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Condition and Feeding of American Plaice (*Hippoglossoides platessoides*) in the North Atlantic with Emphasis in Flemish Cap

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Abstract

The seasonal, annual and geographical changes in the Relative Condition Factor (*Kr*) of a total 24 495 individual biological data of American plaice (*Hippoglossoides platessoides*, Fabricius) were analysed. These samples were collected in three areas of the North Atlantic (NAFO Division 3M and Divisions 3LNO, and ICES Div. IIb) in commercial fishing and scientific surveys from 1992 to 2003. The condition stage presented significant variations among the three areas considering season, sex, size range and year effects, with a little descending general trend in Div. IIb and Div. 3M, and quite constant in Div. 3LNO in the considered period, but no clear pattern over time in any area.

The Div. 3LNO and IIb showed seasonal differences of *Kr* in relation to sex and season, but any clear trend. In Div. 3M, only with spring and summer data, no remarkable change was found.

The spawning period corresponded with the maximum of condition, followed by another period with increase of the feeding intensity. Biomass data estimated and the relative condition in Div. 3M and 3LNO showed similar pattern, but there were no significant correlations.

Food and feeding of 2 119 individuals of American plaice were examined in Flemish Cap in summer (1993-2003). Feeding intensity was higher in Flemish Cap (78.1%) than in other areas. The main preys in the composition of stomach contents were Ophiuroidea (56.3%), Hyperiidea (12.5%) and *Pandalus borealis* (7.5%). Feeding habits by size range and the comparison among different NAFO Divisions were also analysed.

Introduction

American plaice (*Hippoglossoides platessoides*, Fabricius) is an economically and ecologically important flatfish that inhabits both sides of the North Atlantic. The American plaice stock in Flemish Cap (NAFO Div. 3M) has recorded a steady decline since 1988. The 1984, 1986 and 1990 year-classes (ages 18, 16 and 12 in 2002) were the most abundant cohorts in the period, but it was not observed a good recruitment since then. In fact, since the EU Survey in Flemish Cap began in 1988, the American plaice estimated biomass showed a continuous fall from 11.9 tons in 1988 to 1.2 tons in 2000; from this year to 2003 it has shown a minimal annual recovery, but it continued being in very low levels (Saborido and Vázquez, 2003; Casas, 2004). The biomass and SSB in Div. 3L, 3N and 3O were very low compared with historical levels. SSB declined to the lowest observed level in 1994 and 1995. It has increased since then but still remains very low. There should be no directed fishing on American plaice in Div. 3LNO and the by-catches should be kept to the lowest possible (Anon., 2004).

Simple condition indices provide a useful assessment of the physiological well-being of fishes and provide an indirect means of evaluating ecological relations and the effects of various management strategies (Murphy *et al*., 1991). Several studies have demonstrated that these indices are a measure of the energy reserves of fishes and their relationship with the environmental, maturity, feeding or parasitic conditions (Costopoulos and Fonds, 1989).

Other studies indicate the possible relationship between a continuous deficit condition during years and the current situation of a stock. The implications of a poor condition in the current biomass and in the situation of the stock have been studied in Atlantic cod (*Gadus morhua*), being observed an increment of the natural mortality. This fact contributed to a lower production (Lambert and Dutil, 1997; Dutil and Lambert, 2000); and the decrease of the reproductive investment could affect to the reproductive potential (fecundity and total eggs) and possibly recruitment (Lambert and Dutil, 2000).

The temporal condition variations (seasonal and annual) of American plaice (*Hippoglossoides platessoides*) in three areas of North Atlantic, Area NAFO Div. 3M and 3LNO, and Area Svalbard ICES Div. IIb were examined in this study. Sex, maturity, and length were also considered in the period 1992-2003.

A study of the feeding of this species in these areas in the period 1993-2003 was also presented in order to analyse their possible relationship with the condition.

The aim of this study was to examine and to compare the condition stage of the individuals of three populations of the North Atlantic, and it relationship with the feeding habits and maturity cycle. The changes throughout the period 1992-2003 and the possible influence in the population state were also examined.

Material and Methods

24495 individual biological data of American plaice (*Hippoglossoides platessoides*) of the Northwest Atlantic and Arctic from research and commercial surveys during the 1992-2003 period were analysed (Tables 1 and 2). The surveys were the EU survey in Flemish Cap Div. 3M (Casas, 2004), "Platuxa" Spanish Survey in NAFO Div. 3NO (González Troncoso *et al*., 2004), "3L-Fletán Negro" Spanish Survey (*per. comm.* X. Paz); "Fletán Ártico" Spanish Survey in Svalbard ICES Div. IIb (Paz *et al*., 2004). The commercial surveys data correspond to the period 2001-2003 developed in NAFO (Spanish bottom trawl fishery target to Greenland halibut, *Reinhardtius hippoglossoides*), ICES (Spanish pair trawl fishery target to cod, *Gadus morhua*, and Spanish bottom trawl fishery target to northern shrimp, *Pandalus borealis*). The data obtained in the Pilot Action of Experimental Fishing developed in the Sea of Barents-Svalbard (ICES, Div. I and IIb) target to American plaice in 1995 were also included (Durán and Román, 2000).

The biological samplings were carried out on board, and the data collected for each individual were: length (TL to the nearest lower cm), sex, maturity stage (inmature, maturing, spawning and post-spawning), weight (gr) and stomach repletion degree (empty, partial fullness, fullness). The individuals were compiled in size ranges of 10 cm each (20-29, 30-39, 40-49, 50-59 and ≥60 cm) to make their analysis easier (Table 1). The maturity stage was assigned by macroscopic analysis.

Data were grouped by seasons. In some cases it was not possible to complete the annual cycle (in 3M) because were not enough data. The available data for the spring included the months of April and May; those for the summer included from June to August; those for the autumn include from September to November; and those for the winter include the months of December and January. The inter-annual comparisons were only made when it was available, at least, a two year series for the same season.

Individuals smaller than 20 cm have not been kept in mind because their weight presented a very high dispersion caused by mistake in the system of weight. In some cases, individuals ≥60 cm were not consider due to the small amount of individuals in the sample.
Div. 3NO and 3L data were studied as a whole because it is one stock for this species (Anon., 2004).

A condition index was calculated because it provides a useful assessment of the plumpness and physiological well-being of fishes. The Fulton Condition Factor (*K*) is the traditional approach to these indices (Anderson and Gutreuter, 1983).

$$K = W / (L)^3 * 100$$

where: *W* is the observed weight (gr) of the individual *i*
L is the total length (cm) of the individual *i*

The power function is calculated in order to obtain the expected weight (W'), using the mathematical description of weight-length relationship for the individuals of each area, year, season and sex.

$$W' = a * (L)^b$$

where: *L* is the total length (cm) of the individual *i*
a is the intercept
b is the slope

The Relative Condition Factor (K_r) is calculated to compare fishes of the same species of different lengths, sex, locations and years (Le Cren, 1951).

$$K_r = W/W'$$

where: *W* is the observed weight of the individual *i*
W' is the predicted weight based on weight-length equation for the individual *i*

We have also used statistics to measure the amount of variation in the observed values; the mean-centered coefficient of variation (COV) is the result of expressing the standard deviation as a percentage of the mean. The study of the annual and seasonal series of each area has been considered, as well as the comparisons among the three areas with the mean Relative Condition Factor (*Kr*).The GLM Univariate procedure (General Linear Model) has been used to test the hypothesis that the means of the Relative Condition Factor of several groups are not significantly different.

Due to the different sampling conditions, the data from commercial and scientific surveys were analysed in order to analyse their degree of internal variability in each area before working with them as a whole. The differences of the variation coefficient between both sources were small, and they did not show significant differences in the mean *Kr* in the most of the cases, although some exceptions were found (Table 2).

American plaice feeding habits were studied from the same research surveys data: 2 119 individuals in the 1993-03 period in 3M; 5 262 individuals in the 2002-03 period in 3LNO; and 465 individuals in the 2002 period in IIb (Table 3). In each haul, a maximum of 10 stomachs from each 10 cm length range were analysed. Fish whose stomachs were everted or contained preys ingested in the fishing gear were discarded. Specimens that presented total or partial regurgitation were taken into account to estimate the emptiness indice. The methodology was the same used in 1993 (Rodríguez-Marín *et al*., 1994).

