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Feeding Chronology of Yellowtail Flounder (*Limanda ferruginea*) and American Plaice (*Hippoglossoides platessoides*) on Grand Bank (NAFO Division 3N)

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Abstract

A total of 1199 individuals of yellowtail flounder (*Limanda ferruginea*, Storer) and 970 individuals of American plaice (*Hippoglossoides platessoides*, Fabricius) were sampled from six hauls carried out in a period of 24 hours for studying the feeding chronology of these species. The main prey of yellowtail flounder (considered as total weight percentage) were Gammaridae (19.5%), *Ammodytes dubius* (10.1%) Annelida (6.3%), Mysidacea (6.0%) and Anthozoa (5.6%). The predominant preys in American plaice were *Ammodytes dubius* (72.3%), followed by Mysidacea (8.5%) and *Echinarachnius parma* (6.1%). Diet composition varied with size and timetable for both species. The feeding intensity index values in yellowtail flounder were scaled over 24-hr period, and in both species these values slightly decreased during the night and at dawn, but in American plaice there was more variability in the timetable values between the size ranges. The mean weight fullness index values over the 24-hr period in yellowtail flounder were lower than in American plaice. Also, both species presented different behaviour between the size ranges. No significant differences were noted ($p<0.05$) in the estimated values for feed intensity throughout the 24-hr period in any of the ranges of both species studied.

Key words: American plaice, feeding, food, Grand Bank, Yellowtail flounder

Introduction

Knowledge of feeding behaviour is important to understand the trophic relations in the marine ecosystem; this is useful for studying interactions between species and provides information for stock management (Hacunda, 1981).

Yellowtail flounder (*Limanda ferruginea*, Storer) and American plaice (*Hippoglossoides platessoides*, Fabricius) occupy the same habitat, and are distributed both to the east and west of the North Atlantic, although American plaice extends to deeper waters (Iglesias *et al.*, 1996). Both species comprise an important fish resource. The fisheries for the two species on the Grand Bank of Newfoundland (Div. 3LNO) have been regulated since 1973 and the American plaice fishery has been under moratorium since the mid-1990s (Brodie *et al.*, MS 1998; Walsh *et al.*, MS 1998). In recent years, abundance has declined and the stocks appear to remain at a low level, although for the yellowtail flounder population there may have been some slight improvement over the last few years (Anon., 1999).

The different catchability rates for the demersal species during the day and night is a well known phenomenon (Sissenwine and Bowman, 1978). Some authors have reported that, in general, demersal species were significantly more vulnerable to trawl gear during the night than during the day. On the Grand Bank, Walsh (MS 1989) had observed that catches of both yellowtail flounder and American plaice were significantly higher at night, confirming that both species exhibit strong diel behaviour. One of the factors related with the diel behaviour is the feeding habits. No clear diel feeding pattern has been documented for these species on the Grand Bank.

The theoretical and practical importance of knowledge about fish feeding chronology is already well documented in the literature (Boujard and Leatherland, 1992; Jenkins and Green, 1977), however, for these two species few studies cover this aspect (Methven, 1999). The aim of our study is to contribute to knowledge on the feeding patterns yellowtail flounder and American plaice over a 24-hr period. To do this, we apply inferential statistics to an index, which makes it possible to reflect feeding intensity under different aspects. Their respective diets and variation throughout the day are described.

Materials and Methods

In April and May of 1997, a bottom trawl survey was carried out on the Grand Bank of Newfoundland on board the commercial fishing vessel Playa de Menduíña (Paz *et al.*, MS 1997). Although the aim of this survey was to estimate the biomass of the most important species, a series of samples was also taken over a 24-hr period, in order to study the daily feeding behaviour of yellowtail flounder and American plaice. With the information gathered in this survey, an area was chosen with a large abundance of both species with as wide a size range as possible.

From 14 to 15 May 1997, six hauls were carried out in the same zone for a variable duration. Hour of fishing was considered to be the average between haul out and haul in. The main characteristics of each haul are shown in Table 1.

A stratified sampling by length of fish was designed to minimise the influence of length on the results. For the purposes of sampling, 4 size-classes were made which were 5 cm for yellowtail flounder (25–29, 30–34, 35–39 and ≥40 cm), and 10 cm in the case of American plaice (20–29, 30–39, 40–49 and ≥50 cm). In each haul, the intention was to analyse 50 individuals randomly selected from each size-class in both species (Tables 2 and 3). The number of the individuals analysed by size range is shown in Fig. 1.

The total length, sex and degree of stomach fullness were noted for each individual. The stomach contents of all individuals sampled in each range and haul were extracted, collectively weighed (in terms of moist weight), and then frozen. A total of 1 199 individuals of yellowtail flounder and 970 individuals of American plaice was sampled.

At the laboratory, the stomach contents of the whole stomach of each size range and haul were thawed and prey identified to the lowest possible taxonomic class. Each type of prey was weighed individually and the percentage of each was calculated in terms of the total weight of the stomach content (Tables 4, 5 and 6). When a variation between the weight of total stomach contents in each range and haul obtained in laboratory and those weighted on board was noted after thawing, this relationship was studied using Linear Regression Analysis, obtaining a significant linear regression in yellowtail flounder (N = 24; R^2 = 0.973; p<0.05) and in American plaice (N = 24; R^2 = 0.996; p<0.05).

