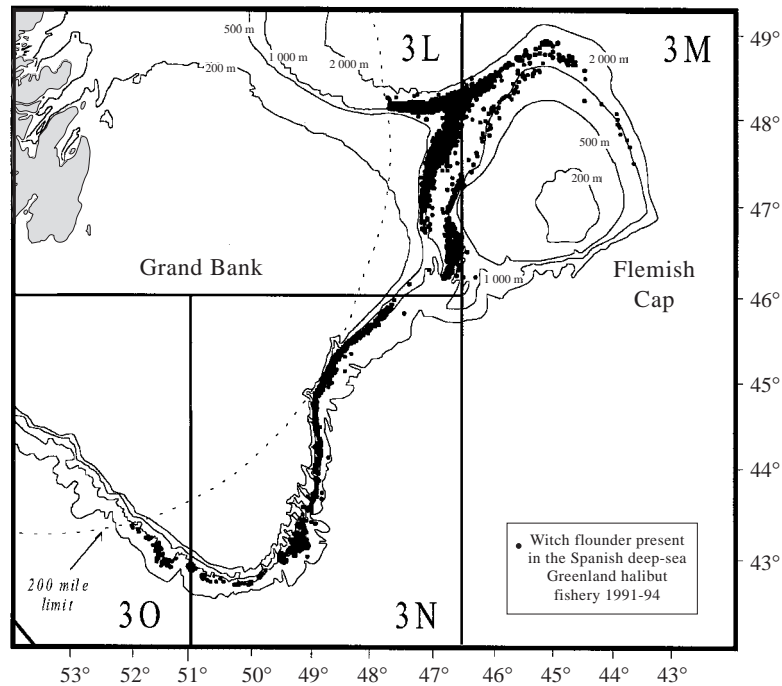
Fig. 1.   Map of NAFO Div. 3LMNO, showing the location of the sampled hauls with witch flounder present in the Spanish deep-sea Greenland halibut fishery (1991–94).
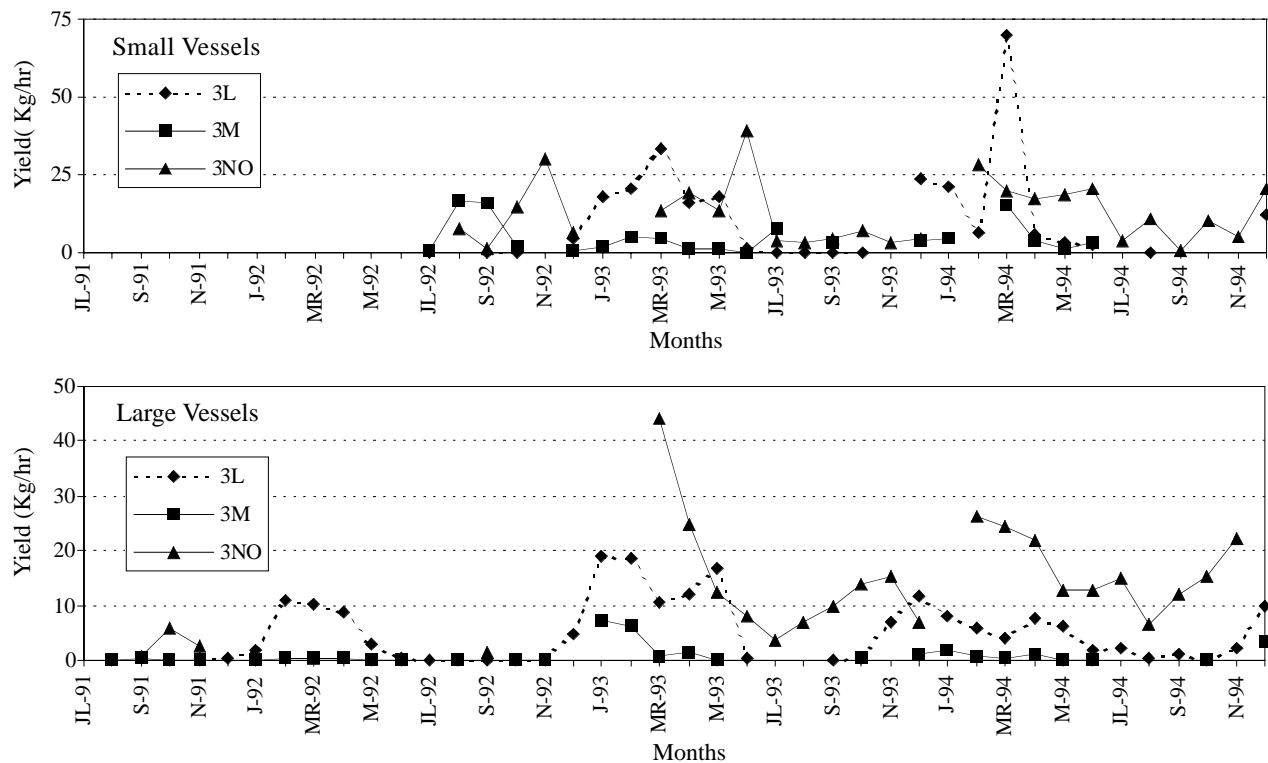

