NAFO Sci. Coun. Studies, 23: 55–64

Effect of the Feeding Activity on the Catch Rates in the Greenland Halibut (*Reinhardtius hippoglossoides*) Fishery in Flemish Pass Area (1991–92)

S. Junquera
Instituto Español de Oceanografia
Apdo. 1552, 36280 – Vigo, Spain

Abstract

Feeding activity of Greenland halibut (*Reinhardtius hippoglossoides*) was compared with the trends in catch rates of the commercial fishery on a seasonal and 24-hr per day basis in the Flemish Pass area in NAFO Div. 3LM and northern part of Div. 3N. The percentage of empty stomachs (PES) was taken as the index of feeding activity. A diel cycle in feeding activity was observed to be related to length, with a day-time (0600–1200 hr interval) maximum in smaller fish (<60 cm) and at evening – night (1800–2400 hr and 0000–0600 hr intervals) in the largest fish (>80 cm). Seasonal variations in the PES, that matched the seasonal pattern of variation in catch rates, were only observed in depths between 700–899 m. In deeper waters no seasonality appeared at all. Feeding activity increased with both depth and size of the fish. Catch rates decreased in autumn, but reached a maximum in winter. In the winter, increased catches occurred mainly at night (0000–0600 hr interval) and were based on the smallest length-class (<60 cm) which feeds the least during this time interval. An inverse relationship between feeding activity and fish availability is proposed.

Key words: Catch rate, feeding, Flemish Pass, Greenland halibut

Introduction

Greenland halibut (*Reinhardtius hippoglossoides*) is the target species of the deep-water Spanish trawler fleet in the Flemish Pass area (NAFO Div. 3LM and northern part of Div. 3N, Fig. 1). This fishery has been monitored since it began in 1990, by observers on board each trawler throughout the fishing season. This provides important information on fishing effort and catch rates, as well as a continuous and thorough biological sampling of this species. In addition it provides an exceptional opportunity to analyze variations in biological traits of the fish which may affect their catchability over long time periods.

The diet and morphology of Greenland halibut indicate that it has a more pelagic way of life than other flatfishes (Smidt, 1969; Haug and Gulliksen, 1982). It is considered to spend a considerable amount of time in the upper water layers, and this is likely to be linked, at least in part, with its feeding behaviour.

The objective of this paper is to examine the seasonal and diel cycles in feeding activity, and to compare them with the catch rates of the fishing fleet, using data provided by observers on board the commercial ships. The basic hypothesis of this paper is that if the extent of the vertical migrations is related with feeding activity, then the withdrawal of fish from the bottom should result in a decrease in catchability as the gear used is a bottom-trawl.

Materials and Methods

From July 1991 to July 1992, 114 835 stomachs, of Greenland halibut in the Flemish Pass ranging in length from 30 to 105 cm, were examined (Table 1). For data processing, the fish length range was divided into three categories: <60 cm, 60–80 cm and >80 cm. Fishing activity was restricted to depths greater than 700 m, and three depth strata were defined: 700–899 m, 900–1 099 m and 1 100–1 500 m.

Tows lasted an average of five hours, and the position, time, depth and catch were recorded for each one. In the tows sampled, the Greenland halibut total length, sex and maturity stage were recorded. The degree of stomach fullness was visually determined according to a 4-point scale: 1 – empty; 2 = 1/2 full; 3 = full; 4 = everted or with signs of regurgitation. For each month, data from 5 observers (on board 5 ships) sampling randomly on a 24-hr per day basis throughout the entire depth range were selected. Only 4 of these observers meeting the criteria were available for the period January and April 1992.

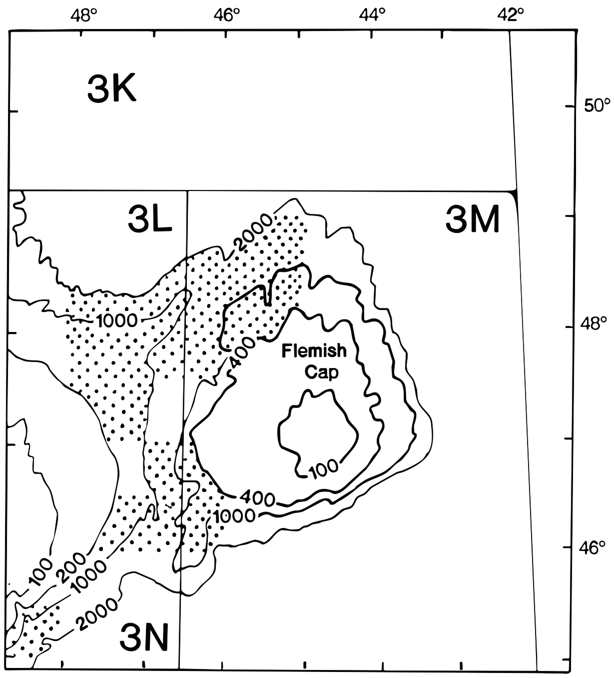

Fig. 1. Sampling area in the Flemish Pass during July 1991–July 1992 (depth in meters).

The percentage of empty stomachs (PES) was used as a measure of feeding intensity. It was selected as the simplest and least ambiguous of the degrees of fullness, to avoid bias due to differing criteria between observers. The PES was assumed to properly describe trends in feeding activity since regurgitation in this species was found to be negligible (1.5% of the stomachs examined), in accordance with observations in other flatfish (Bowman, 1986). Diel changes in the PES were analyzed by the means obtained by grouping samples by length categories and by depth strata, for each 6-hr interval of the 24-hr day. For this purpose, the midpoint of the tow from which they came was the reference time. Monthly feeding activity was analyzed by the monthly means of the PES obtained by grouping samples by length categories and by depth strata. The PES was calculated independently for each observer to evaluate the consistency of the results. Only large samples (more than 50 individuals examined per tow) were taken into account for the calculations. The differences in PES among observers in relation to the variability in the monthly and daily means were evaluated by respective two-way ANOVA (observer-month and observer-time), using the program BMDP 7D (Dixon *et al.*, 1983). The homoscedasticity of the factors compared had been previously tested by means of a Levene's test.