For all calculations, the weights obtained in the laboratory were used.

The weight-length equation for both species was estimated from, least-squares regression of individual weight and length measurements after logarithmic transformation. Data were collected from sampling length and weight during the survey.

Yellowtail flounder	males:	a = 0.0093	b = 2.9910	R^2= 0.98	n. indiv. = 588
	females:	a = 0.0071	b = 3.0823	R^2= 0.99	n. indiv. = 985
American plaice	males:	a = 0.0050	b = 3.1326	R^2= 0.99	n. indiv. = 1 102
	females:	a = 0.0027	b = 3.3277	R^2= 0.99	n. indiv. = 1 456

TABLE 1. Characteristics of hauls sampled.

Haul	Reference	Mean time of haul (hr UTC)	Tow duration (min)	Location	Depth (m)
1	Midday	11:20	135	43º 31'79N 50º 48'79W	66
2	Afternoon	16:20	135	43º 39'06N 50º 53'51W	66
3	Dusk	21:25	150	43º 40'02N 50º48'92W	66
4	Night	02:30	135	43º 39'62N 50º 48'90W	66
5	Dawn	06:30	120	43º 39'49N 50º 48'83W	66
6	Morning	09:30	60	43º 33'15N 50º 49'44W	66

TABLE 2. Haul mean hour (UTC), size range (cm), number of individuals sampled, mean weight ± Standard Deviation (g), Feeding Intensity Index (FI), weight of stomach contents (g), and the Mean Weight Fullness Index of yellowtail flounder (*Limanda ferruginea*).

Haul (UTC)	Size range (cm)	No. Indiv. sampled	Mean weight ± SD (g)	F I	Weight stomach contents (g)	MWFI
Midday (11:20 h)	25–29	50	190.7±24.9	94.0	36.60	0.41
	30–34	50	318.7±37.0	96.0	35.47	0.23
	35–39	50	466.0±56.7	92.0	44.33	0.21
	≥40	50	735.9±116.2	92.0	127.90	0.38
Afternoon (16:20 h)	25–29	50	193.5±25.9	100	33.41	0.35
	30–34	50	313.5±34.4	88.0	34.16	0.25
	35–39	50	464.1±62.0	96.0	83.48	0.38
	≥40	50	780.1±124.5	94.0	51.49	0.14
Dusk (21:25 h)	25–29	50	193.5±25.1	94.0	53.89	0.59
	30–34	50	316.7±35.9	90.0	62.31	0.44
	35–39	50	482.8±61.3	84.0	68.56	0.34
	≥40	50	765.3±126.1	88.0	144.94	0.43
Night (02:30 h)	25–29	50	190.1±27.5	88.0	41.04	0.49
	30–34	50	311.9±37.2	88.0	42.82	0.31
	35–39	49	485.7±58.8	83.7	62.36	0.31
	≥40	50	792.7±129.2	86.0	105.63	0.31
Dawn (06:30 h)	25–29	50	192.2±25.3	90.0	26.81	0.31
	30–34	50	310.5±35.5	88.0	16.47	0.12
	35–39	50	482.9±57.7	82.0	41.81	0.21
	≥40	50	753.8±131.9	76.0	61.92	0.22
Morning (09:30 h)	25–29	50	203.6±23.0	96.0	49.03	0.50
	30–34	50	312.7±38.5	94.0	47.83	0.32
	35–39	50	474.2±62.4	88.0	61.61	0.30
	≥40	50	799.5±162.2	90.0	91.80	0.25

Data processing

The problems and limitations of the uses of different methods and indices in fish feeding have been studied by various authors (Amezaga, 1988; Hansson, MS 1980; Hyslop, 1980). In this study, gravimetric methods are used. Gravimetric measurement of stomach contents is usually considered to overemphasise the contribution of single heavy items to the diet. Weight measures should be used to reflect dietary nutritional value (Macdonald and Green, 1983). Gravimetric methods are used in this article.

In the description of diet composition, the importance of each prey is expressed as a percentage of the total weight of the preys.

Two indices were used to analyse the feeding activity. These indices were calculated for each size range by haul as follows:

– Feeding Intensity Index (FI): percentage of individuals with stomach content. This is a measurement of feeding activity.

$$FI_{ti} = (n_{ti} / N_{ti}) \times 100$$

n_{ti} is the number of individuals with stomach content in range *i* and period *t*.
N_{ti} is the total number of individuals sampled in range *i* and period *t*.

– Mean Weight Fullness Index (MWFI): weight percentage of stomach content weight in terms of predator weight. This index reduces the effect of predator size on stomach content weight.

$$MWFI_{ti} = (Pc_{ti} / Pt_{ti}) \times 100$$

Pc_{ti} is the stomach content fresh weight in range *i* and period *t*.

Pt_{ti} is the fresh weight of all individuals sampled with stomach content in range i and period t.

According to Jenkins *et al.* (1977), it is more efficient to use inferential statistics to analyse the variations in feeding intensity over time of day than explaining these variations including only qualitative and quantitative comparisons, because stomach content weights or number of empty stomach individuals alone, do not suffice to assess feeding continuity or to interpret diel feeding chronology. For this reason, we used inferential tests to analyse this feeding activity over a 24-hr period.