Fig. 2.   Witch flounder yield (kg/hr) by Division, year and month in the Spanish deep-sea Greenland halibut fishery, in the large vessel and small vessel fleet.

The number of length distribution samples and individuals involved by Division and year are given in Tables 2 to 4. In each length frequency sample, an average of 145 individuals was measured at random and the total length was determined by sex to the lowest centimetre. A total of 9 889 individuals were measured on board the large vessels and 17 974 individuals in the small vessels. Data from the whole studied area were used to estimate the sex ratio in the catches. Length frequency and sex ratio data from 1995 and 1996 Spanish bottom trawl survey in Div. 3NO were also included in this study. A total of 2 469 individuals were measured in this survey.

In the length-weight samples, the total round weight (g) of each fish was recorded with a precision of ± 5g. A total of 3 711 individuals were sampled. For the length-total weight relationship, a function of the form $W = a\,L^b$ was fitted to the data, where W = weight (g) and L = length (cm). These relationships have been estimated by Division and year. The number of length-weight samples and the individuals involved in each case are shown in Table 5.

Results and Discussion

In the Spanish Greenland halibut deep-sea fishery, witch flounder occurs in all the studied depth range from 800 m to 1 500 m (Durán *et al.*, 1997). The witch flounder yield in the commercial fleet by Division, year and month is shown in Fig. 2. The peak yield occurred from February to May. This seasonal variation is in agreement with the observations of Pechenik and Troyanivskii (1971), although they indicate a depth range more limited in the pre-spawning concentrations (500 m to 750 m). The seasonal variation also coincides with other more recent literature (Bowering *et al.*, MS 1994). Annual yield showed an increasing trend (Fig. 3), although the corresponding fishing effort was highly variable. The fishing effort in Div. 3NO increased in the final year (1994) (Junquera, MS 1994), as shown in the sampled haul distribution (Table 1).

The main fish species accompanying the witch flounder catches are given in Table 1. In addition to the target species, Greenland halibut, other by-catch species were skates, grenadiers, American plaice and redfish. The increase in the skate catches was particularly notable in 1994 for Div. 3NO. This seems to indicate a recent change in the fishing

strategy involving directing the effort to non-regulated species.

The length distribution showed no differences to those previously obtained by other authors at shallower depths (Gorchinsky *et al.*, MS 1995; Bowering, 1987). The disappearance of the older age groups had already been noted by these authors, and their absence continued in the decade of the present study.

The length frequency by sex, Division and year from commercial vessels and bottom trawl survey are shown in Tables 2 to 4. In Div. 3NO, the proportion of juvenile individuals was less than in Div. 3M for the two fleets, which coincides with findings by Gorchinsky *et al.* (MS 1995) who also found the smaller mean length in the southern Divisions (Div. 3NO).

The mean length in the commercial catches decreased slightly throughout the period analyzed (Fig. 4). This trend may be due to an increase in the fishing depth, as a negative size correlation with depth, mainly in summer and autumn, is found in this species (Burnett *et al.*, 1992, Paz and Casas, 1996). In the Spanish bottom trawl survey in Div. 3NO, the decrease in the mean length may have been due to the recruitment of the recent year-classes.

The sex ratio by Division showed a different pattern mainly in Div. 3M. This has been indicated as one of the separate stock characteristics (Bowering, 1987). In the large vessels, the sex ratio showed a higher proportion of males for all Divisions in 1993 compared to 1994. In 1993 the proportion of males rose to 75% at 42 cm and 100% at 44 cm in Div. 3M (Fig. 5). There are no clear reasons for this. In the small vessels, no clear trend appeared in the sex ratio throughout the period (Fig. 6). The male proportion from the Spanish survey data was higher in 1995 than 1996 (Fig. 7).