The catch rates (kg/hr) by month and by the time intervals defined above were computed, with only two of the five vessels used to obtain the PES (one from July to January 1991 and another from January to July 1992). The reason for this was that it is known that the different characteristics of the fishing vessels produce a great amount of variability in their catch rates (Junquera *et al.*, MS 1992; Cárdenas *et al.*, MS 1993), and this could mask any seasonal variation. To make the trends in the yield of these two trawlers comparable, a coefficient was applied to balance their differences in fishing power, obtained by means of the multiplicative model of Vazquez (1981). Catch rates in the 6-hr intervals were distributed amongst the length categories, using the length distributions of the corresponding month and hour interval to obtain the fraction in weight of those length categories in the total catch.

TABLE 1. The sampling carried out by the observers during the Spanish fishery for Greenland halibut from July 1991 to July 1992.

Sampling period	No. of observers	No. of stomachs	No. of sets
Jul 1991	5	12 292	125
Aug 1991	5	13 747	147
Sep 1991	5	9 455	105
Oct 1991	5	10 208	128
Nov 1991	5	11 430	135
Dec 1991	5	6 271	69
Jan 1992	4	5 580	61
Feb 1992	5	7 602	82
Mar 1992	5	8 003	90
Apr 1992	4	6 905	75
May 1992	5	10 289	112
Jun 1992	5	13 053	142
Total		114 835	1 271

As the length distribution of this species in the catch is closely related with depth (Junquera *et al.*, MS 1992), a narrow range of depth was selected (900–1 099 m). In this way the differences in yield by length can be safely compared with the hour, whereas if a larger depth range were involved, the increase in abundance of the larger fish with depth would hide any variation due to the time of day. Catch rates in the time intervals have been calculated for the periods July–August, October–November, January–February and April–May.

Results

Monthly variations in the PES

The monthly means in the PES by depth strata are shown in Fig. 2. Maximum feeding activity (minimum values of PES) in the shallowest depth stratum (700–899 m) was observed from September to November, but no seasonality was evident at greater depths. However, average PES decreased with depth indicating an increase in feeding activity. Monthly variations in the PES obtained by depth strata were significant (5% significance level) only in the 700–899 m depth stratum (F = 10.29; d.f. = 11,132) while 'observer' factor was not significant in any case. There was a lack of seasonality in the monthly means of the PES based on length categories (Fig. 3) in both groups 60–80 cm and >80 cm. In the smaller one (<60 cm), a slight decrease in the PES appeared again in autumn, but it was associated with an increased variance. In fact, the ANOVA of the monthly means of the PES obtained in this way showed that monthly variations in the PES were not significant in any length group, whereas the 'observer' factor had monthly significant variations (5% significance level) in the <60 cm length category (F = 10.78; d.f. = 11,132) and in the 60–80 cm length category (F = 5.20; d.f. = 11,132).

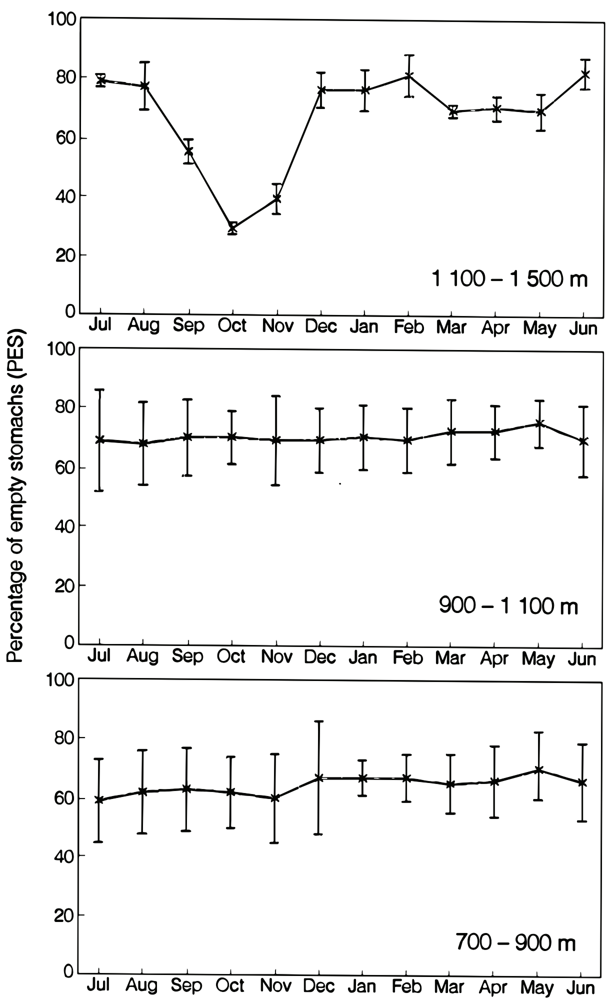

Fig. 2. Monthly means and standard deviations in the percentage of empty stomachs (PES) by depth strata.