In order to know if there were significant differences in the proportion of individuals with stomach content presence among the various hauls and ranges, we applied a χ^2 test to the values of the FI (Sokal and Rolhf, 1981).

Results

The characteristics of individuals of the yellowtail flounder and American plaice individuals sampled are shown in Tables 2 and 3. The largest size range in American plaice is weakly represented (Fig. 1b).

In the yellowtail flounder individuals analysed, a low number of individuals with an empty stomach was noted (Fig. 1a). In American plaice, however, the number of individuals with empty stomach increases proportionally as size increases (Fig. 1b).

TABLE 3. Haul mean hour (UTC), size range (cm), number of individuals sampled, mean weight ± Standard Deviation (g), Feeding Intensity Index (FI), weight of stomach contents (g), and the Mean Weight Fullness Index of American plaice (*Hippoglossoides platessoides*).

Haul (UTC)	Size range (cm)	No. Indiv. sampled	Mean weight ± SD (g)	F I	Weight stomach contents (g)	MWFI
Midday (11:20 h)	20–29	50	159.7±37.4	90.0	42.40	0.59
	30–39	50	325.0±78.0	70.0	99.30	0.86
	40–49	50	704.5±113.1	72.0	291.97	1.12
	≥50	11	1942.2±653.9	18.2	22.14	0.54
Afternoon (16:20 h)	20–29	39	169.4±25.5	84.6	36.51	0.66
	30–39	50	384.7±104.4	74.0	117.92	0.83
	40–49	49	787.4±158.1	71.4	273.24	1.04
	≥50	23	1801.7±632.0	43.5	117.90	0.76
Dusk (21:25 h)	20–29	50	147.1±39.8	94.0	44.81	0.65
	30–39	50	360.8±91.1	84.0	133.07	0.88
	40–49	50	777.8±138.1	52.0	247.50	1.24
	≥50	16	2018.7±876.1	31.2	157.52	1.74
Night (02:30 h)	20–29	50	162.7±31.4	84.0	36.01	0.53
	30–39	50	378.1±78.4	72.0	120.43	0.87
	40–49	50	786.5±154.2	32.0	152.53	1.15
	≥50	10	1912.2±728.9	30.0	21.75	0.52
Dawn (06:30 h)	20–29	49	169.6±24.5	81.6	36.70	0.54
	30–39	50	367.6±96.1	54.0	155.61	1.49
	40–49	50	757.8±161.4	64.0	284.63	1.17
	≥50	6	1483.2±224.5	16.7	3.23	0.23
Morning (09:30 h)	20–29	50	161.3±32.3	90.0	24.76	0.35
	30–39	50	327.6±88.7	74.0	85.83	0.72
	40–49	49	724.3±142.0	62.0	348.32	1.67
	≥50	18	1763.5±571.2	44.4	81.90	0.61

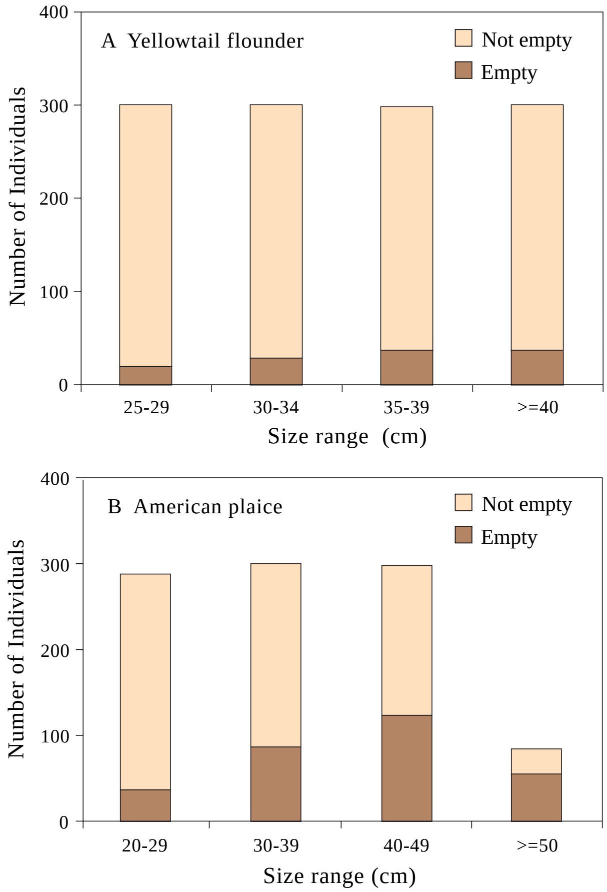

Fig. 1. Number of individuals by size range (cm) in yellowtail flounder (a) and American place (b) samples.

Food

The main prey, using the percentage of the total weight of preys, of yellowtail flounder obtained over a 24-hr period were: Gammaridae (19.5%), *Ammodytes dubius* (10.1%), Annelida (6.3%), Mysidacea (6.0%) and Anthozoa (5.6%), although the important contribution of the unidentified group of prey must be taken into account (43.8%) (Table 4). The predominant prey in American plaice was *A. dubius* (72.3 %), followed by Mysidacea (8.5%) and *Echinarachnius parma* (6.1%) (Table 5).