The values of the parameters for length/weight relationships by sex, year and Division are shown in Table 5. All length-weight regressions were highly significant ($P < 0.001$) with coefficients of determination (r^2) ranging from 0.89 to 0.96. The value of the parameter estimates were not very different to those obtained previously by other authors for other areas (Bowering and Stansbury, 1984; Burnett *et al.*, 1992). The values of

TABLE 2.   Witch flounder length distribution (‰) by Division and year in the Spanish deep sea Greenland halibut fishery, for the large vessel fleet. (I = Individuals; S = Samples).

Length group (cm)	Div. 3L						
	1992	1993			1994		
	Combined	Males	Females	Combined	Males	Females	Combined
22	–	–	0.5	0.5	–	0.4	0.4
24	–	–	–	–	–	0.4	0.4
26	–	–	–	–	5.4	7.9	13.4
28	3.0	1.0	1.5	2.5	12.1	6.6	18.7
30	18.0	2.6	1.5	4.1	9.9	14.6	24.5
32	22.4	4.8	4.3	9.1	10.8	14.7	25.5
34	46.5	10.5	5.9	16.4	14.6	13.1	27.7
36	28.1	16.5	22.4	38.8	32.6	33.1	65.7
38	29.7	35.0	32.6	67.7	57.5	59.8	117.3
40	43.7	52.4	37.6	90.0	59.5	82.4	142.0
42	94.8	70.1	43.9	114.0	50.6	82.1	132.7
44	134.1	99.9	45.8	145.7	36.8	62.8	99.6
46	119.0	80.8	63.7	144.4	44.1	63.9	108.0
48	147.9	58.5	68.7	127.1	16.9	54.6	71.5
50	110.0	22.8	68.4	91.2	10.7	50.2	60.9
52	84.3	10.0	54.3	64.2	2.2	45.7	47.9
54	54.9	0.6	40.1	40.6	1.1	25.0	26.1
56	37.2	0.7	25.3	26.0	0.8	12.4	13.2
58	11.6	–	11.1	11.1	–	3.6	3.6
60	12.9	–	4.6	4.6	–	0.9	0.9
62	1.0	–	1.6	1.6	–	–	–
64	–	–	0.3	0.3	–	0.6	0.6
66	–	–	0.3	0.3	–	–	–
68	0.9	–	0.3	0.3	–	–	–
I	1 209			3 503			1 776
S	10			22			10

Length group (cm)	Div. 3M				Div. 3NO					
	1992	1993			1993			1994		
	Combined	Males	Females	Combined	Males	Females	Combined	Males	Females	Combined
26	–	–	–	–	–	–	–	–	0.4	0.4
28	–	5.8	–	5.8	–	–	–	–	0.4	0.4
30	4.9	11.6	–	11.6	0.7	–	0.7	6.4	7.9	14.3
32	4.9	11.6	11.6	23.2	–	–	–	20.8	24.2	44.9
34	10.7	17.4	5.8	23.2	6.2	1.3	7.5	44.9	56.4	101.3
36	4.9	29.0	11.6	40.6	23.0	5.1	28.1	53.1	72.4	125.5
38	25.5	17.4	29.0	46.4	43.3	19.9	63.2	42.8	81.4	124.2
40	26.4	46.6	23.2	69.8	45.2	24.9	70.1	46.8	63.6	110.4
42	62.6	46.6	5.8	52.4	30.7	47.1	77.7	32.3	58.1	90.4
44	187.8	133.8	0.0	133.8	37.7	59.0	96.7	33.1	58.0	91.1
46	73.3	104.8	46.6	151.3	34.7	99.2	133.9	26.1	58.1	84.2
48	135.9	40.8	64.0	104.8	33.9	123.4	157.4	13.8	59.6	73.4
50	177.1	29.0	64.0	93.0	28.8	118.9	147.7	12.3	39.7	52.0
52	130.1	17.4	75.6	93.0	17.4	90.2	107.6	10.3	42.5	52.8
54	62.6	5.8	58.2	64.0	10.7	58.2	69.0	0.9	20.1	21.0
56	62.6	–	52.4	52.4	4.0	17.4	21.4	4.0	6.3	10.4
58	20.6	–	23.2	23.2	1.4	14.1	15.5	–	2.4	2.4
60	4.9	–	11.6	11.6	–	1.7	1.7		1.2	1.2
62	4.9	–	–	–	–	1.7	1.7		–	–
I	192			172			1 081			1 956
S	2			1			14			12

TABLE 3. Witch flounder length distribution (°/∘∘) by NAFO Division and year in the Spanish deep sea Greenland halibut fishery, for the small vessel fleet. (I = Individuals; S = Samples).