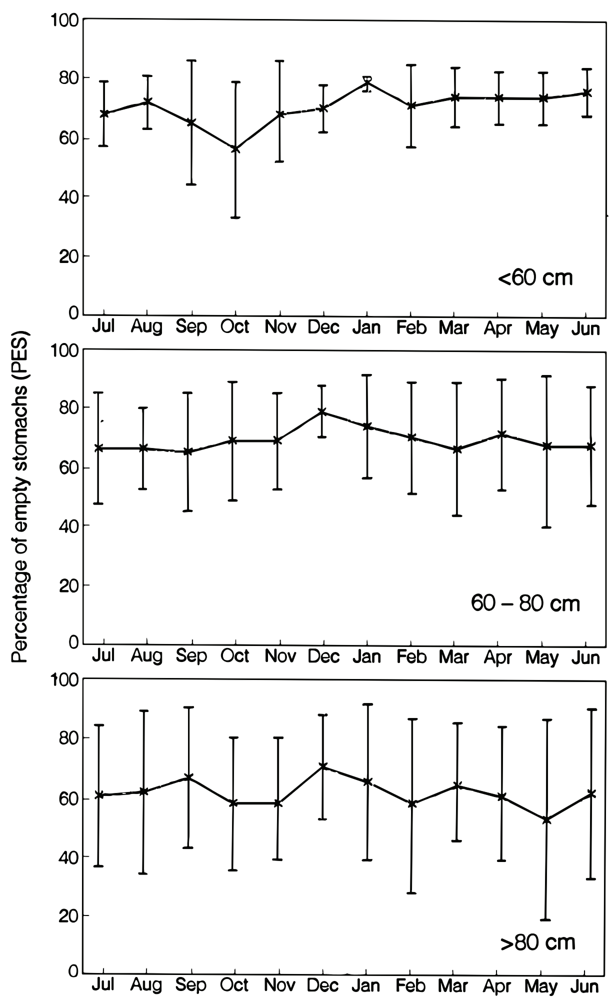

Fig. 3. Monthly means and standard deviations in the percentage of empty stomachs (PES) by fish length categories.

Diel variations in the PES

When data were grouped by depth strata, the mean PES among observers for the hour intervals showed no detectable trend. The two-factor ANOVA applied on data grouped in this way indicated that neither the 'observer' factor nor the 'hour interval' factor had a significant influence on the variance of the results (5% significance level) during the year. However, if data were grouped by length categories (Table 2), a clear pattern of daily variation in PES was seen (Fig. 4). For the smaller fish (<60 cm), peak feeding activity (minimum values of the PES) was at day-time, in the 0600–1200 hr interval throughout the year, although high feeding activity also occurred in the 1200–1800 hr interval in late summer and autumn. In January, the differences in the means of PES by hour were small, although a slight decrease in the 0600–1200 hr interval could still be observed. Conversely, in the largest fish (>80 cm), the peak in feeding activity occurred, for most part of the year, in the 1800–2400 hr interval, and also at night (0000–0600 hr interval). In the intermediate category (60–80 cm) the minimum in PES was observed every month in the 0600–1200 hr interval and the maximum in the 1200–1800 hr interval. With the exception of the smallest length category, these patterns in feeding activity remained invariant throughout the year. The two factor ANOVA of the data grouped in this way (Table 3) showed that the differences in the means of the PES by time intervals were significant for all length categories (5% significant level), while the 'observer' factor was not significant in any case.

Trends in catch rates

Figure 5 shows the monthly catch rates (kg/hr) for the period July 1991 to June 1992 in the depth range 900–1 099 m. They decreased continuously during summer and autumn, with a pronounced minimum in November, increased in winter when maximum values were attained, and decreased again in spring. Catch rates by hour intervals showed a similar pattern of seasonal variation. It was remarkable however that in winter, the indicated increase in catch rates was most pronounced at night (0000–0600 hr and 1800–2400 hr intervals) while being far less important at day-time (0600–1200 hr interval).

As fish of different lengths showed different feeding patterns, the possible influence on catchability could not be observed with an overall CPUE index. So catch rates by length groups were calculated and compared with the corresponding 24-hr cycle in feeding activity. The results (Fig. 6a,b) indicated that, for the smallest fish (<60 cm), lower catch rates coincided with the hours of high feeding activity (lower PES), which was in day-time. Some discrepancy was observed in winter, where low catch rates coincided with high values of PES in both 1200–1800 hr and 1800–2400 hr intervals and in spring, where the lowest catch rate coincided with a high PES in the 1800–2400 hr interval. In the largest fish (>80 cm), peak catch rates occurred in day-time and also coincided with the lowest feeding activity. Fish of this length category disappeared in winter and spring from the depth range analyzed here (900–1 099 m). In the intermediate length category (60–80 cm), the correspondence between hours of low PES and high catch rates was not so clear, as it did not appear in autumn, when catch rates remained almost invariant around the 24-hour cycle and in winter, when high PES were found together with low catch rates in the 0900–1200 hr interval. In this season, however, peak catch rates coincided again with low feeding activity in the 1800–2400 hr interval. The seasonal cycle of catch rates for each length-class at the reference depth stratum (900–1 099 m) showed that small (<60 cm) and medium (60–80 cm) sized fish were dominant and equally represented in summer and autumn catches, although the largest fish (>80 cm) still contributed significantly. However, in winter and spring, the medium size fish contributed little and the largest fish nothing. This may indicate a seasonal shift of medium and large fish into deeper waters.