Diet composition in relation to time. In yellowtail flounder Gammaridae, *A. dubius* and Annelida appeared in all hauls in a considerable percentage, with maximum values of 25.2% at night, 21.8% at midday and 10.4% in the afternoon, respectively. Mysidacea increased their presence in the afternoon to dawn (maximum 7.8% at dawn). Anthozoa, however, was notable at midday (13.1%) (Table 4). In American plaice *A. dubius*, appeared in a high percentage (maximum values of 79.7% and 79.5% at dusk and dawn, respectively), Mysidacea (maximum 12.4% at night) and *E. parma* was notable in the morning (17.9%) (Table 5).

Diet composition in relation to length. In yellowtail flounder the importance of *A. dubius*, Annelida and Anthozoa gradually increased respect size. *Ammodytes dubius* is notable ≥40 cm (30.2%), Gammaridae in all ranges (maximum of 22.3% in 35–39 cm), Annelida (maximum values of 10.9% and 10.6% in 35–39 and ≥40 cm respectively), and Mysidacea (maximum 14.9% in 25–29 cm) (Table 6). In the case of American plaice *A. dubius* was notable in all the ranges (maximum 82.3% in 40–49 cm), followed by Mysidacea (maximum 53.5% in 20–29 cm) and *E. parma* (maximum 18.9% in ≥50 cm). Generally, *A. dubius* increased with the size of American plaice, as did *E. parma*; and Mysidacea decreased (Table 6).

Feeding intensity

The Feeding Intensity Index values (FI) per haul in yellowtail flounder were high for all sizes, showing slightly higher values at afternoon, except for the 30–34 cm range. Lower values were observed in the morning, except in the 25–29 range. All ranges showed higher values between the morning to afternoon and lower values during the dawn to night. The 30–34 cm range presented no clear trend (Fig. 2a).

In American plaice, the highest FI values for the size range of 20–29 and 30–39 cm were in the morning to dusk interval, reaching the maximum at dusk and the minimum at dawn. For the size range 40–49 cm the maximum values were at midday-afternoon, and the minimum occurred at night. The ≥50 cm range presented the lowest values throughout the 24-hr period, with two maximum values (morning and afternoon) and two minimum values (dawn and midday) (Fig. 2b).

Determining what influence sex might have on the FI in both species was difficult because sample sizes were small and unevenly distributed when the data were distributed among both sex and time.

The Mean Weight Fullness Index (MWFI) values in yellowtail flounder presented maximum values in all sizes at dusk, except for the 35–39 cm range, which was in the afternoon. Moreover,

TABLE 4. Total weight (%) of prey items found in yellowtail flounder (*Limanda ferruginea*) stomachs sampled.

Prey taxa	Haul 1	2	3	4	5	6	Total
CNIDARIA	13.13	4.00	3.90	2.67	3.47	2.58	5.62
Scyphozoa							
Anthozoa	13.13	4.00	3.90	2.67	3.47	2.58	5.62
ANNELIDA	8.43	10.41	7.98	8.63	8.18	9.87	6.30
CRUSTACEA	22.48	33.51	26.19	38.22	31.51	28.33	31.83
Cumacea	1.62	2.75	1.22	2.34	2.39	0.86	1.99
Mysidacea	3.48	5.19	5.39	5.80	7.84	3.04	6.02
Isopoda	1.70	5.22	2.21	3.33	2.58	3.74	2.34
Amphipoda							
Gammaridae	14.11	18.08	12.62	25.24	18.03	17.45	19.46
Caprellidae		0.16		0.20	0.15		0.08
Other Amphipoda	0.96	0.52	2.39	0.56		2.40	0.58
Decapoda							
Brachyura							
Chionoecetes opilio							
Other Brachyura	0.07	0.33				0.18	0.08
Natantia			1.52				0.76
Other Crustacea	0.54	1.26	0.84	0.75	0.52	0.66	0.52
ECHINODERMATA	1.83	1.01	0.96	1.70	2.24	1.73	1.15
Ophiuroidea							
Ophiura	0.03						0.01
Echinoidea							
Echinarachnius parma	1.80	1.01	0.96	1.70	2.24	1.73	1.14
MOLLUSCA	0.54	0.56	1.12	0.77	1.09	0.97	0.53
Gastropoda							
Bivalvia	0.54	0.56	1.12	0.77	1.09	0.97	0.53
PISCES	22.15	17.54	20.97	15.65	14.17	11.50	10.78
Ammodytes dubius	21.80	17.54	19.89	15.37	14.17	11.50	10.10
Mallotus villosus							
Cottidae							
Unidentified Pisces	0.35		1.08	0.28			0.68
Unidentified prey	31.44	32.97	38.88	32.36	39.31	45.03	43.80

minimum values at dawn in smaller ranges (25–29 cm and 30–34 cm) were noted. The 35–39 range presented a minimum value at midday and finally in the ≥40 cm range in the afternoon. The 25–29 cm range showed a greater variability in MWFI values throughout the 24-hr period (Fig. 3a).

In American plaice, maximum MWFI values 20–29 cm and ≥50 cm ranges were at dusk, 30–39 cm range at dawn, and 40–49 cm range in the morning. Whereas minimum values in the 20–29 and 30–39 cm ranges coincided in the morning, in the 40–49 cm range in the afternoon, and in the ≥50 cm range at dawn.