Length group (cm)	Div. 3L 1993 Males	Females	Combined	1994 Males	Females	Combined	Div. 3M 1993 Males	Females	Combined
24	–	0.2	0.2	–	–	–	–	–	–
26	–	1.0	1.0	–	–	–	4.1	–	4.1
28	0.9	0.8	1.7	7.9	–	7.9	–	–	–
30	2.9	2.3	5.2	31.4	–	31.4	4.3	–	4.3
32	4.6	2.6	7.2	29.5	–	29.5	4.1	4.1	8.3
34	9.4	7.5	16.9	23.6	5.9	29.5	12.6	10.9	23.5
36	20.3	14.7	35.0	49.6	15.1	64.7	17.0	10.7	27.6
38	28.6	19.5	48.1	100.2	21.3	121.5	21.7	27.6	49.3
40	49.0	23.3	72.3	139.1	56.9	195.9	34.1	33.7	67.8
42	81.3	34.3	115.6	86.4	121.4	207.8	64.1	57.4	121.5
44	109.5	40.3	149.8	56.9	102.1	158.9	82.8	70.2	153.0
46	89.3	57.2	146.5	17.7	50.9	68.6	36.3	80.7	117.0
48	54.7	72.7	127.4	21.5	19.6	41.1	29.8	78.9	108.7
50	21.7	75.4	97.1	5.9	29.4	35.3	31.7	99.8	131.5
52	8.9	69.1	78.0	–	3.9	3.9	4.3	91.7	96.1
54	3.2	51.3	54.4	–	–	–	2.2	38.5	40.7
56	0.9	26.0	26.9	–	3.9	3.9	–	33.7	33.7
58	0.3	9.6	9.9	–	–	–	–	8.5	8.5
60	0.01	5.5	5.5	–	–	–	–	4.3	4.3
62	–	0.7	0.7	–	–	–	–	–	–
64	–	0.5	0.5	–	–	–	–	–	–
66	–	–	–	–	–	–	–	–	–
68	–	–	–	–	–	–	–	–	–
70	–	–	–	–	–	–	–	–	–
72	–	0.1	0.1	–	–	–	–	–	–
I			8 296			212			346
S			50			2			2

Length group (cm)	Div. 3NO 1992 Males	Females	Combined	1993 Males	Females	Combined	1994 Males	Females	Combined
24	–	–	–	–	–	–	–	–	–
26	–	–	–	–	–	–	0.4	0.1	0.5
28	–	–	–	0.5	–	0.5	1.0	0.4	1.4
30	–	–	–	0.1	0.6	0.7	6.6	13.6	20.2
32	–	4.3	4.3	0.8	0.6	1.4	28.0	37.1	65.0
34	12.7	19.1	31.8	8.6	11.3	19.8	38.7	75.6	114.3
36	21.2	60.0	81.2	33.4	32.7	66.1	54.7	110.7	165.4
38	65.7	57.8	123.6	55.3	63.9	119.3	64.4	112.8	177.2
40	82.0	55.4	137.5	52.0	86.4	138.4	41.0	107.5	148.5
42	127.7	52.2	179.9	33.9	78.5	112.4	19.1	77.3	96.3
44	57.7	73.5	131.1	21.8	99.5	121.4	10.9	57.8	68.7
46	58.2	64.6	122.8	9.4	110.1	119.5	3.0	50.3	53.2
48	22.6	58.4	81.0	3.5	123.8	127.3	5.3	33.0	38.3
50	4.6	46.3	50.9	1.2	80.0	81.2	0.9	26.0	26.9
52	–	22.9	22.9	0.1	54.7	54.9	–	11.0	11.0
54	0.4	13.2	13.6	0.4	21.7	22.1	0.2	9.9	10.1
56	5.0	9.0	14.1	–	7.5	7.5	–	1.8	1.8
58	0.5	2.1	2.7	–	6.2	6.2	–	0.6	0.6
60	–	2.2	2.2	–	0.9	0.9	–	0.2	0.2
62	–	–	–	–	0.4	0.4	–	0.2	0.2
64	–	–	–	–	0.4	0.4	–	0.2	0.2
66	–	0.5	0.5	–	0.4	0.4	–	0.2	0.2
68	–	–	–	–	–	–	–	–	–
70	–	–	–	–	–	–	–	–	–
72	–	–	–	–	–	–	–	–	–
I			870			4176			4074
S			17			26			24

TABLE 4. Witch flounder length distribution (°/oo) in the Spanish Bottom Trawl Survey for Div. 3NO. (I = Individuals; S = Samples).