Discussion

The seasonal variability of the catch rates, where peak values are attained in winter and minimum values in autumn, is a known characteristic of the Greenland halibut fishery in Flemish Pass (NAFO Div. 3LM and northern area of Div. 3N) (Junquera *et al.*, MS 1992; De Cárdenas *et al.*, MS 1993). The existence of a relationship between vertical migrations of fish and catch rates has already been described in several fish stocks (Beamish, 1966; De Groot, 1971; Bowering and Parsons, 1986). On the basis of the data analyzed here, it is concluded that feeding activity of fish, which is assumed to be closely related with vertical migrations, may have an influence on the availability to the fishing gear and may contribute to explain the seasonal patterns in catch rates. Nevertheless, this relationship must be considered with caution, partly because data do not always support it and because there are many other factors which produce variability in both catch rates and PES.

Some authors give information on the seasonal variations in the feeding activity of Greenland halibut, but these results refer to shallower depths than the ones involved here. Chumakov and Podrazhanskaya (1986) indicate an increase, in the Northwest Atlantic, in feeding activity during the summer and autumn and a decline during the winter, coinciding with the results of Solmundssen (1994) in the north and east of Iceland, while in the

TABLE 2. Monthly percentages of empty stomachs (PES) by hour interval and length-classes, indicating the number of stomachs examined and standard deviations.

Date	Time Interval	Length <60 cm PES	Length <60 cm Num.	Length <60 cm SD	Length 60–80 cm PES	Length 60–80 cm Num.	Length 60–80 cm SD	Length >80 cm PES	Length >80 cm Num.	Length >80 cm SD
Jul 1991	0–6 hr	77	1 085	14	41	1 383	16	37	98	17
	6–12 hr	49	686	16	29	150	13	79	1 863	17
	12–18 hr	59	215	16	72	2 483	13	48	614	15
	18–24 hr	75	2 088	17	45	1 140	11	28	158	11
Aug 1991	0–6 hr	82	1 414	7	51	1 041	16	21	131	4
	6–12 hr	57	1 746	17	35	255	16	79	1 723	10
	12–18 hr	70	1 032	15	66	2 967	20	49	630	9
	18–24 hr	78	1 770	12	56	904	7	29	137	12
Sep 1991	0–6 hr	84	680	7	53	539	11	43	149	18
	6–12 hr	64	734	13	27	127	7	80	1 767	13
	12–18 hr	28	143	6	73	456	11	60	793	8
	18–24 hr	83	863	8	51	1 113	15	28	99	13
Oct 1991	0–6 hr	83	564	7	60	397	17	26	91	13
	6–12 hr	45	736	10	30	122	14	71	2 312	11
	12–18 hr	24	410	2	76	2 228	9	53	1 333	12
	18–24 hr	72	616	14	55	1 307	13	29	654	18
Nov 1991	0–6 hr	91	263	7	61	1 104	13	31	223	13
	6–12 hr	53	593	19	37	241	9	72	1 382	14
	12–18 hr	50	544	9	73	2 934	14	47	704	19
	18–24 hr	81	1 455	9	49	1 893	12	36	94	15
Dec 1991	0–6 hr	81	322	12	63	508	5	49	225	14
	6–12 hr	59	342	17	54	204	13	75	402	19
	12–18 hr	81	411	10	73	1 608	10	64	217	12
	18–24 hr	74	916	12	63	823	19	38	146	13
Jan 1992	0–6 hr	84	400	5	45	205	9	45	91	11
	6–12 hr	74	209	13	37	97	9	80	1 001	6
	12–18 hr	80	430	3	72	1 409	20	61	271	12
	18–24 hr	80	744	5	64	618	14	23	83	9
Feb 1992	0–6 hr	78	756	7	45	305	5	33	121	15
	6–12 hr	47	617	14	43	102	10	80	975	6
	12–18 hr	80	524	11	81	2 350	5	43	172	9
	18–24 hr	79	899	5	49	660	3	15	106	6
Mar 1992	0–6 hr	84	503	3	51	517	12	33	122	12
	6–12 hr	57	238	11	30	109	5	77	1 127	6
	12–18 hr	75	189	19	81	2 328	7	52	234	8
	18–24 hr	79	1 308	6	50	887	12	44	145	13
Apr 1992	0–6 hr	82	762	7	48	465	11	40	124	12
	6–12 hr	60	728	13	44	148	13	77	205	6
	12–18 hr	75	196	9	83	2 092	4	49	76	7
	18–24 hr	81	1 129	7	55	883	8	25	97	6
May 1992	0–6 hr	86	602	5	47	507	16	22	123	16
	6–12 hr	63	845	15	28	125	19	85	1 805	3
	12–18 hr	76	1 046	5	81	3 516	5	44	571	8
	18–24 hr	80	2 129	9	51	982	13	15	154	10
Jun 1992	0–6 hr	82	642	5	49	559	13	29	75	12
	6–12 hr	65	2 033	20	36	255	10	84	2 143	8
	12–18 hr	83	1 260	4	81	2 501	8	54	903	8
	18–24 hr	82	1 987	6	56	714	12	28	101	7

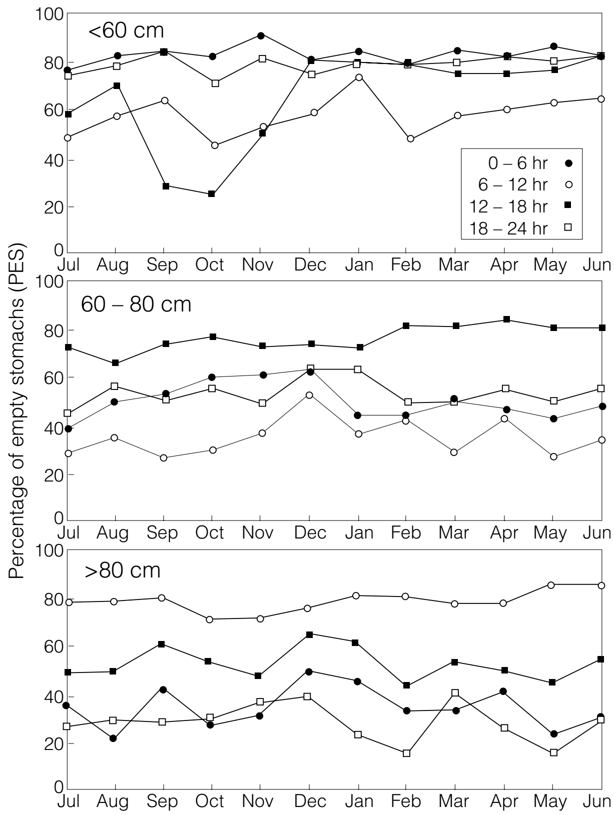

Fig. 4. Monthly means of the percentage of empty stomachs (PES) by hour intervals of the day and fish length categories.