For each predator, the data collected were: total length to the nearest lower cm; volume of the stomach content, quantified in c.c. using a trophometer (Olaso, 1990); the percentage of each prey in the total volume, and digestion stage and number of each prey. Preys were identified by species when the digestion stage permitted it, or to the lowest possible taxonomic level.

The Feeding Intensity Index (FI) is the percentage of individuals with stomach content and is calculated to analyse the feeding intensity for each predator: $FI = n_f / N_t * 100$, where n_f is the number of individuals with stomach contents and N_f is the total number of individuals sampled.

The importance of each prey taxa in the stomach contents was evaluated using the percentage by volume: $V = v / V_t * 100$, where v is the volume of a determined prey, and V_t is the total volume of preys. The volumetric method over values the importance of large organisms (Hyslop, 1980).

Results

The Fulton Condition Factor (*K*) values did not present big changes along the studied period. Males in 3LNO presented the highest values of mean Fulton Condition Factor (*K*) (0.997) followed by males in 3M; and for females, this index was superior in 3M (1.046) followed by females in 3LNO. The seasons of better condition varied for each sex and area (Tables 4, 5 and 6), but the differences were small. The Fulton Condition Factor showed an upward trend with the size in all the areas, with higher values in 3M. It is remarkable the fall of this factor in individuals ≥40 cm in IIb (Fig. 1).

The total mean of the Relative Condition Factor (K_r) value was quite constant in 3LNO, it fell very smoothly in 3M and it declined a little in IIb (Fig. 2, 3 and 4). Both sexes generally presented similar values of *Kr*, showing a little difference in IIb (Tables 4, 5 and 6). The size ranges with the higher value of Relative Condition Factor (*Kr*) varied with the area, reflecting once more the fall of condition of individuals ≥40 cm in IIb (Fig. 1). This index showed very little seasonal variation, except in the condition of the males in winter in 3LNO and IIb (Fig. 5).

Comparing the three areas, this index showed significant differences, taking into account the interaction of the sex, size range, season and year ($F(4,24221) = 3.945$, $p \leq 0.005$). However, considering independently the main effect of each factor, only the year showed significant differences ($F(11,24221) = 2.117$, $p \leq 0.05$).

Relative Condition in Division 3M (Flemish Cap)

The mean Relative Condition Factor (*Kr*) showed oscillations in all the size ranges throughout the series in the data for the summer samplings from 1992 to 2003. In general, the condition of females has improved throughout the series, being equaled in the last years. The oscillations in both sexes present opposite trends in some years. In 1995, high values for both sexes were remarkables. The general trend was quite constant all over the period the studied period (Fig. 2).

The total mean relative condition (*Kr*) of males was 1.006 ± 0.09 with a 8.8% the coefficient of variation (COV), and this value in females was 1.008 ± 0.09 with a COV 9.2 (Table 4). In this division there were only spring and summer data, finding few differences between both seasons in relation to sex and size (Fig. 5 and 6).

The biomass in the same period has suffered a great fall from very low levels, however, it showed an increase in the last year (Saborido and Vázquez, 2003; Casas, 2004). In Fig. 2, it can be appreciated a slight likeness between the condition and the estimated biomass for the area during these years, but they did not present a significant correlation, because the *Kr* value hardly varied in spite of the high fall of the biomass.

The *Kr* value in this division did not show significant differences in none of the interactions among season, sex, size range and year. And, with regard to the main effects of these components, it only showed significant differences in relation to the size range ($F(3,7588) = 5.109$, $p \leq 0.005$) and year ($F(11,7588) = 1.794$, $p \leq 0.05$).

Relative Condition in Division 3LNO

The Relative Condition Factor in the spring series in the period 1995-2003 showed oscillations for both sexes with similar trend (except in 1998), with an interval of higher values from 1999-2001, but the general trend was shown almost constant (Fig. 3). The total mean *Kr* value in the studied period was similar for both sexes (1.005) with similar standard deviation and coefficient of variation (Table 5). The seasonal variations in both sexes were small, with similar values for both and the biggest difference was found in winter (Fig. 5).

The condition in the period 1995-2003 was slightly constant for the sizes 20-49 cm in spring, and it was lower and more oscillating for the sizes ≥50cm. In summer, a slight increase of the condition appeared in the ranges 30-39 and 40-49 cm and it decreased in the range of 50-59 cm, but the opposite process appeared in autumn (Fig. 7).

The estimated biomass in Div. 3NO (Gónzález Troncoso *et al*., 2004) showed an increase in the period 1999-2001, and it showed a slight likeness with the condition from 1998, but it was not like that in previous years. However, condition and estimated biomass did not show a significant correlation (Fig. 3).

The mean Relative Condition Factor presented significant differences in the interaction of the season, sex, year and size range ($F(3,11616) = 4.102$, $p \leq 0.01$), but for the main effects of these variables there were only significant differences with regard to the year ($F(8,11616) = 4.075$, $p \leq 0.000$).

Relative Condition in Division IIb

In the annual series of autumn in the period 1997-2003, the mean *Kr* value showed the same trend in both sexes, with more oscillations from 2000, in general being the higher condition in males. The general trend was slight decreasing in both. Estimated biomass and *Kr* did not show correspondence (Fig. 4).

The total mean *Kr* value was higher in males (1.007 ± 0.11) during the studied period with 10.9% of variation coefficient and it was 1.001 ± 0.10 with a COV of 9.8% in females (Table 6). The *Kr* factor suffered few changes among seasons, except in males in winter; this result can be distorted because of the few number of sampled individuals (Fig. 5). In relation to size, the condition showed slight seasonal and annual oscillations, especially in individuals ≥40 cm, decreasing their condition in summer and autumn (Fig. 8).

In this division, this value was significantly different in the year, season and sex interactions ($F(1,5017) = 4.882$, $p \leq 0.05$), however it was not like that when these effects were studied independently.

Relative Condition in Relation with the Maturity and the Feeding Intensity

Individuals with better condition corresponded with spawning females, keeping in mind that the condition was also high in immature individuals. Likewise, the *Kr* value was higher in 3LNO during the spawning than in other areas, and the lower value was in 3M. The condition changes in males during the different maturity stages were much smaller than in females (Fig. 9).

Analysing the *Kr* of spawning females, the highest values were in summer in 3LNO, and in spring in IIb. And the feeding intensity of females in 3LNO was higher in autumn; and in summer for females in IIb. There are only data of Div. 3M for spring (Fig. 10).

Feeding habits study

Data of feeding habits showed a high feeding intensity in Div. 3M and very low in IIb (Table 3 and Fig. 11). The main preys composition in the diet has changed in the last years. Echinodermata was the main preys during the 1993-1999 period, however, it presented a drastic decrease in the stomach contents from 2000, being substituted by crustaceans and other invertebrates (Fig. 12).

The main prey groups in volume in the stomach contents in 3M for the studied period were Echinodermata (Ophiuroidea, 56.3%) and crustaceans (mainly hyperiids with 12.5%). Echinodermata predominated in sizes ≥20 cm, and fish (4.8%) were more abundant in individuals ≤20 cm (Table 7 and Fig. 13).

The main prey groups in 3LNO were fish (62.4%), mainly *Ammodytes dubbius* (4.02%), and crustaceans (14.6%); equinoderms (10.8%) were also important, mainly myssids and dollar sand (*Echinarachnius parma*). Crustaceans predominated in sizes ≤20 cm and fish in sizes ≥30 cm (Table 8 and Fig. 13).

And finally, the more important preys in the diet of American plaice in IIb were crustaceans (40.8%), mainly northern shrimp (22.1%), and fish (40%), mainly *Melanogrammus aeglefinus* (35.4%). Individuals <30 cm preyed crustaceans, Mollusca and equinoderms, and individuals ≥30 cm preyed fish and crustaceans in similar quantities (Table 9 and Fig. 13).

Discussion

The bibliography shows that the spawning of American plaice (*H. platessoides*) varies geographically, taking place at the beginning of April in Flemish Cap, earlier than in Grand Bank (at the end of May) and in Labrador (at the beginning of June). Walsh (1994) compared western and eastern North Atlantic American plaice populations and found that the southern populations of this area presented a quick growth, early maturation and their spawn was from the beginning of the winter until the spring unlike the northern populations that presented a slow growth, late maturation and their spawning took place in the spring-summer period.