The MWFI values for American plaice were higher and showed a higher variability over a 24-hr period than those of yellowtail flounder (Fig. 3b).

TABLE 5. Total weight (%) of prey items found in American plaice (*Hippoglossoides platessoides*) stomachs sampled.

	Haul						
Prey taxa	1	2	3	4	5	6	Total
CNIDARIA	0.19	0.05	1.17	0.27	0.10	0.01	0.32
Scyphozoa			1.17				0.23
Anthozoa	0.19	0.05		0.27	0.10	0.01	0.09
ANNELIDA	0.01	0.04	0.00	0.13	0.30	0.16	0.10
CRUSTACEA	8.60	17.70	9.40	13.72	9.37	5.82	10.71
Cumacea							
Mysidacea	8.02	10.00	8.75	12.36	8.70	4.54	8.53
Isopoda	0.21	0.18	0.29	0.35	0.04	0.46	0.25
Amphipoda							
Gammaridae	0.15	0.17		0.18	0.19	0.07	0.12
Caprellidae	0.02	0.02	0.05	0.02			0.02
Other Amphipoda	0.21		0.21	0.15			0.09
Decapoda							
Brachyura							
Chionoecetes opilio		6.87					1.32
Other Brachyura				0.35		0.35	0.10
Natantia						0.37	0.06
Other Crustacea		0.46	0.09	0.31	0.43	0.04	0.22
ECHINODERMATA	4.81	7.43	3.75	2.19	2.68	17.89	6.75
Ophiuroidea							
Ophiura	0.08	2.85	0.35	0.13	0.12		0.66
Echinoidea							
Echinarachnius parma	4.73	4.59	3.40	2.06	2.56	17.89	6.09
MOLLUSCA	4.39	0.08	0.37	0.24	0.19	0.47	0.93
Gastropoda					0.19		0.03
Bivalvia	4.39	0.08	0.37	0.24		0.47	0.90
PISCES	76.58	71.34	79.65	76.66	81.32	71.12	76.01
Ammodytes dubius	75.48	56.80	79.65	76.19	79.45	68.73	72.27
Mallotus villosus		6.92					1.33
Cottidae	1.09	0.78			1.87	2.39	1.05
Unidentified Pisces		6.84		0.47			1.36
Unidentified preys	5.43	3.35	5.67	6.79	6.04	4.52	5.17

Daily feeding pattern

After applying a test χ^2 for homogeneity to FI values in the different hauls of each size range over the 24-hr period, no significant differences ($p<0.05$) were obtained in yellowtail flounder. In American plaice there were significant differences ($p<0.05$) in 35-39 cm ($\chi^2 = 11.67$) and 40–49 cm ($\chi^2 = 23.26$) ranges, although in 20–29 cm and ≥50 cm ranges no significant differences ($p<0.05$) were observed.

Discussion

There are three possible trophic types among fishes: those which feed on pelagic, benthopelagic or benthic organisms. There are other characteristics such as body shape and size, mouth position and structure and stomach morphology, which contribute to characterising, diet composition, and where fishes feed (Hacunda, 1981). American plaice is described as a specialist feeding benthic species

TABLE 6. Prey items found in yellowtail flounder (*Limanda ferruginea*) stomachs by 5 cm length classes and of American plaice (*Hippoglossoides platessoides*) stomachs by 10 cm length classes. Data are expressed as percentage of the total weight of thawed stomach contents (+ indicates present but <0.5%).

	Yellowtail flounder				American plaice			
Prey taxa	25–29	30–34	35–39	≥40	20–29	30–39	40–49	≥50
CNIDARIA	+	1.5	2.7	9.8	+	+	+	+
Scyphozoa							+	
Anthozoa	+	1.5	2.7	9.8	+	+	+	+
ANNELIDA	2.8	7.8	10.9	10.6	+	+	+	+
CRUSTACEA	36.3	33.4	32.7	23.4	55.2	16.9	4.5	+
Cumacea	1.7	3.0	2.1	1.1				
Mysidacea	14.9	7.2	2.9	1.2	53.5	15.0	1.5	
Isopoda	3.1	4.1	2.7	2.8	+	0.5	+	
Amphipoda								
Gammaridae	13.8	14.7	22.3	16.6	+	+	+	
Caprellidae	+	+	+	+	+	+	+	
Other Amphipoda	1.4	1.5	1.8	0.9	+	+	+	
Decapoda								
Brachyura								
Chionoecetes opilio							2.4	
Other Brachyura		+	+	+		+	+	+
Natantia		1.7		+		+		
Other Crustacea	1.1	0.9	0.8	0.6	0.7	+	+	
ECHINODERMATA	+	0.9	1.1	2.6	+	1.5	6.4	21.1
Ophiuroidea								
Ophiura				+		+	0.6	2.2
Echinoidea								
Echinarachnius parma	+	0.9	1.1	2.6	+	1.4	5.8	18.9
MOLLUSCA	0.5	0.7	0.7	1.2	+	+	+	4.4
Gastropoda							+	
Bivalvia	0.5	0.7	0.7	1.2	+	+	+	4.4
PISCES	5.7	3.1	14.0	30.2	11.3	74.5	86.4	73.9
Ammodytes dubius	5.7	1.3	13.8	30.2	11.3	73.8	82.3	64.0
Mallotus villosus								9.5
Cottidae						0.7	1.7	
Unidentified Pisces		1.8	+				2.4	+
Unidentified preys	54.1	52.7	37.9	22.3	33.0	6.9	1.8	+
Number of stomachs	300	300	299	300	288	300	298	84
Total Stomach Weight	330	308.5	506.8	789	266	881	2095	470

together with witch flounder, Arctic eelpout and Northern wolffish (Rodríguez-Marín, MS 1995; Rodríguez-Marín *et al.*, MS 1994).

