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The Feeding of American plaice (Hippoglossoides platessoides),
Redfish (Sebastes marinus) and Cod (Gadus morhua) in the
Flemish Cap during July 1988

by

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ABSTRACT

A randomly stratified bottom-trawl survey was realized in the Flemish Cap (NAFO Div.3M) in July 1988. The stomach contents of three species were studied: 320 of American plaice (Hippoglossoides platessoides), 203 of redfish (Sebastes marinus) and 468 of cod (Gadus morhua). The cod specimens were classified taking into account age groups; in the case of other species by length classes.

The food items, the prey occurrence index and the diversity index were determined too. The Schoener overlap index was calculated to study the intraspecific diet overlap in cod and the interspecific diet overlap between the three species. The relation between predator size (cod) and prey size (redfish) was also studied.

INTRODUCTION

During a cruise carried out by B/O "Cornide de Saavedra" in July 1988, 120 trawl hauls (see fig 1) were performed in the Flemish Cap following the NAFO specifications for these surveys (Doubleday, 1931).

The gear used was a "Lofoten" one with a mesh size of 35 mm. It was trawled for thirty minutes in every location at a speed of 3.5-4 knots.

The qualitative and quantitative composition of the fish feeding is thought to be important in growth, maturity and fecundity changes. Predation by cod on smaller cod and redfish may also produce variable mortality in juveniles, contributing in this way to variability in year class strength (Lilly 1985).

METHODS

Biological samples were collected during the research survey. The stomach contents of three species were studied on board : 329 of american plaice, 203 of redfish and 468 of cod.

The total length was measured to the nearest 1 cm. in every individual and the weight, with a precision of ± 2 grs., was noted. In the case of cod the otoliths were extracted for age determination. Stomach contents were examined and the food components were also separated and noted as far as possible (Tables I, II, III).

In order to evaluate the food components the data formed groups by length classes following the NAFO Secretariat criteria (1986). At the same time cod was grouped in age classes.

In each species by class the following indices were calculated:

- the prey occurrence index (stomach with a prey number/total stomach number).
- the Simpson diversity feeding index : $D = 1 - \sum_{i=1}^s \frac{N_i(N_i-1)}{N(N-1)}$

where N_i is the number of times in which the type of prey p_i in the total number of stomachs appears, N the total number of preys in the total number of stomachs, and s the number of types of preys.

-the Fulton condition factor: C.F. = $100 \times W/L \exp.3$, where W is a total weight in g. and L the total length in cm.

-The diet overlap index. The Schoener diet overlap index (Sinton et al.1981) was used:

$$R_o = 1 - \frac{1}{2} \sum_{i=1}^n (P_{ji} - P_{ki})$$

where P_{ij} is the frequency of appearance of the prey i in the individuals of the class j , P_{ik} is the frequency of appearance of the prey i in the individuals of the class k . The said index was calculated for each species by length groups and in cod it was also determined between prerecruits (1 and 2 years old), immature juveniles (3,4 and 5 years old) and mature individuals (6 years or longer). Following Zaret and Rand (1971) and Mathur (1977) the value accepted as a limit was 0.6 in order to consider the existence of the diet overlap.

The relationship between the predator size (cod) and the size of its prey (redfish) was also studied.

RESULTS AND DISCUSSION

American plaice

In table I the food components are shown classified into length classes. The diet of the american plaice during the above mentioned month in the Flemish Cap is little varied, the prey spectrum very narrow, and the class of echinodermata the principal component. The ophiuroidea reach 86.5% in the length class 33-38cm., going beyond 40% in all the others.

The Simpson diversity index in all length groups (Table IV) has lower values than in the case of redfish and cod.

The prey occurrence index appears in table V.

The condition factor (table VI) mean was 1.02 ± 0.01 in the month studied.

Redfish

203 individuals (only 60 of them contained prey) were studied.