Morgan (2001) examined samples from 3LNO in the period 1971-1999 and found low inter - annual variation in the spawning, except in recent years, that the spawning took place in deeper waters and it was more abundant in 3NO than in 3L. In 3L, spawning was later (May) than in 3NO (April) with a significant late spawning in the 1990s. The spawning period took up a wide seasonal period. Spawning females were found from February to August, they were even observed in the months of November and December. This author found post-spawning individuals all the year round, with the biggest proportion of them from April to August. Individuals from maturing to spawning stages were also found in all the seasons, and a high proportion of mature individuals appeared from September to December. This aspect of the duration of the spawning has been noted by other authors (Johnson *et al*., 1999).

Walsh (1994, 1996) indicated that the spawning in the eastern North Atlantic (in the Barents Sea and Svalbard area) began in March and ended in July, and had a peak in the spring. These populations were much larger in age and size at maturity than in other areas.

Taking into account the *Kr* values obtained throughout the studied period for the three areas of the North Atlantic, two groups of individuals would be expected: the smaller and the bigger size for the first maturation.

The first ones should present low *Kr* values and small seasonal and inter-annual variability, while the others should present high values with seasonal fluctuations. These two groups would correspond to two moments of the vital cycle; the first period, with important somatic growth and scarce reserves, in which the energy is used in the own growth; and another period of small somatic growth, in which the energy is used in reproductive functions with a small rate of growth.

In this way, the hypothetical mechanism of the energy distribution (Rijnsdorp, 1990) throughout the year could be extrapolated to the vital cycle of the population, where the value of the condition index would represent the threshold of the energy distribution.

Our results showed significant differences in the relative condition among the three areas, keeping in mind the sex, season, size range and year interactions, but the independent study of each factor did not show significant differences, except for the year factor. This fact could indicate that the relative condition differences among the three compared areas were not important. The spawning females showed better condition than in other maturity stages, differing the season in each area (in summer in 3LNO, and in spring in IIb). An increase of the feeding intensity was also found in the following station, in autumn in 3LNO and in summer in IIb. Males presented a more uniform geographical and seasonal behaviour. On the other hand, some differences can be appreciated in seasonal behaviour in the different sizes. These differences varied with the area and they could be due to the early or late spawning in relation to age. This fact has been reported in American plaice and other species. If the spawning was extended throughout the year, the different maturity stages would be overlapped, and this fact would cause low seasonal differences in the mean of *Kr*.

Morgan (2003) examined the spatial and temporal condition of American plaice among 3L, 3N and 3O. She found seasonal differences with a higher condition in autumn versus spring. She also observed a significant annual difference in the condition, and not significant correlations between condition and abundance. Opposite to this study, our results did not show the best condition in autumn, but both studies agree in the significant annual variability and in the non correlation of the condition and the biomass (abundance in the study of Morgan, 2003). These differences in the results can be related with the fact of treating the data of 3LNO as a whole, when the differences among these three divisions are being demonstrated.

Differences in the diet composition were found by areas and the diet also varied in relation with size, facts reported in another study (González Iglesias *et al*., 2003). The differences in the feeding intensity and composition of preys were also influenced by the different period of sampling in each area and the seasonal and geographical availability of preys.

In these condition studies there are other aspects that should be considered, such as the seasonal distribution across depth/temperature observed (Morgan and Brodie, 1991) or the spawning migrations (Milinsky, 1944a; Albert *et.al*., 1994), in order to avoid a slanted sampling of the population and to distort the results. Another aspect that would help in the study of the condition could be its analysis keeping in mind the eviscerated weight.

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Table 1.- Number of individuals of *H. platessoides* sampled by area (NAFO Divs. 3LNO and 3M; ICES Div. IIb), year (1992-2003) and size range (cm).

Area	**Size range (cm)**	**Year**												***Total***
		1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	
3M	20-29	145	202	58	25	17	18	12	9	15	21	6	12	*540*
	30-39	573	366	488	308	239	171	127	102	127	208	45	195	*2949*
	40-49	430	373	397	307	244	176	211	208	191	224	106	233	*3100*
	50-59	60	88	110	117	60	67	90	130	72	114	87	95	*1090*
	Total	*1208*	*1029*	*1053*	*757*	*560*	*432*	*440*	*449*	*405*	*567*	*244*	*535*	*7679*
3 LNO	20-29				511	184	801	372	102	136	246	479	667	*3498*
	30-39				388	181	1076	542	134	206	594	515	531	*4167*
	40-49				151	120	446	405	83	128	522	452	359	*2666*
	50-59				28	67	82	161	29	54	276	273	168	*1138*
	>= 60				5	48	22	37	13	28	48	34	31	*266*
	Total				*1083*	*600*	*2427*	*1517*	*361*	*552*	*1686*	*1753*	*1756*	*11735*
IIb	20-29				278		295	183	252	167	374	415	483	*2447*
	30-39				804		135	91	91	59	294	468	374	*2316*
	40-49				153		7	3	4	3	21	78	49	*318*
	Total				*1235*		*437*	*277*	*347*	*229*	*689*	*961*	*906*	*5081*
	Total	*1208*	*1029*	*1053*	*3075*	*1160*	*3296*	*2234*	*1157*	*1186*	*2942*	*2958*	*3197*	*24495*

Table 2.- Number of individuals and Coeffiecient of Variation (COV%) of *Kr* in *H. platessoides* sampled by area (NAFO Divs. 3LNO and 3M; ICES Div. IIb), year (1992-2003), data source (CV=commercial vessel; RV=research vessel) and season.

Area	RV or CV	Season	1992		1993		1994		1995		1996		1997		1998		1999		2000		2001		2002		2003		*Total*	
			No.	COV	No.	COV	No.	COV	No.	COV	No.	COV	No.	COV	No.	COV	No.	COV	No.	COV	No.	COV	No.	COV	No.	COV	*No.*	*COV*
3M	CV	Spring																					21	6,6			*21*	*6,6*
	RV	Summer	1208	8,8	1029	9,0	1053	8,8	757	8,7	560	9,1	432	9,4	440	9,3	449	9,3	405	8,6	567	8,7	223	9,4	535	9,4	*7658*	*9,0*
	Total		*1208*	*8,8*	*1029*	*9,0*	*1053*	*8,8*	*757*	*8,7*	*560*	*9,1*	*432*	*9,4*	*440*	*9,3*	*449*	*9,3*	*405*	*8,6*	*567*	*8,7*	*244*	*27,6*	*535*	*9,4*	*7679*	*10,4*
3 LNO	CV	Spring																					107	9,2			*107*	*9,2*
	RV	Spring							1083	12,4	600	9,6	2427	9,7	1517	9,9	361	9,7	552	9,7	720	9,5	866	9,7	1272	12,1	*9398*	*10,4*
	CV	Summer																			100	7,3	126	8,6			*226*	*8,1*
	RV	Summer																							484	13,2	*484*	*13,2*
	CV	Autumn																			456	10,1	654	9,2			*1110*	*9,6*
	CV	Winter																			410	11,9					*410*	*11,9*
	Total								*1083*	*10,5*	*600*	*12,4*	*2427*	*9,4*	*1517*	*10,2*	*361*	*9,7*	*552*	*9,7*	*1686*	*9,9*	*1753*	*9,7*	*1756*	*9,6*	*11735*	*12,4*
IIb	CV	Spring																					192	11,8			*192*	*11,8*
	CV	Summer							1235	8,9													145	13,4	65	13,1	*1445*	*9,7*
	CV	Autumn																			142	11,3	158	10,2	85	10,5	*385*	*11,1*
	RV	Autumn											437	12,4	277	12,7	347	10,6	229	9,7	547	9,2	463	9,5	695	9,9	*2995*	*10,5*
	CV	Winter																					3	7,8	61	8,2	*64*	*8,2*
	Total								*1235*	*8,9*			*437*	*12,4*	*277*	*12,7*	*347*	*10,6*	*229*	*9,7*	*689*	*9,8*	*961*	*10,8*	*906*	*10,2*	*5081*	*10,3*
Total			*1208*	*8,8*	*1029*	*9,0*	*1053*	*8,8*	*3075*	*10,2*	*1160*	*9,4*	*3296*	*10,1*	*2234*	*10,2*	*1157*	*9,8*	*1186*	*9,4*	*2942*	*9,9*	*2958*	*9,9*	*3197*	*11,4*	*24495*	*10,0*

Table 3.- Characteristics of individuals sampled of *H. platessoides* in the feeding study by area (NAFO Divs. 3LNO and 3M; ICES Div. IIb) by year (1993-03). Nº empty = Number of empty stomachs; % FI = Feeding intensity; Nº Reg. = Number of regurgitated stomachs; % Food: Fullness percentage; Nº hauls = Number of hauls.