Barents Sea Yang and Livingston (1988) find the lowest percentage of empty stomachs in summer and the highest in spring (except for fish larger than 70 cm) and no results reported in winter. Conversely, Pedersen and Riget (1993), in West Greenland waters, find no seasonal differences in the average degree of stomach fullness. In the present study, an increase in feeding activity was only observed in autumn at the shallowest depths (700–899 m) and in the smallest length category (<60 cm). However, the seasonal variations in the latter were not statistically significant due to an increase in the variance between observers, probably related to the diel pattern which appeared in this length category. In both deeper strata and larger fish no seasonal trend was observed although there was an increase in feeding activity with depth, as already shown by Chumakov and Podrazhanskaya (1986). This result is consistent with the higher feeding activity observed in the largest fish which are more abundant in the deepest areas (Junquera *et al.*, MS 1992).

De Groot (1971) described the Pleuronectidae as day feeders but lists many exceptions to this general rule. From the present study, it may be concluded that diel patterns in feeding activity are length related, since the smaller fish (<60 cm) seem to be mostly day feeders and the largest ones (>80 cm) night feeders, while the intermediate length category (60–80 cm) showed no definite diel pattern. Other studies show varied results: Yang and Livingston (1988) indicate the absence of a clear diel feeding trend in Greenland halibut in the eastern Bering Sea, although from their data there appears to be a tendency towards higher feeding activity in day-time in their smaller length group (30–49 cm), and less clearly, at night in their largest one (> = 79 cm), with no trend in the intermediate length group (50–69 cm) which agrees with the results of the present study; Tremblay and Axelsen (1981) suggest the possible existence of diel variations in feeding activity in the Gulf of St. Lawrence as an explanation for the high percentage of empty stomachs that they found. Conversely, Shuntov (1970) in the Okhotsk Sea, and Bowering and Lilly (1992), in Labrador and northwest Newfoundland, found that this species fed continuously, although the former indicate that feeding was somewhat higher during the night. The lack of agreement between those results and the differences between length-classes may indicate that Greenland halibut shows no definite common diel pattern in feeding activity but rather diel variations related with prey availability. It is well known in this species that diet varies with size (Smidt, 1969; Chumakov and Podrazhanskaya, 1986; Bowering and Lilly, 1992, Rodriguez-Marin *et al.*, 1995). Differences between length groups in the peak hours of feeding may be explained by the rhythms in the availability of their respective prey, as already indicated in other flatfishes (Zamarro, 1992). In the intermediate sized fish, the most prominent feature was a minimum in

TABLE 3. Two-factor ANOVA of the percentage of empty stomachs (PES) by fish length categories.

Factor	Length		
	<60 cm	60–80 cm	>80 cm
Time interval (d.f. = 3,416)	33.22	71.90	59.99
Observer (d.f. = 13,416)	2.12	1.21	1.00
Interaction (d.f. = 156,416)	1.00	1.35	1.24