This fact indicates a low feeding intensity index: 0.30. The presence of food components is shown in table II, where it is observed the existence of predation on cod and cannibalism, this happens in the range 26 to 50 cm. Gavaris and Legge (1981) and Konstantinov et al. (1985) found the beginning of cannibalism in higher length classes. We calculated the presence of a cannibalism index of 3.8%, whereas Konstantinov et al (1985) give a 7% in 1979 and 5% in 1981. It can be explained if it is considered that a Summer season features a lower cannibalism rate.

Fish comprises 100% of the diet for individuals above 44 cm. long. Crustacean, mainly amphipoda and copepoda, are the major food components under to 38 cm..

Albikovskaya et al. (1988) indicate that the copepoda are 65-74% of the items in the food of the juvenile redfish, whereas we found a 31% in the individuals smaller than 27cm.

Considering only the fishes, the dominant prey was their own species: redfish, and in the second place the myctophidae. Lilly (1986) still confirms that between 1979 and 1982 the dominant prey was the myctophidae and that young redfish appeared incidentally.

The highest frequency of occurrence corresponds to the pelagic invertebrates (table VII): copepoda, amphipoda, etc. and it agrees with that noted by Konstantinov et al. (1985).

The condition factor by length groups and the total one is shown in table VIII. For the total lengths the C.F. was 1.50 ± 0.07 .

The Simpson feeding diversity index by length groups appears in table IX.

Cod

Table III indicates the feeding components observed in the stomachs of cod by age classes. The most varied diet is seen in the age groups of 3, 4 and 5, transition ages from prerecruits to mature individuals. Predation on redfish appeared at the age of 2, persisting in all ages studied. The other fishes are incorporated into the diet at the age of 3 and their presence increases with age. Fish is 60% of the diet of 7 year old cod. Predation on Pandalus borealis was regular from 2 to 7 years.

Cannibalism was observed from 3 to 7 years (table X and figure 4) affecting, almost exclusively the year class 2. Lilly (1985) confirms that predation in young cod takes place in the year classes 1 and 2 in the Winter of 1983, and in the year classes 1 and 3 in the next year. A presence index of cannibalism is shown in table X. The average was 3.8% between 3 and 7 years old.

The range of prey in cod was relatively narrow, such as is reported by other authors: Konstantinov et al (1985), Lilly (1985) and Lilly (1986). Table XI shows the prey occurrence index of cod by age groups. For the crustaceans the index descends from 0.67 in class 2 to 0.36 in class 7. The prey occurrence index of fish increases from 0.06 to 0.50 respectively.

The condition factor by year classes is indicated in table XII, being the condition factor for all of them 0.95 ± 0.03 .

The Simpson Feeding diversity index is present in table XIII. The average index is 0.81 ± 0.03 .

The diet overlap was calculated intraspecifically (Keast, 1973; Wallace and Ransey, 1983) to have a better idea of the feeding similarities between the three groups considered. In addition to this Schoener index was calculated and estimated between prerecruits (1 and 2 years old) and immature recruits (3, 4, and 5 years old): $R_o=0.665$; between prerecruits and mature individuals (6 or more years old): $R_o=0.251$; and between mature and immature recruits: $R_o=0.493$. There is a diet overlap only in the first case: between pre-recruits and immature recruits. These values confirm the distinct trophic habits of the three groups considered.

The relationships between the length of the predator (cod) and its prey (redfish) were studied. In table XIV and in figures 2 and 3 it is shown the number and length of the prey for each predator length group. The correlation calculated was: $r = 0.61$, $t = 7.54$, $f.d. = 98$ ($p < 0.001$). These values indicated that the length increase of the prey has a close relationship with the length of the predator.

The diet overlap between the three species

The diet overlap was calculated using the Schoener index. Length groups were made for each species: smaller than 38 cm. and longer than 38 cm. in the redfish and cod; smaller than 44 cm. and longer than 44 cm. for the american plaice. Finally the Schoener indices were reckoned to estimate the diet overlap between the total of the three species. The values are shown in table XV. The american plaice diet is almost independent of the length and has a higher overlap in all sizes (0.943). Besides, there is no overlap either with redfish (0.488), or cod (0.274). The redfish diet overlap value was higher with the cod (0.705) than with the american plaice (0.488) and the highest one was (0.933) between its two length groups. The cod presents a smaller diet overlap by length groups (0.211) than that one calculated between redfish and cod (0.705). These two species have important trophic relation.