Survey	Div.	Year	Nº Empty	Nº Full	Nº Reg.	Total	% FI	Size range (cm)	Depth range (m)	Nº hauls	No. Prey Items
"Flemish Cap"	3M	1993	71	338	0	409	82.6	18 - 59	148-639	50	22
"Flemish Cap"	3M	1996	63	193	0	256	75.4	12-60	135-450	40	30
"Flemish Cap"	3M	1997	41	137	0	178	77.0	12-58	133-324	28	26
"Flemish Cap"	3M	1998	15	126	1	142	89.4	21-55	139-477	30	25
"Flemish Cap"	3M	1999	20	214	0	234	91.5	26-60	133-377	33	28
"Flemish Cap"	3M	2000	43	172	15	230	81.3	5-56	228-589	40	31
"Flemish Cap"	3M	2001	91	229	0	320	71.6	12-59	132-631	52	37
"Flemish Cap"	3M	2002	34	135	0	169	79.9	25-57	131-352	50	28
"Flemish Cap"	3M	2003	86	95	0	181	52.5	12-58	130-534	43	18
"Platuxa"	3NO	2002	1369	868	0	2237	38.8	6-67	39-1460	85	42
"Platuxa"	3NO	2003	1236	1290	0	2526	51.1	5-72	44-888	80	41
"Div. 3L - Fletán negro"	3L	2003	321	178	0	499	35.7	6-54	118-864	25	18
"Fletán Ártico"	II b	2002	465	13	0	478	2.7	9-42	530-1118	81	11
Total	***Div 3M***	***1993-2003***	***464***	***1639***	***16***	***2119***	***78.1***	***5-60***	***130-639***	***366***	***70***
	Divs. 3LNO	***2002-03***	***2926***	***2336***	***0***	***5262***	***44.4***	***5-72***	***39-1460***	***190***	***50***
	Div. II b	***2002***	***465***	***13***	***0***	***478***	***2.7***	***9-42***	***530-1118***	***81***	***11***

Table 4.- No. individuals of *H. platessoides* sampled, Mean Fulton Condition Factor, and Relative Condition Factor ± Std. Deviation (SD) with Coefficient of Variation (COV %) of *Kr* by sex in Flemish Cap (NAFO Div. 3M) from 1992 to 2003.

Season	Year	No. indiv. sampled		Mean Fulton Condition Factor		Relative Condition Factor ± Std. Deviation				COV (%)	
		Male	Female	Male	Female	Male	SD	Female	SD	Male	Female
Spring	2002	8	13	0,871	0,902	1,014	0,07	1,006	0,07	6,4	6,9
Summer	1992	586	622	0,998	1,063	0,994	0,09	1,005	0,09	8,9	8,7
	1993	481	548	0,955	1,040	1,014	0,09	1,000	0,09	8,7	9,2
	1994	466	587	0,973	1,059	1,008	0,09	1,013	0,09	8,6	9,0
	1995	366	391	0,940	1,043	1,015	0,09	1,019	0,09	8,5	8,9
	1996	323	237	0,965	1,030	1,003	0,08	1,014	0,10	8,5	9,9
	1997	221	211	0,959	1,052	1,006	0,10	0,995	0,09	9,9	8,9
	1998	187	253	0,977	1,058	1,001	0,09	1,015	0,10	9,1	9,5
	1999	151	298	0,966	1,056	1,000	0,09	1,004	0,09	9,5	9,2
	2000	212	193	0,942	1,001	1,005	0,08	1,000	0,09	8,4	8,9
	2001	363	204	0,930	1,008	1,010	0,08	1,011	0,10	8,2	9,7
	2002	69	154	0,937	1,045	1,003	0,09	1,005	0,10	9,2	9,6
	2003	367	168	0,957	1,049	1,007	0,09	1,003	0,10	9,0	10,3
	Total summer	*3792*	*3866*	*0,962*	*1,046*	*1,006*	*0,09*	*1,008*	*0,09*	*8,8*	*9,2*
Total (Flemish Cap, 3M)		*3800*	*3879*	*0,962*	*1,046*	*1,006*	*0,09*	*1,008*	*0,09*	*8,8*	*9,2*

Table 5.- No. individuals of *H. platessoides* sampled, Mean Fulton Condition Factor, and Relative Condition Factor ± Std. Deviation (SD) with Coefficient of Variation (COV %) of *Kr* by sex in NAFO Div. 3LNO from 1995 to 2003.

Season	Year	No. indiv. sampled		Mean Fulton Condition Factor		Relative Condition Factor ± Std. Deviation				COV (%)	
		Male	Female	Male	Female	Male	SD	Female	SD	Male	Female
Spring	1995	623	460	1,003	1,010	1,008	0,12	1,022	0,13	12,4	12,3
	1996	230	370	0,978	0,997	0,998	0,10	0,990	0,09	10,2	9,1
	1997	1044	1383	0,986	0,997	1,002	0,09	1,003	0,10	9,1	10,1
	1998	571	946	1,005	1,026	1,007	0,09	0,994	0,10	9,2	10,3
	1999	174	187	0,979	1,009	1,004	0,09	1,016	0,11	8,6	10,7
	2000	235	317	0,979	1,006	0,998	0,10	1,012	0,10	9,6	9,8
	2001	248	472	0,998	1,017	1,005	0,09	1,009	0,10	8,7	9,9
	2002	294	679	1,008	1,015	1,001	0,08	0,993	0,10	8,4	10,1
	2003	470	802	1,017	1,012	1,008	0,12	1,008	0,12	11,9	12,3
	Total spring	*3889*	*5616*	*0,997*	*1,010*	*1,004*	*0,10*	*1,003*	*0,11*	*10,1*	*10,6*
Summer	2001	37	63	0,990	1,016	1,004	0,07	1,004	0,08	6,5	7,8
	2002		126		1,011			1,008	0,09		8,6
	2003	115	369	0,979	1,000	1,007	0,14	1,028	0,13	14,2	12,9
	Total summer	*152*	*558*	*0,982*	*1,005*	*1,007*	*0,13*	*1,021*	*0,12*	*12,7*	*11,6*
Autumn	2001	104	352	1,038	1,041	1,006	0,09	0,995	0,10	9,4	10,3
	2002	239	415	0,991	1,005	1,000	0,08	1,011	0,10	8,5	9,6
	Total autumn	*343*	*767*	*1,005*	*1,021*	*1,002*	*0,09*	*1,004*	*0,10*	*8,8*	*9,9*
Winter	2001	67	343	1,003	1,034	1,050	0,14	1,012	0,12	13,6	11,4
Total (3LNO)		*4451*	*7284*	*0,997*	*1,012*	*1,005*	*0,10*	*1,005*	*0,11*	*10,2*	*10,697*

Table 6.- No. individuals of *H. platessoides* sampled, Mean Fulton Condition Factor, and Relative Condition Factor ± Std. Deviation (SD) with Coefficient of Variation (COV %) of *Kr* by sex in ICES Div. IIb from 1995 to 2003.