Length group (cm)	1995			1996		
	Males	Females	Combined	Males	Females	Combined
20	1.0	–	1.0	–	1.5	1.5
22	1.0	–	1.0	–	1.5	1.5
24	1.9	1.0	2.9	3.6	3.4	7.0
26	2.9	4.9	7.8	4.6	10.5	15.1
28	1.0	6.8	7.8	18.7	29.7	48.4
30	4.9	9.7	14.6	37.1	59.1	96.2
32	13.6	17.5	31.2	49.2	103.1	152.2
34	49.7	49.7	99.3	77.2	128.0	205.2
36	85.7	58.4	144.1	52.2	115.3	167.5
38	75.9	76.9	152.9	28.6	72.0	100.6
40	55.5	72.1	127.6	20.2	48.8	69.0
42	32.1	94.4	126.6	14.3	34.1	48.4
44	27.3	56.5	83.7	7.6	19.1	26.7
46	19.5	47.7	67.2	3.4	19.8	23.2
48	8.8	38.9	47.7	1.1	14.1	15.2
50	5.8	29.2	35.1	1.1	9.3	10.5
52	–	22.4	22.4	0.4	3.2	3.6
54	1.0	10.7	11.7	–	3.0	3.0
56	–	11.7	11.7	–	1.5	1.5
58	–	2.9	2.9	–	3.2	3.2
60	–	–	–	–	–	–
62	–	1.0	1.0	–	0.3	0.3
I			857			1 612
S			35			15

TABLE 5. Length–weight relationship parameters from regressions for male, female and sexes combined for witch flounder collected from NAFO Regulatory Area, 1993–94. (N = Individuals)