Yellowtail flounder food in the zone is not as studied as American plaice. Although there are few quantitative studies on yellowtail flounder diet, they

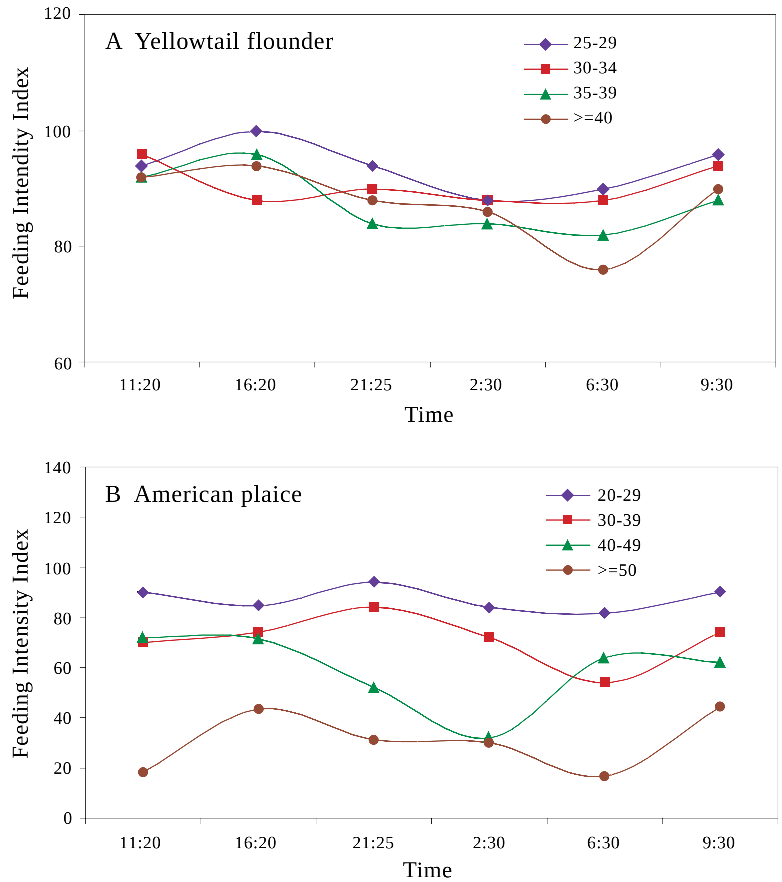

Fig. 2. Feeding Intensity Index (FI) by size range (cm) *vs* time of day (hr) for (**A**) Yellowtail flounder and (**B**) American plaice.

coincide in that the main preys are small Crustacea (mainly Amphipoda) and Polychaeta. For the south of New England and George Bank, Langton (1983) found that the Polychaeta and Amphipoda accounted for 50–70% of the stomach contents. No size determining influence was observed in the diet composition. However, the Amphipoda were more important in the small sizes, the Polychaeta in the larger and the Anthozoa in the individuals of over 26 cm. Similar results were obtained by Pitt (1976) for the Grand Bank.

In this study, the Gammaridae were the most important prey in terms of the percentage of the total stomach content weight of yellowtail flounder. The presence of *A. dubius* (10.1%) is also notable in the larger sizes. We found that a percentage of *A. dubius*, Annelida and Anthozoa increased as size increased, the opposite trend being noted in Mysidacea (Table 6, Fig. 4a). Preys varied in percentage depending on the timetable (Table 4) and this was attributable to the different habits and preferences of the size ranges and to the availability of the preys (Table 7); in this study, the presence of Pisces was considerable, unlike the results obtained in other studies (Hacunda, 1981).

There are several studies on the food of American plaice in Northwest Atlantic, and all coincide in the fact that it preys on fish and benthonic invertebrates (Pitt, 1973), fish species being more important in the diet of the larger sized individuals, and Amphipoda and Echinodermata in the smaller sizes. Vázquez *et al*. (1989) found Echinodermata and Bivalvia as the main prey in American plaice off Flemish Cap. Rodríguez-Marín *et al*. (MS 1994) also observed off Flemish Cap that Ophiura and, to a lesser extent, Hyperiidae, were the most important prey in the diet of American plaice using volumetric methods. Pitt (1976) found that the diet of American plaice on the Grand Bank comprises large prey, such as Echinodermata and especially Pisces, although in the small individuals (<29 cm) Crustacea were the main prey. In his study (Zamarro (1992) of American plaice south of the Grand Bank of Newfoundland of individuals over