Season	Year	No. indiv. sampled		Mean Fulton Condition Factor		Relative Condition Factor ± Std. Deviation				COV (%)	
		Male	Female	Male	Female	Male	SD	Female	SD	Male	Female
Spring	2002	50	142	0,871	0,890	1,005	0,12	1,012	0,12	11,8	11,8
Summer	1995	186	1049	0,897	0,899	1,003	0,10	1,007	0,09	9,5	8,8
	2002	41	104	0,809	0,865	0,993	0,13	1,009	0,14	12,9	13,6
	2003	7	58	0,850	0,896	1,113	0,16	1,008	0,13	14,3	12,7
	Total summer	*234*	*1211*	*0,880*	*0,896*	*1,005*	*0,11*	*1,008*	*0,10*	*10,5*	*9,5*
Autumn	1997	269	168	0,840	0,909	1,016	0,14	1,006	0,11	13,3	10,8
	1998	189	88	0,914	0,973	1,009	0,14	1,004	0,10	13,8	9,8
	1999	249	98	0,839	0,996	1,003	0,11	1,005	0,11	10,5	10,8
	2000	162	67	0,902	0,999	1,003	0,10	1,014	0,10	9,5	10,1
	2001	370	319	0,912	1,002	1,003	0,10	0,977	0,09	9,8	9,5
	2002	337	284	0,892	1,027	1,011	0,10	1,006	0,09	10,0	9,4
	2003	445	335	0,882	0,974	1,008	0,10	0,987	0,10	10,1	9,8
	Total autumn	*2021*	*1359*	*0,883*	*0,986*	*1,008*	*0,11*	*0,995*	*0,10*	*10,9*	*9,9*
Winter	2002		3		0,921			1,041	0,08		7,8
	2003	4	57	0,855	0,976	0,860	0,01	0,996	0,08	1,4	7,6
	Total winter	*4*	*60*	*0,855*	*0,973*	*0,860*	*0,01*	*0,998*	*0,08*	*1,4*	*7,6*
Total (IIb)		*2309*	*2772*	*0,882*	*0,942*	*1,007*	*0,11*	*1,001*	*0,10*	*10,9*	*9,8*

Table 7.- Volume (%) of the main preys for *H. platessoides* by lenght groups in Flemish Cap (Div. 3M) in 1993-2003 period.

Prey	Size range (cm)					Total
	10-19	**20-29**	**30-39**	**40-49**	**> 50**	
PISCES	*75,5*	*4,8*	*8,3*	*5,0*	*2,5*	*4,8*
Lumpenus lumpretaeformis	67,3	3,7	3,3	2,7	0,3	2,0
Other Pisces	8,2	1,2	5,0	2,3	2,2	2,8
CRUSTACEA	*10,5*	*45,9*	*22,2*	*22,6*	*23,4*	*23,2*
Hyperiidea		0,3	6,7	16,1	12,1	12,5
Euphausiacea		2,6	1,4	1,2	0,7	1,1
Pandalus borealis	2,5	21,6	8,6	4,4	9,8	7,5
Other crustaceans	8,0	21,4	5,5	0,9	0,8	2,1
MOLLUSCA		*0,3*	*1,3*	*1,1*	*0,4*	*0,9*
ECHINODERMATA	*14,0*	*44,2*	*64,5*	*62,9*	*52,7*	*59,2*
Ophiuroidea	14,0	43,9	62,8	60,3	48,8	56,3
Echinoidea regularia		0,3	1,4	1,9	2,1	1,8
Other Echinodermata			0,2	0,8	1,8	1,0
OTHER INVERTEBRATES		*4,7*	*3,4*	*8,1*	*21,0*	*11,8*
Polychaeta		2,3	2,0	3,7	2,7	3,0
Chaetognata		1,5	1,0	2,0	1,9	1,8
Ctenophora				1,9	15,9	6,6
Other invertebrates		0,9	0,3	0,6	0,4	0,5
OTHER		*0,1*	*0,3*	*0,2*	*0,1*	*0,2*
No. indivs. sampled with stomach contents	14	125	528	657	315	1639

Table 8.- Volume (%) of the main preys for *H. platessoides* by lenght groups in NAFO (Divs. 3LNO) in 2002 -03 period.

	Size range (cm)						**Total**
Preys	**1-9**	**10-19**	**20-29**	**30-39**	**40-49**	**> 50**	
PISCES		*2,5*	*37,0*	*73,3*	*77,6*	*41,1*	*62,4*
Ammodytes dubbius			17,0	36,9	52,8	32,9	40,2
Mallotus villosus			14,0	28,3	22,5	8,0	18,9
Liparis sp.		0,3	1,9	5,4	1,1		1,8
Other Pisces		2,2	4,1	2,7	1,1	0,2	1,5
CRUSTACEA	*80,1*	*81,5*	*52,1*	*21,0*	*5,7*	*5,7*	*14,6*
Gammaridea	25,0	18,0	4,6	1,5	0,7	0,5	1,5
Mysidacea	50,8	54,6	41,9	17,1	3,8	0,9	10,3
Chionoecetes opilio			0,0	0,2	0,8	2,7	1,1
Other crustaceans	4,3	8,9	5,6	2,1	0,4	1,5	1,7
MOLLUSCA	*0,1*	*0,5*	*2,5*	*0,7*	*3,7*	*21,5*	*7,3*
Bivalvia	0,1	0,3	2,2	0,6	3,3	21,3	7,0
Other Mollusca		0,2	0,3	0,1	0,4	0,1	0,3
ECHINODERMATA	*0,2*	*3,1*	*2,2*	*2,5*	*9,2*	*24,5*	*10,8*
Echinarachnius parma		0,0	0,6	1,2	4,9	11,2	5,2
Ophiuroidea	0,2	1,4	1,6	1,3	4,1	13,2	5,5
Other echinodermata		1,6	0,0		0,3		0,1
OTHER INVERTEBRATES	*15,7*	*11,7*	*5,1*	*1,7*	*3,4*	*7,3*	*4,4*
Polychaeta	15,7	11,4	3,8	1,2	0,5	0,1	1,1
Ctenophora			0,0	0,3	1,7	5,8	2,2
Anthozoa		0,3	1,1	0,2	1,1	1,4	1,0
Other invertebrates		0,1	0,2	0,0	0,2	0,0	0,1
OTHER	*4,0*	*0,6*	*1,1*	*0,8*	*0,4*		*0,4*
No. indivs. sampled with stomach contents	82	570	632	467	401	184	2336

Table 9.- Volume (%) of the main preys for *H. platessoides* by lenght groups in Div. II b (ICES) in 2002.

Preys	Size range (cm) 20-29	30-39	Total
PISCES		40,0	40,0
Melanogrammus aeglefinus		40,6	35,4
Unidentified Pisces		7,1	6,2
CRUSTACEA	*42,2*	*40,6*	*40,8*
Gammaridea	0,9		0,1
Mysidacea	41,4	5,1	9,7
Paguridea		10,2	8,8
Pandalus borealis		25,4	22,1
MOLLUSCA	23,3	0,0	3,0
Pectinidae	23,3		3,0
ECHINODERMATA	*24,1*	*0,5*	*3,5*
Ophiuroidea	24,1	0,5	3,5
OTHER INVERTEBRATES	*10,3*	*11,2*	*11,1*
Anthozoa		11,2	9,7
Bryozoa	3,4		0,4
Polychaeta	6,9		0,9
No. indivs. sampled with stomach contents	6	7	13

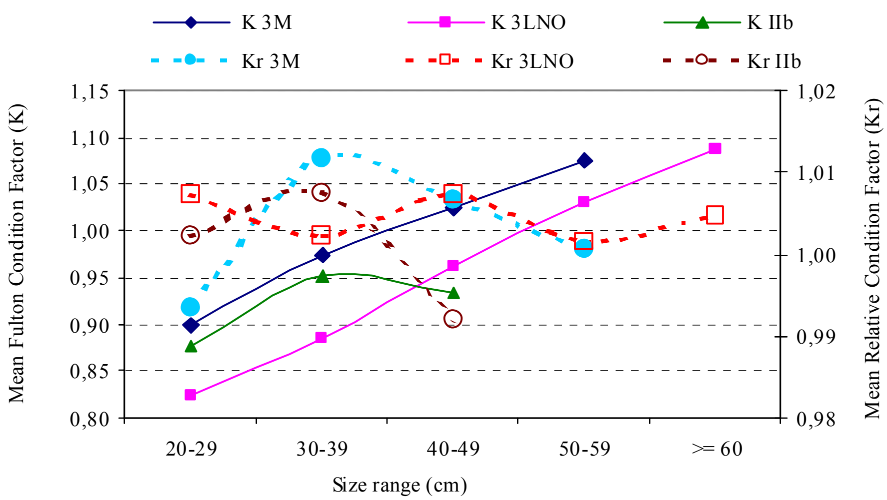

Figure 1.- Mean Fulton Condition Factor (left) and Mean Relative Conditon Factor (right) of *H. platessoides* by size range (cm) and area. The sampled periods were: 1992-03 in 3M, 1995-03 in 3LNO and IIb.