| Year	Div.	Samples	Sex	N	a	S. E.	b	S.E.	R^2	S. E.
1993	3L	10	Males	110	0.011198	0.003716	2.86750	0.08799	0.908	0.1071
			Females	180	0.006774	0.001346	3.00965	0.05206	0.949	0.1127
			Combined	290	0.003113	0.000288	3.21274	0.02431	0.950	0.1076
	3NO	7	Males	166	0.001780	0.000616	3.35772	0.09328	0.888	0.1383
			Females	380	0.001033	0.000200	3.50458	0.05122	0.925	0.1354
			Combined	546	0.001154	0.000185	3.47511	0.04268	0.923	0.1356
1994	3L	8	Males	191	0.004897	0.001135	3.09057	0.06179	0.930	0.1057
			Females	418	0.002654	0.000316	3.26565	0.03096	0.964	0.1056
			Combined	609	0.002605	0.000272	3.26695	0.02732	0.959	0.1081
	3NO	20	Males	340	0.002501	0.000536	3.27028	0.05846	0.902	0.1136
			Females	1 298	0.001224	0.000121	3.456031	0.026321	0.930	0.1334
			Combined	1 638	0.001464	0.000128	3.40980	0.02335	0.930	0.1304
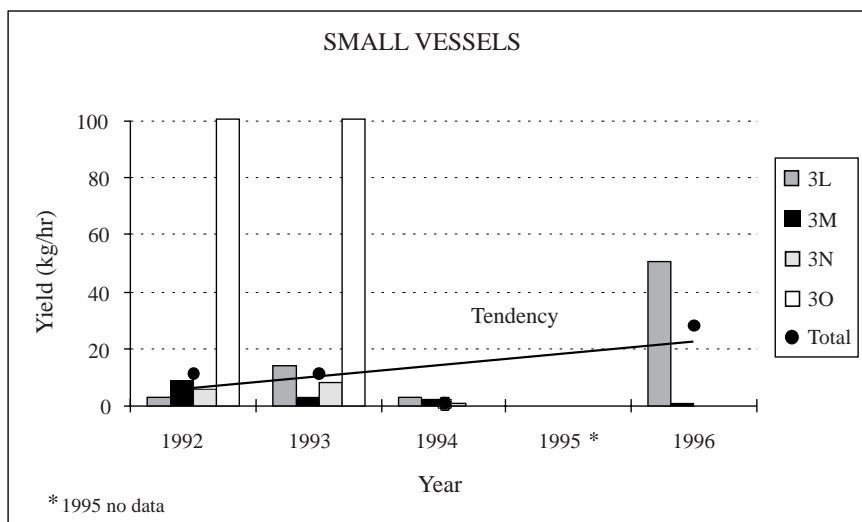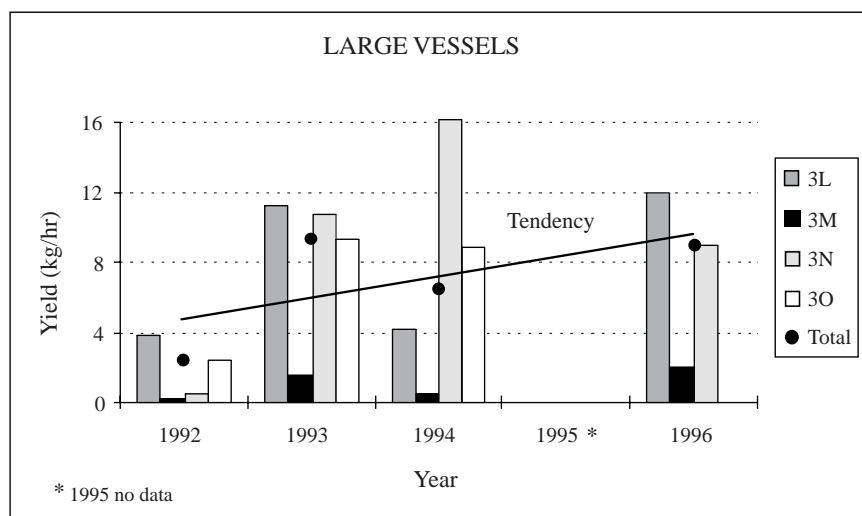
Fig. 3.   Witch flounder annual yield (kg/hr) by fleet and Division in the Spanish deep-sea Greenland halibut fishery in the large vessel and small vessel fleet.
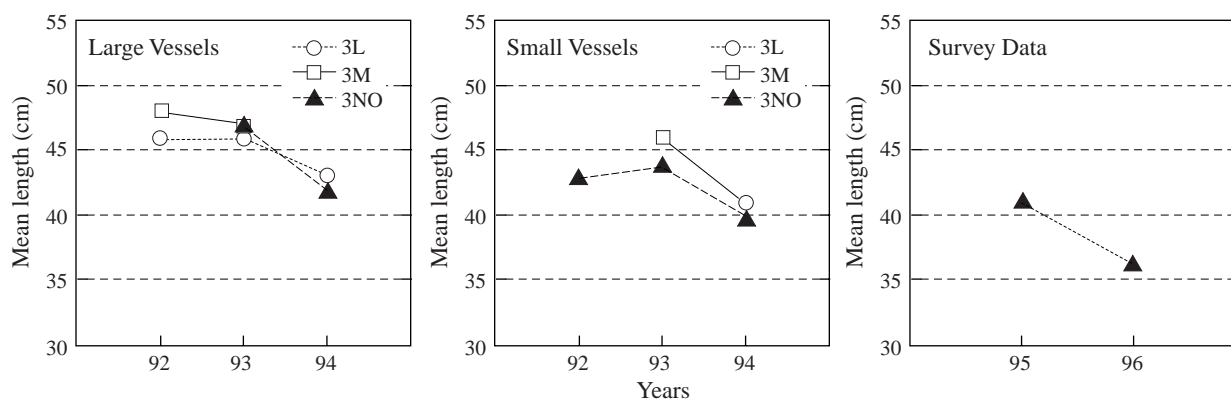