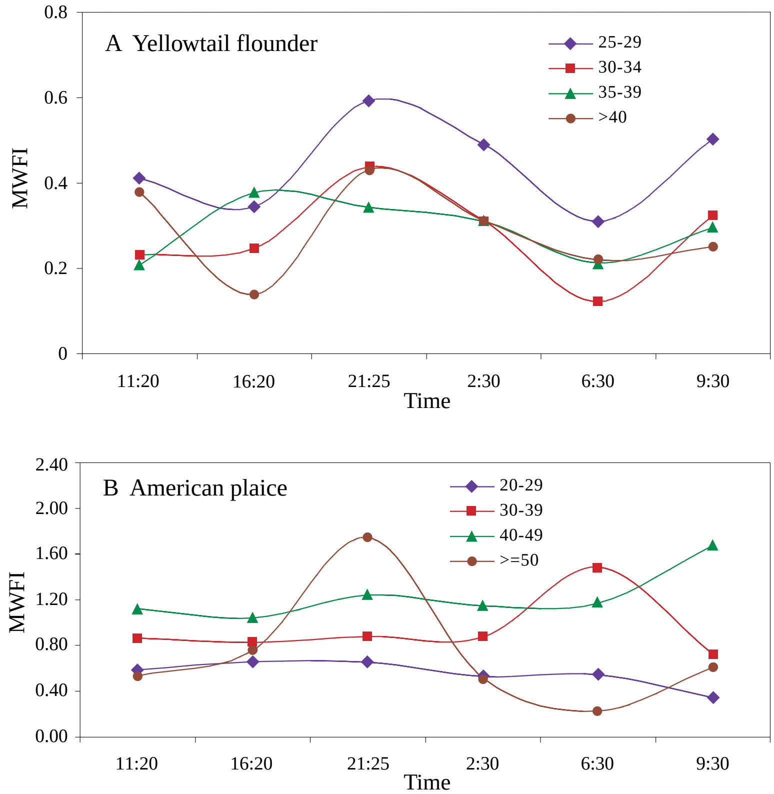

Fig. 3. Mean Weight Fullness Index (MWFI) by size range (cm) *vs* time of day (hr) for (**A**) Yellowtail flounder and (**B**) American plaice.

40 cm, it was noted that their main prey were *A. dubius*, *Mallotus villosus* and Ophiura.

In this study, the main prey of American plaice was *A. dubius***.** We noted a clear relationship between size and the importance of certain preys; *A. dubius* and *E. parma* increase as size increases, and the opposite occurs with Mysidacea. The importance of *A. dubius* in individuals measuring ≥50 cm was less than expected. This may be due to the low number of individuals sampled in this range (Table 6, Fig. 4b). Scott (1973), however, noted a greater food variation by geographical area than when taking size into account. The importance of preys also varied with the timetable; *A. dubius* increased at dusk-night-dawn period (Table 5). Beamish (1966) noted that American plaice was the only flatfish migrating vertically by night, a time when *A. dubius* also migrates.

Pitt (1976) comparing the diets of both species on the Grand Bank and using gravimetric and occurrence methods, found how the main common preys in the diets of both species are: Crustacea, Pisces, Annelida and Echinodermata. Annelida and Crustacea occurred more frequently in yellowtail flounder diet, but smaller American plaice (<30 cm) take proportionally larger quantities of Crustacea in relation to the total food than in yellowtail flounder. Pisces were selected more frequently by American plaice and, for those larger than 30 cm, comprised the largest proportion of total food weight.

In this study, the results were similar, but differences were noted. In American plaice, the main component of the diet in weight was Pisces (76%) (Table 5), which, having a certain importance in yellowtail flounder (11%) (Table 4), was greater than that obtained by Pitt (1976) (Table 8).

Crustacea are an important prey of yellowtail flounder (30%) in all size ranges, and in American plaice their importance lessened as size increased, being the main prey in the smallest size range (54%). The Annelida are an important component of yellowtail flounder diet, although in American plaice it is minimal. In all cases, the presence of

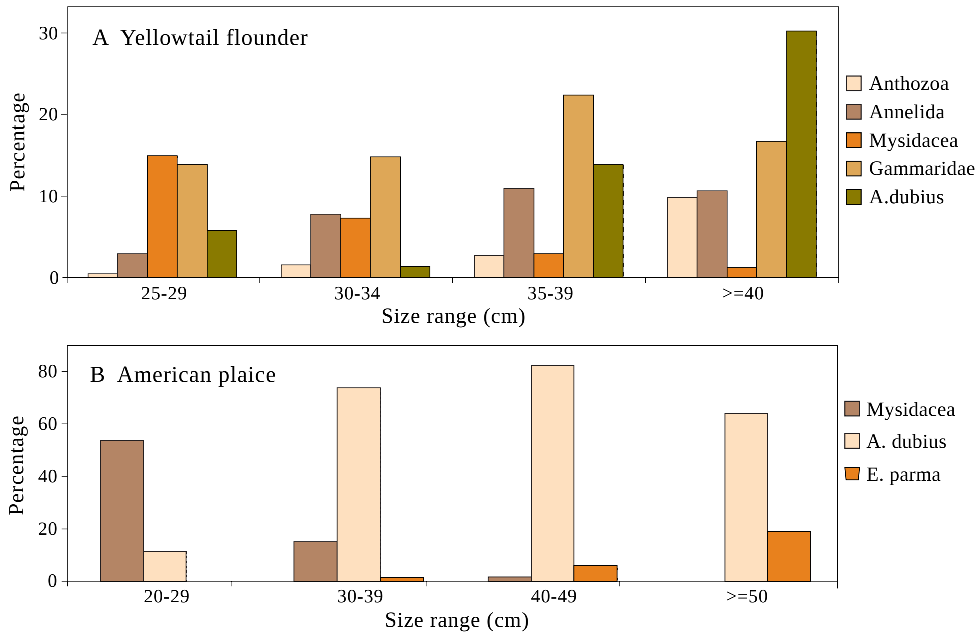

Fig. 4. Percentage of stomach content weight of main preys *vs* size range (cm) for (**A)** Yellowtail flounder and (**B**) American plaice.