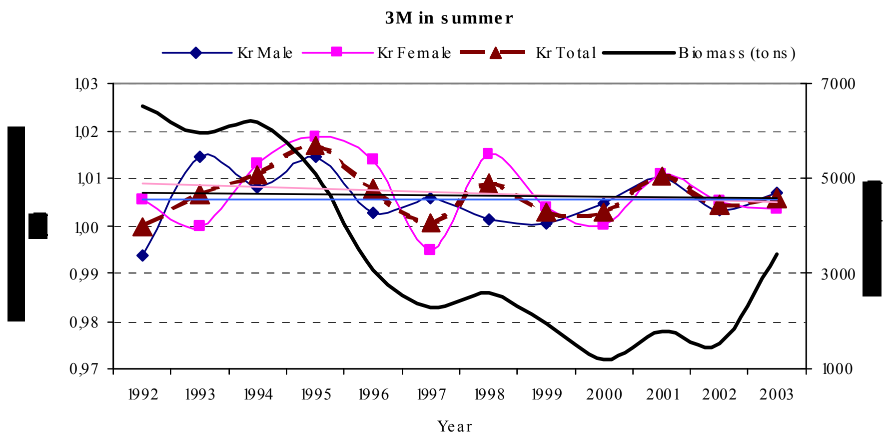

Figure 2.- Mean Relative Condition Factor and biomass estimated of *H. platessoides* by year in summer in 3M from 1992 to 2003.

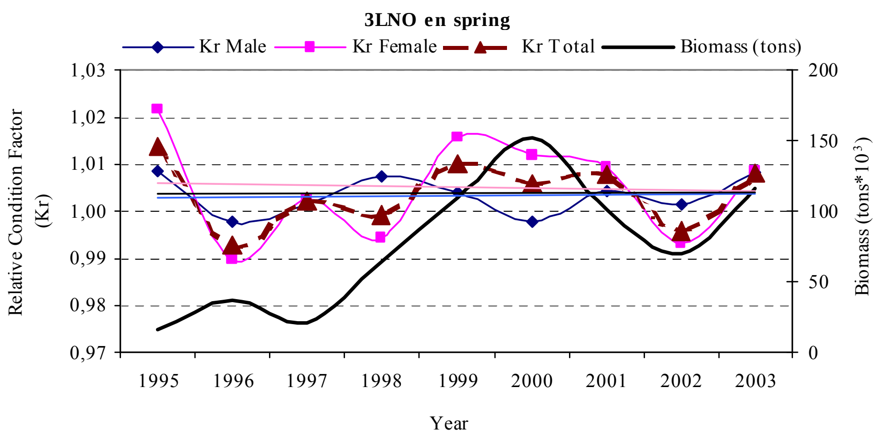

Figure 3.- Mean Relative Condition Factor and biomass estimated of *H. hippoglossoides* by year in spring in 3LNO from 1995 to 2003. Biomass data corresponds with Platuxa Spanish Survey in 3NO.

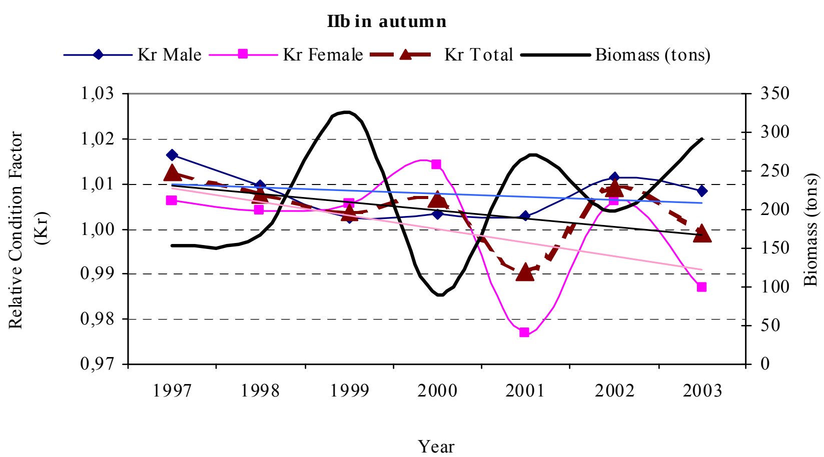

Figure 4.- Mean Relative Condition Factor and biomass estimated of *H. platessoides* by year in autumn in IIb from 1995 to 2003. Data biomass from "Fletán Ártico" Spanish Survey in Svalbard area (IIb).

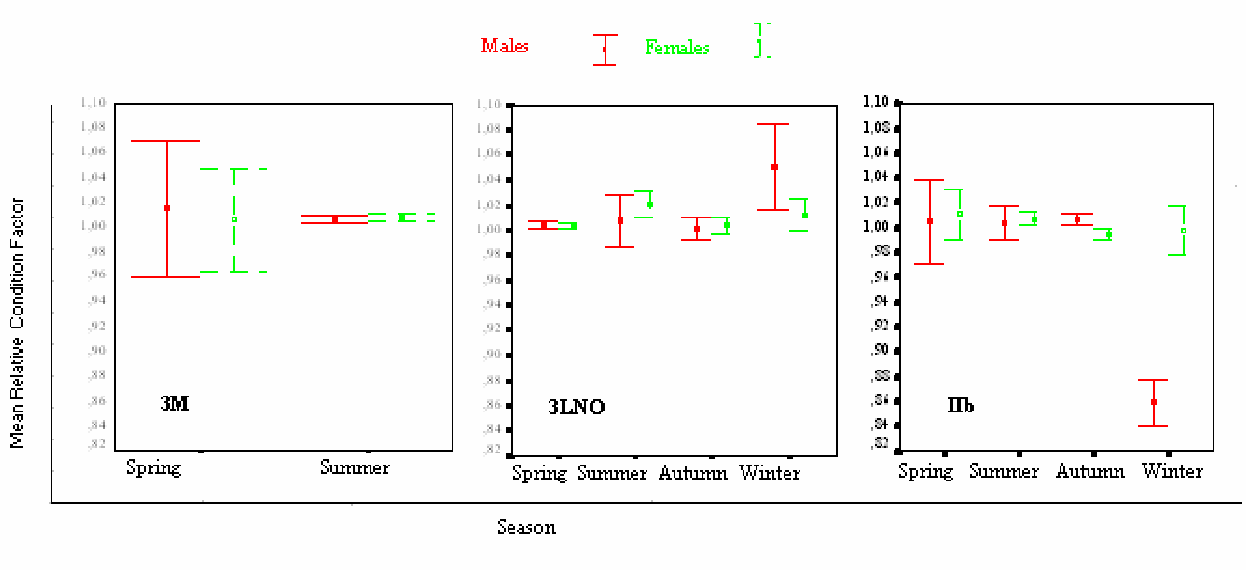

Figure 5.- Mean Relative Condition Factor (with 95% confidence interval) of H. platessoides by sex and season in each area. The sampled periods were: 1992-03 in 3M, and 1995-03 in 3LNO and IIb.

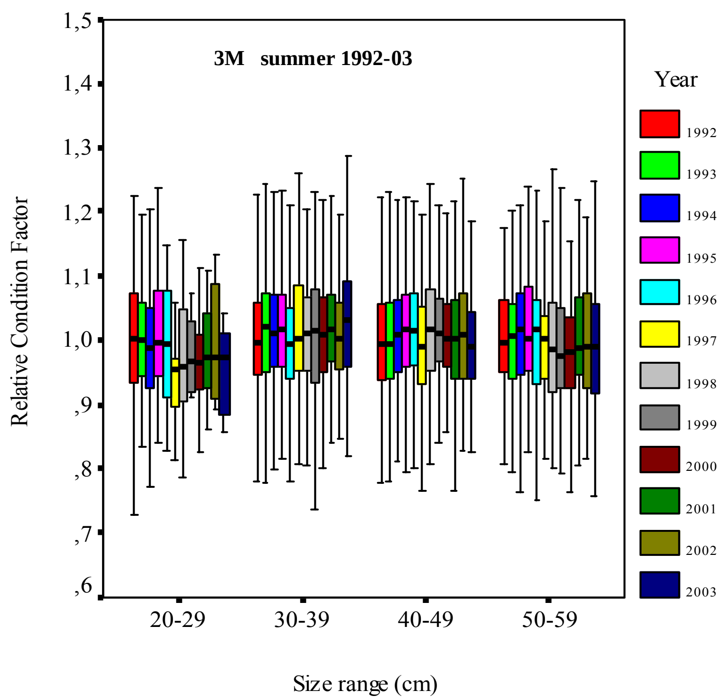

Figure 6.- Mean Relative Condition Factor of *H. platessoides* by year and length (cm) in each season in 3M from 1992 to 2003. Boxplots show the median and interquartile range.