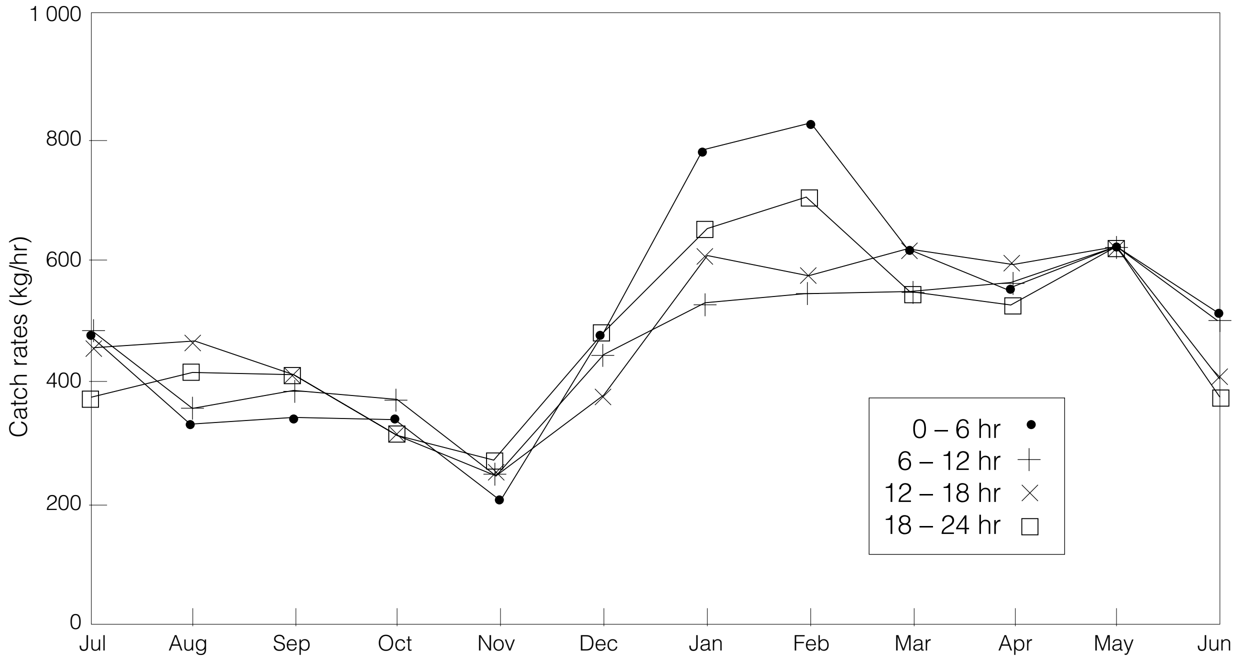

Fig. 5. Monthly catch rates (kg/hr) by hour intervals of the day in the depth range of 900–1 099 m.

feeding activity in the afternoon (1200–1800 hr interval) throughout the year. Feeding was usually maximal by day, but some feeding also occurred by night, and was occasionally quite significant.

Bowering and Lilly (1992) report an abrupt change in diet at lengths of 64–69 cm. So the length interval used here (60–80 cm) may be somewhat difficult to compare as it may include fish with different feeding habits. Another factor to be taken into account is the long time which would be expected for stomach evacuation in a fish feeder species (De Groot, 1971) which would tend to obscure the detection of any pattern of diel variability. There was no available field information on stomach evacuation rates of Greenland halibut in the area analyzed. From Yang and Livingston (1988), based on theoretical parameterization of the Elliott and Parsons (1978) model, and for the diet of this species in this area, mainly fish and cephalopods (Rodriguez-Marin *et al*., 1995), it may be deduced that digestion might take longer than one day. However, the results of the present study, which are based on long-term field sampling, and the high degree of agreement between observers, supports the fact that, at least for the period of time and the area analyzed here, the PES do vary significantly within a diel cycle.

The catch rates calculated in this study with only two vessels, coincide with the seasonal patterns as described above (De Cárdenas *et al*., MS 1993), shown by the whole fleet . It must be noted that in the present study the catch rates were analyzed in the 900–1 099 m stratum, and at this depth no seasonal change in the PES was detected, while the autumn increase in feeding activity was only relevant in the shallowest depth stratum and in the smallest length category (<60 cm). Consequently, seasonal variations in the PES and in the catch rates refer to different depths. The possible link between both observations could be based on the smallest fish (<60 cm), as they were dominant in the shallowest depth stratum, but were still an important part of the catches in the stratum selected to analyze the catch-rate trends.

The relationship between catch rates and feeding activity was also supported by the observed trends in diel cycles in feeding activity. The smallest (<60 cm) and the largest fish (>80 cm) showed opposite daily cycles since the former feed mainly by day and the latter by night. The winter catch rates were higher by night (0000–0600 hr interval) and this increase was mostly based on smaller fish (<60 cm), which showed the highest PES during this time interval. The coincidence was clear between high catch rates and low feeding activity, and the reverse was quite clear too in the largest fish (>80 cm) in summer and spring. But the patterns of the larger fish should not affect catch rates greatly since their contribution by weight to the catch is low. Bowering and Parsons (1986) find diel changes in the vertical distribution and in the availability to bottom