Fig. 4.   Witch flounder mean length (cm) by year and Division in the Spanish deep-sea Greenland halibut fishery, in the large vessel and small vessel fleet and in the Spanish Bottom Trawl Survey for Div. 3NO.
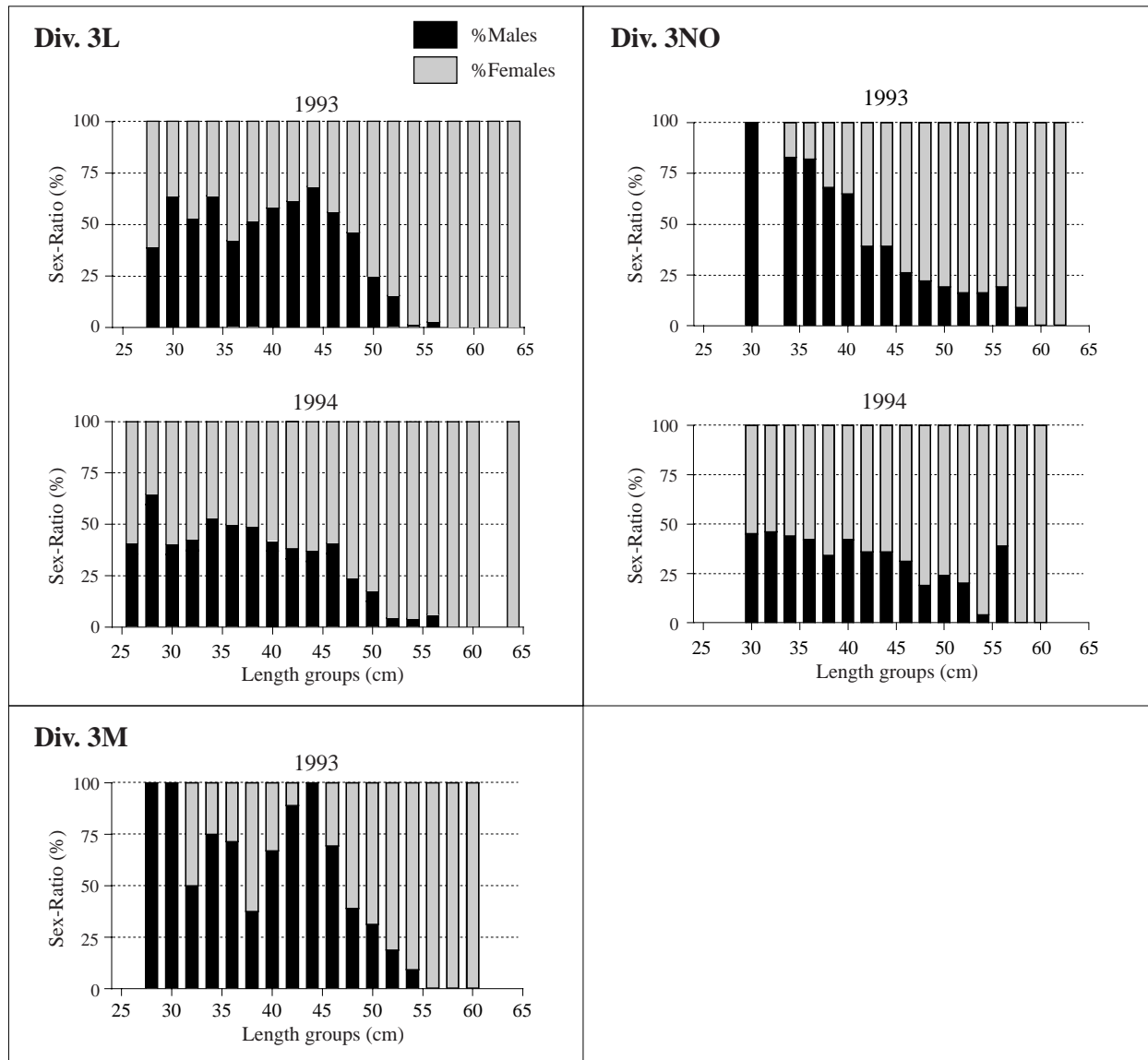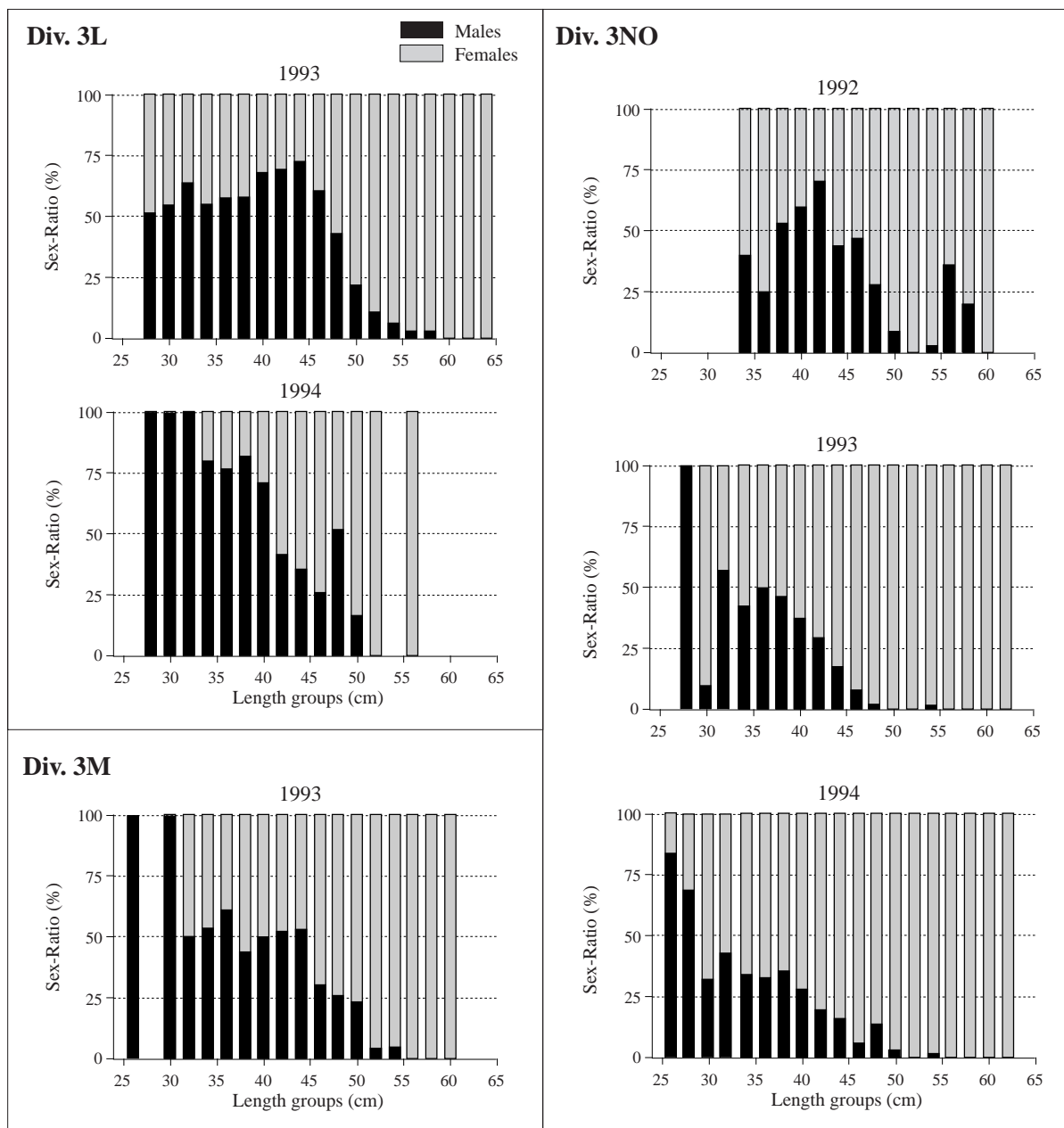
Fig. 5. Witch flounder Sex Ratio (%) by Division and year in the Spanish deep-sea Greenland halibut fishery, in the large vessel fleet.