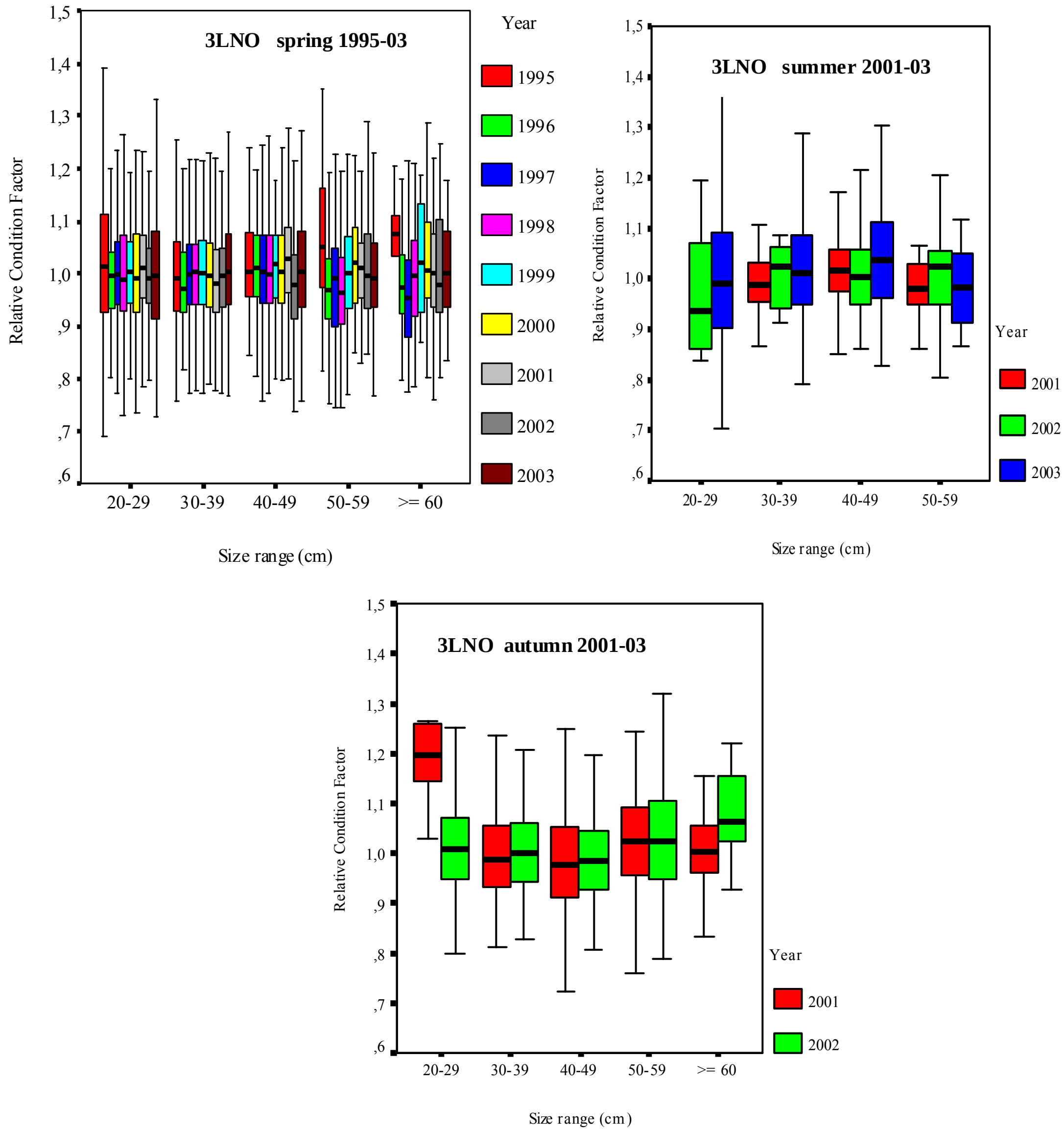

Figure 7.- Mean Relative Condition Factor of *H. platessoides* by year and length (cm) in each season in 3LNO from 1995 to 2003. Boxplots show the median and interquartile range.

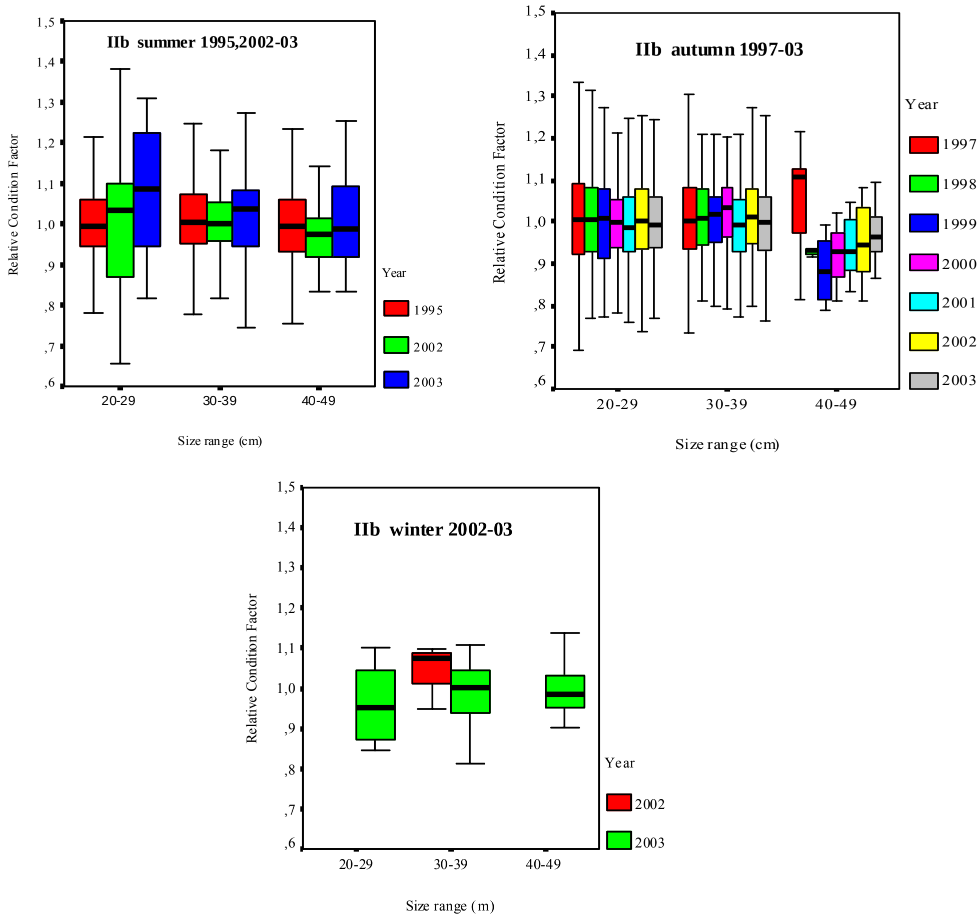

Figure 8.- Mean Relative Condition Factor of *H. platessoides* by year and length (cm) in each season in IIb from 1995 to 2003. Boxplots show the median and interquartile range.

Figure 9.- Mean Relative Condition Factor of *H. platessoides* by sex and maturity in each area from 1992 to 2003.