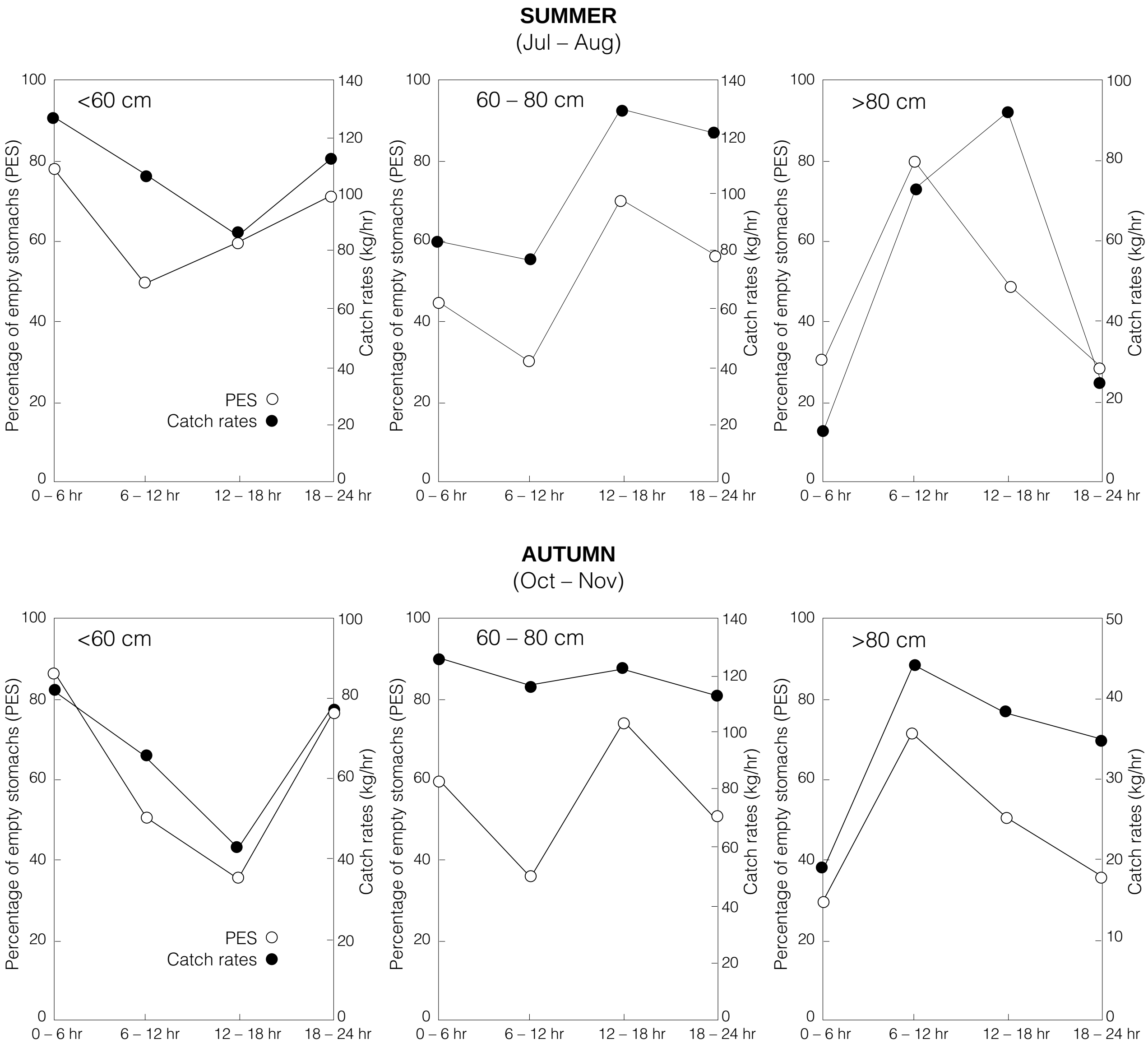

Fig. 6a. Catch rates (kg/hr) and PES by length categories and hour intervals of the day in summer (July–August) and autumn (October–November), in the depth range of 900–1 099 m.

trawling of Greenland halibut of different sizes in the Labrador Channels in summer. However, these results are opposite to the ones obtained in the present study, as they report higher numbers and smaller sizes of fish caught during the hours of daylight, but they do not relate the diel trends with the feeding activity of fish. Discrepancies observed in the results of the present study between the diel cycle in feeding activity and catch rates by length-class may be due to two causes: one is that the former is calculated with data from 5 vessels, while catch rates are derived from only one vessel in summer and autumn, and another vessel in winter and spring. A second cause may be that feeding activity is not the only expected factor affecting fishing efficiency.

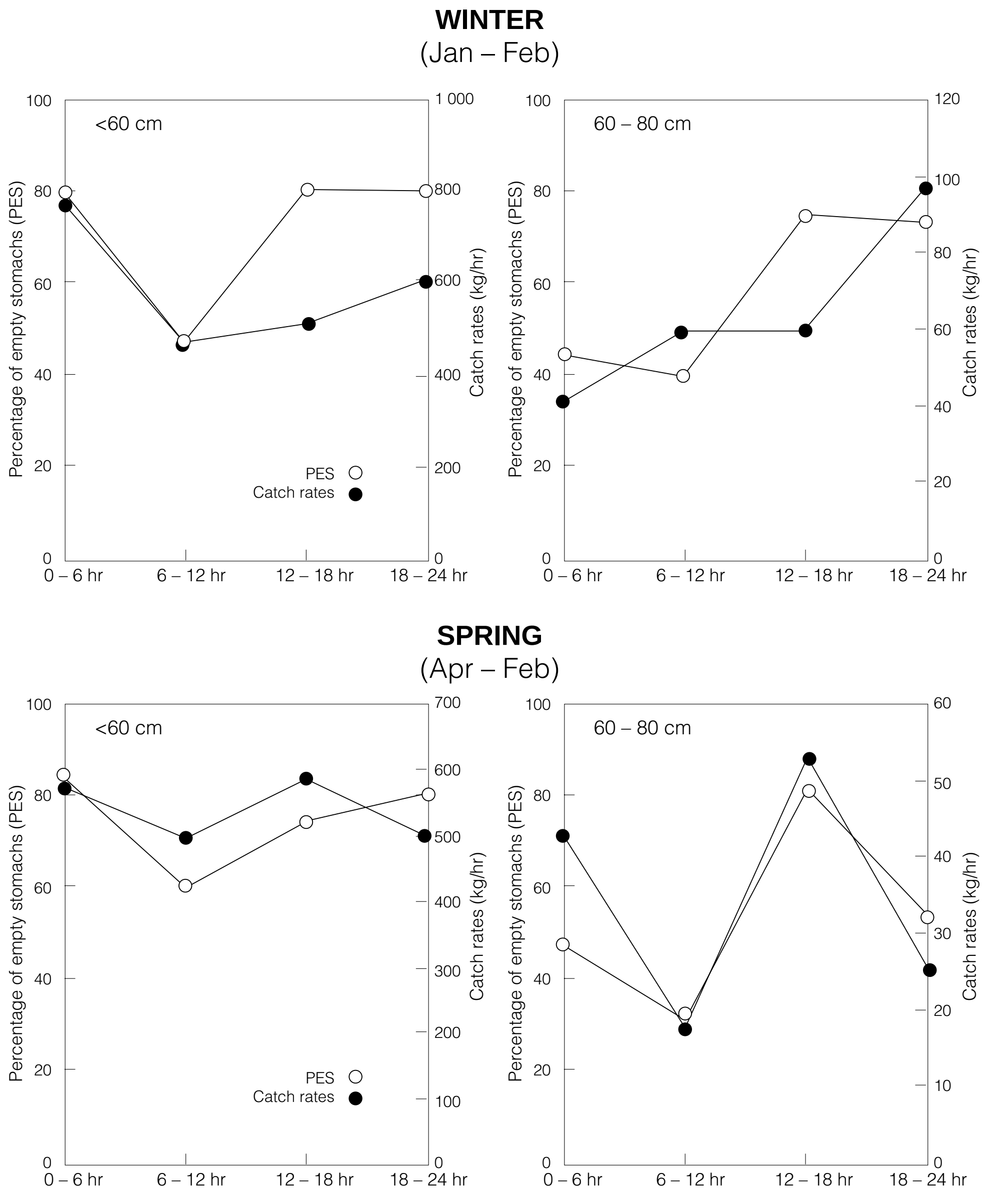

Fig. 6b. Catch rates (kg/hr) and PES by length categories and hour intervals of the day in winter (January–February) and spring (April–May), in the depth range of 900–1 099 m.