length-weight parameters and the characteristics of the length distribution in all Divisions have not changed as regards those obtained previously by other authors (Bowering and Stansbury, 1984), i.e., they do not indicate changes in the population dynamics over the last decade. These characters seem to indicate that witch flounder stocks continue to be depressed.

Acknowledgements

Fig. 6.   Witch flounder Sex Ratio (%) by Division and year in the Spanish deep-sea Greenland halibut fishery, in the small vessel fleet.
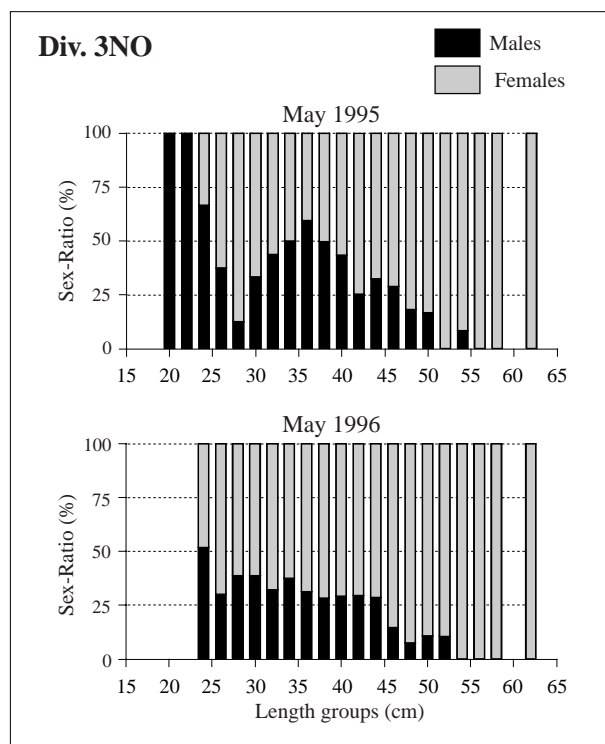
Fig. 7.   Witch flounder Sex Ratio (%) in the Spanish Bottom Trawl Survey in Div. 3NO.

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