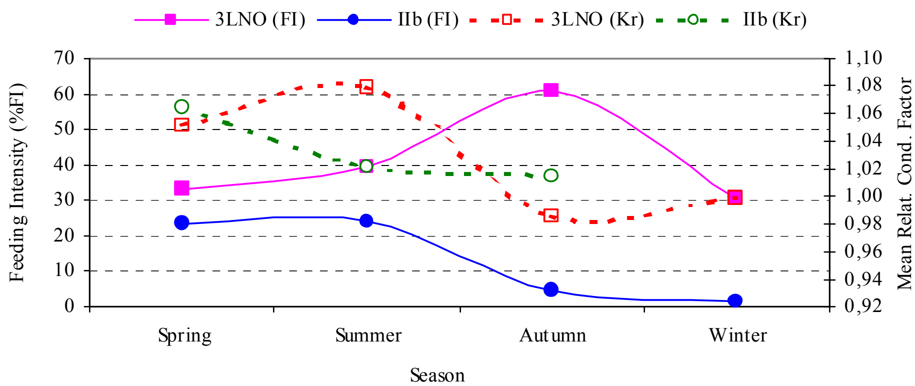

Figure 10.- Feeding Intensity (FI%) and Mean Relative Condition Factor (*Kr*) of spawning females of *H. platessoides* from 1995 to 2003. F=Females; M=Males

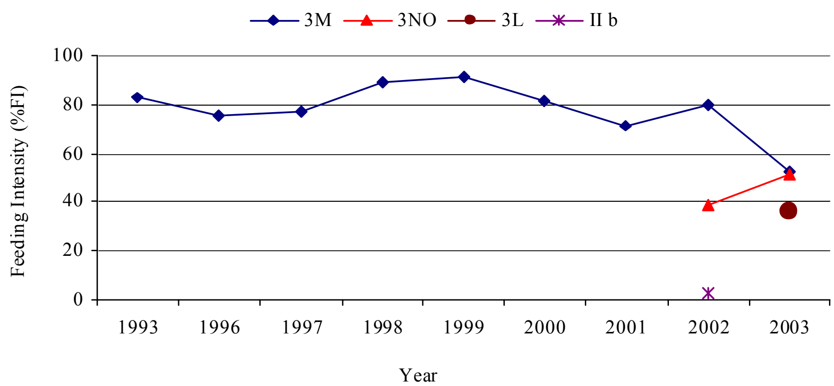

Figure 11.- Feeding Intensity in the feeding habits data of *H. platessoides* in North Atlantic area. NAFO (3M, 1993-03; 3LNO, 2002-03) and ICES (IIb, 2003).

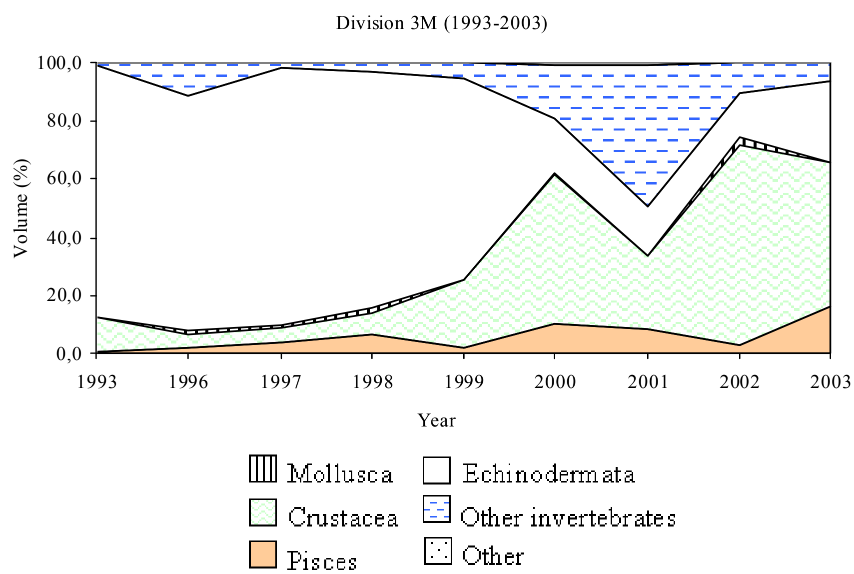

Figure 12.- Volume (%) of the main prey groups for *H. platessoides* in Flemish cap (Div. 3M), 1993-2003.

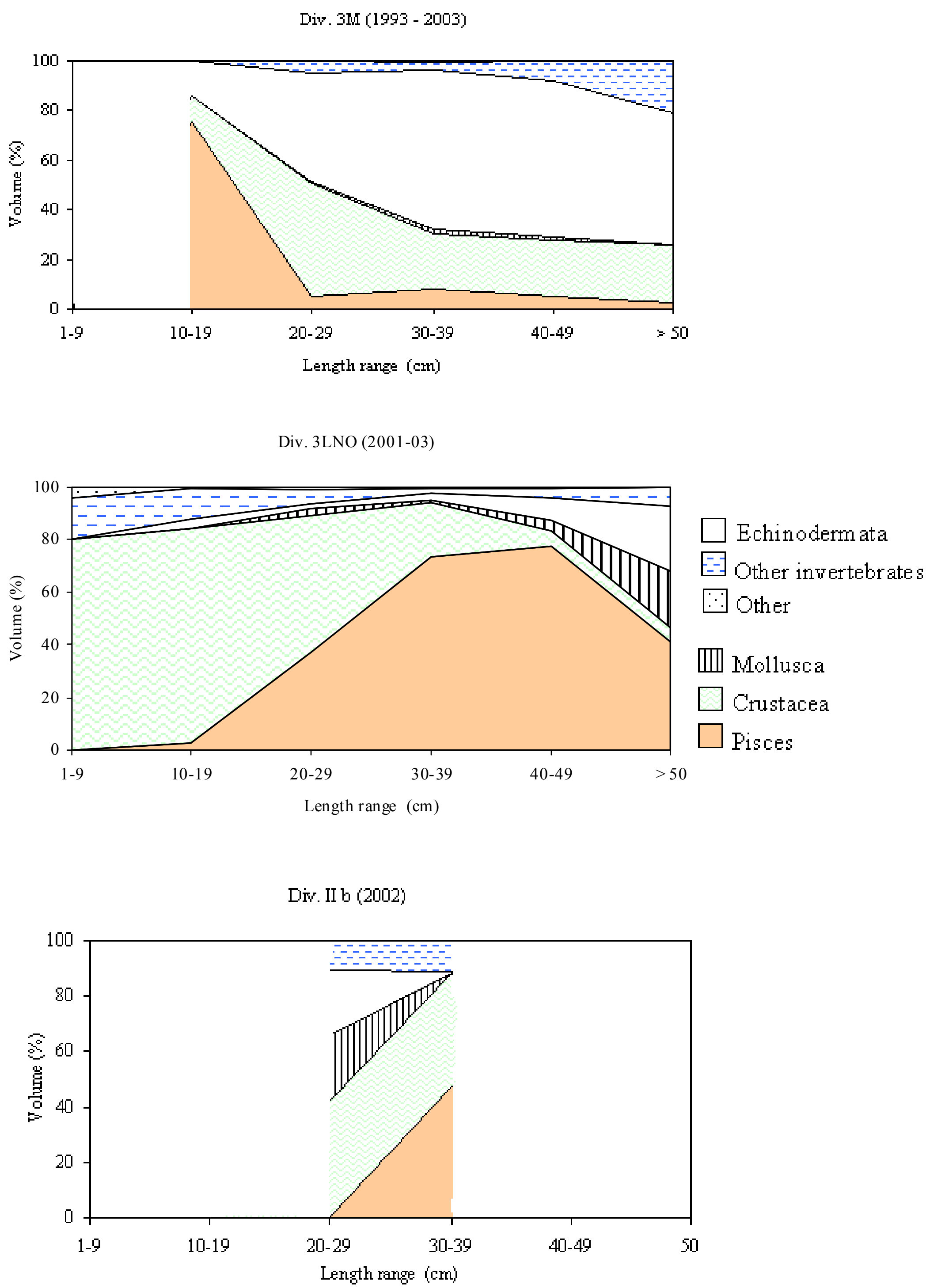

Figure 13.- Volume (%) of the most prey groups by size range (cm) for *H. platessoides* in NAFO (3M, 1993-03; and 3LNO, 2001-03) and ICES (IIb, 2002).