TABLE 7. Principal prey (% weight) found in yellowtail flounder (*Limanda ferruginea*) in different geographic areas (from published literature).

	Langton		Pitt
Prey taxa	Southern New England	Georges Bank	Grand Bank
Anthozoa	1.93	3.52	–
Annelida	47.52	40.46	38.00
Amphipoda	6.88	4.88	29.30
Pisces	–	–	7.50
Mallotus villosus	–	–	3.70
Ammodytes dubius	–	–	3.80

TABLE 8. Principal prey (% weight) found in American plaice (*Hippoglossoides platessoides*) in different geographic areas (from published literature).

Prey Taxa	R. Marín Flemish Cap	Pitt Div. 3NL
Anthozoa	–	–
Annelida	0.78	1.40
Echinodermata	86.31	17.20
Ophiura	84.79	9.10
Bivalvia	0.43	–
Hiperidae	10.49	–
Amphipoda	10.53	1.90
Pisces	0.45	59.40
Mallotus villosus	–	23.90
Ammodytes dubius	–	33.00

the different prey varies with the size of the predator (Table 6, Fig. 4b).

Pleuronectidae are generally described as day feeders, although there are many exceptions to this general rule (De Groot, 1971). It should also be taken into consideration that feeding activity is related to length, as is the case of the Greenland halibut where 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) shows no definitive diel pattern (Junquera, 1995). There are occasional problems in detecting feeding patterns because of their behaviour, such as in the case of Cape hakes, which show little indication of any diel feeding pattern because even though they feed pelagically at night, the abundance of the feeding portion of the population would be underestimated in bottom trawl samples (Pillar and Barange, 1997).

The FI values in yellowtail flounder obtained in this study appear to reflect a fairly homogenous behaviour in all size ranges over a 24-hr period. In American plaice, however, this aspect is only noted in the lower two ranges. Also, in American plaice, lower FI values were obtained and these lessen as size increases, attaining low values (below 50%) in the ≥50 cm range.

According to Langton (1983), the yellowtail flounder of the south of New England and Georges Bank preferably feeds during the day and presents its maximum MWFI value at nightfall. In our study, yellowtail flounder presents FI values, which appear to indicate that feed activity increases in the daylight period (except for the 30–34 cm range), although the FI rate is high in all times (Fig. 2a and 3a). However, no significant differences were noted at any range using FI values in different hauls. Furthermore, as shown in Fig. 3a almost all ranges have the highest MWFI values at dusk. This seems to indicate that in yellowtail flounder there is a daily feeding pattern with a greater feed intensity during the day, with a flexible timetable, depending on the type of prey.

Zamarro (1992), studying individuals measuring over 40 cm south of the Grand Bank, affirms that American plaice preferably feeds during the day and that its behaviour shows a flexible timetable to feed off its prey when they are more accessible. This author also states that the daily changes in feed intensity are particularly related to the prey Pisces (Zamarro, MS 1991). Pitt (1976) also suggests that American plaice is a daylight feeder.

In our study, American plaice may be interpreted as a largely day feeder, with higher FI values during the day and lower values during night-dawn. Furthermore, we found significant differences in the 30-39 cm and 40–49 cm ranges over a 24-hr period. Although in terms of MWFI, no clear conclusion can be obtained, the highest values of overall ranges were during the day. This appears to indicate a greater feed intensity in American plaice during the day, but this is not reflected in the time variation of stomach content (Fig. 2b and 3b).

Walsh (MS 1987) describing the daily variation in catchability of yellowtail flounder in Div. 3LNO of Grand Bank observed that more abundant catches are obtained at night rather than by day. In a further study, Walsh (MS 1989) obtained a greater catch and greater vulnerability of large sizes in nocturnal fishing both in yellowtail flounder and in American plaice, the average size of yellowtail flounder being greater by night than by day. In our study, we noted that yellowtail flounder and American plaice present a lesser feed intensity during the night, and the smaller sizes present a more benthonic prey in the diet, this being particularly the case in American plaice. This feeding behaviour may be related to the different catchability by day/night.

It is not possible to conclude that a regularly recurrent feeding pattern exists by sampling only a few 24-hr periods. Only after long-term experimental analysis can a cyclic nature in any behaviour be determined. This study is restricted by the short sampling period and by not taking into account the different degrees of digestibility and evacuation of the various types of prey. To confirm these results, further studies should be carried out at various times of the year, preferably during the period of maximum feeding activity, and to integrate the various evacuation rates of the main preys.

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