References

BEAMISH, F. W. H. 1966. Vertical migration by demersal fish in the Northwest Atlantic. *J. Fish. Res. Bd. Canada*, **23**(1): 109–139.

BOWERING, W. R., and G. R. LILLY. 1992. Greenland halibut (*Reinhardtius hippoglossoides*) off southern Labrador and northwestern Newfoundland (Northwest Atlantic) feed primarily on capelin (*Mallotus villosus*). *Neth. J. Sea Res.*, **29**(1–3): 211–222.

BOWERING, W. R., and D. G. PARSONS. 1986. Diel variability in trawl catches of Greenland halibut from the channels off coastal Labrador and implications for resource assessment. *North Am. J. Fish. Manag.*, **6**: 149–155.

BOWMAN, R. E. 1986. Effect of regurgitation on stomach content data of marine fishes. *In*: Contemporary studies on fish feeding. (Ed.): C. A. Simesad and G. M. Caillet: 1971–1981.

DE CÁRDENAS, E., S. JUNQUERA, and A. VAZQUEZ. MS 1993. Abundance indices of Greenland halibut in deepwater fishing zones of NAFO Divisions 3LMN. *NAFO SCR Doc.*, No. 61, Serial No. N2244, 8 p.

CHUMAKOV, A. K., and S. G. PODRAZHANSKAYA. 1986. Feeding of Greenland halibut (*Reinhardtius hippoglossoides*) in the Northwest Atlantic. *NAFO Sci. Coun. Studies*, **10**: 47–52.

DE GROOT, S. J. 1971. On the interrelationships between morphology of the alimentary tract, food and feeding behaviour in flatfishes (Pisces: Pleuronectiformes).

Neth. J. Sea Res., **5**(2): 121–196.

DIXON, W. J., M. B. BROWN, L. ENGELMAN, J. W. FRANE, M. A. HILL, R. I. JENNRICH, and J. D. TOPOREK. 1983. BMDP statistical software. University of California Press, Berkeley.

ELLIOTT, J. M., and L. PARSONS. 1978. The estimation of daily rates of food consumption for fish. *J. Anim. Ecol.*, **47**: 977–991.

HAUG, T., and G. GULLIKSEN. 1982. Size, age, occurrence, growth and food of Greenland halibut, *Reinhardtius hippoglossoides* (Walbaum), in coastal waters of western Spitzbergen. Sarsia, **68**: 293–298.

JUNQUERA, S., S. IGLESIAS, and E. DE CÁRDENAS. MS 1992. Spanish fishery of Greenland halibut (*Reinhardtius hippoglossoides*) in 1990–1991. *NAFO SCR Doc.*, No. 28, Serial No. N2075, 14 p.

RODRIGUEZ-MARIN, E., A. PUNZÓN, and J. PAZ. 1995. Feeding patterns of Greenland halibut (*Reinhardtius hippoglossoides*) in Flemish Pass (Northwest Atlantic). *NAFO Sci. Coun. Studies*, **23**: 43–54.

PEDERSEN, S. A., and F. RIGET. 1993. Feeding habits redfish (*Sebastes* spp.) and of Greenland halibut, *Reinhardtius hippoglossoides*, in West Greenland waters. *ICES J. Mar. Sci.*, **50**: 445–459.

SHUNTOV, V. P. 1970. Seasonal distribution of black and arrowtooth halibuts in the Bering Sea (In Russian). Trudy Vses. Nauch.-Issled. *Ins. Morsk. Rybn. Khoz. Okean.*, **70**: 391–401. Available: Natl. Tech. Inf. Serv., Springfield, VA, TT 71–501271.

SMIDT, E. L. B. 1969. The Greenland halibut, *Reinhardtius hippoglossoides* (Walb.), biology and exploitation in Greenland waters. *Med. Danm. Fisk. Havundersog.*, **6**: 79–148.

SOLMUNDSSEN, J. 1994. Food and feeding habits of Greenland halibut (*Reinhardtius hippoglossoides*) in Icelandic waters. *Natturufradingurinn*, **64**(1): 67–76.

TREMBLAY, C., and F. AXELSEN. 1981. Biologie et phe du fletan du Groenland *Reinhardtius hippoglossoides* (Walbaum) dans le Golfe du Saint Laurent. *Trav. Ch. Quebec*, **48**, 101 p.

YANG, M. S., and P. A. LIVINGSTON. 1988. Food habits and daily ration of Greenland halibut, *Reinhardtius hippoglossoides*, in the Eastern Bering Sea. *Fish. Bull.*, **86**(4): 675–690.

VAZQUEZ, A. 1981. Nuevo mtodo para el cálculo de poderes de pesca e indices de abundancia en pesquerias. *Inv. Pesq.*, **45**(2): 241–255.

ZAMARRO, J. 1992. Feeding behaviour of the American plaice (*Hippoglossoides platessoides*) on the southern Grand Bank of Newfoundland. *Neth. J. Sea Res.*, **29**(1–3): 229–238.