CONCLUSIONS

Cod and redfish in Flemish Cap has a strong predator-prey relationship. The predation is particularly important on small redfish length groups. Cod stock size may be an important factor in natural mortality of redfish prerecruited year classes.

The importance of cod cannibalism on the one year age group increases with the predator age up to age 6, according to data presented. This suggests a mortality component due to cannibalism for first age groups. Further works to quantify the influence of predator of large cod on cod and redfish young age groups would be useful to assess these stocks.

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Table I. Food components observed in the stomachs of the american plaice in Div.3M in July 1988.

food objects	American plaice length (cm)							
	<21	21-26	27-32	33-38	39-44	45-50	51-56	>57
Class Polichaeta								
O. Errantia				+				
Fam. Aphroditidae					+			
O. Sedentaria						+		
Other Polichaeta				+				
Class Echinodermata								
O. Echinoidea				+	+	+	+	
O. Asteroidea					+			
O. Ophiuroidea	+	+	+	+	+	+	+	
O. Holoturoidea						+		
Class Crustacea								
O. Amphipoda			+					
O. Decapoda			+					
Class Bivalvia	+		+	+	+	+	+	
Taxodonta (comprb)					+			
Class Pisces								
Fam. Gadidae								
<u>Gadus morhua</u>								+
Larvas pisces			+					

Table II. Food components observed in the stomachs of the redfish in Div. 3M in July 1988.

food objects	redfish length (cm)							
	<21	21-26	27-32	33-38	39-44	45-50	>57	
Class Crustacea								
O. Isopoda								
O. Copepoda	+	+	+	+	+			
O. Amphipoda		+	+	+	+			
O. Euphausiacea		+	+		+			
O. Decapoda								
<u>Pandalus borealis</u>			+	+				
Class Chaetognata			+	+				
Class Pisces								
Fam. Scorpaenidae								
<u>Sebastes spp</u>			+	+	+	+	+	
Fam. Gadidae								
<u>Gadus morhua</u>						+	+	
Fam. Myctophidae			+					
Larvas pisces								
Other pisces		+	+	+	+	+		

Table III. Food components observed in the stomachs of cod, by age classes in Div.3M in July 1988.

Food objects	Cod age							
	1	2	3	4	5	6	7	8
Class Ctenophora		+	+	+	+	+	+	
Class Ascidiias					+			
Class Polichaeta								
O. Errantia		+	+	+	+		+	
Fam. Aphroditidae					+			
O. Sedentaria			+					
Class Crustacea								
O. Isopoda		+	+					
O. Copepoda		+						
O. Amphipoda		+	+	+	+	+	+	
O. Euphausiacea		+	+	+				
O. Decapoda								
<u>Pandalus borealis</u>		+	+	+	+	+	+	
<u>Pagurus bernardus</u>			+					
Other decapoda		+	+	+				
Class Bivalvia				+				
Class Cephalopoda								
<u>Illex illecebrosus</u>			+	+	+			
<u>Onichoteuthis sp</u>				+				
Other cephalopoda		+	+	+	+	+		
Class Ophiuroidea		+		+				
Class pisces								
Fam. Scorpaenidae								
<u>Sebastes spp..</u>		+	+	+	+	+	+	+
Fam. Gadidae								
<u>Gadus morhua</u>			+	+	+	+	+	
<u>Urophycis chuss</u>						+		
Fam. Anarhichadidae								
<u>Anarhichias sp</u>			+		+		+	+
Fam. Myctophidae			+	+				
Fam. Zoarcidae								
<u>Lycodes sp</u>				+			+	
Larvas pisces			+	+				
Other pisces			+	+	+	+	+	

Table IV. The Diversity Index of American Plaice by length groups in Div.3M in July 1988.

<21	21-26	27-32	33-38	39-44	45-50	>50
0.61	0	0.15	0.28	0.41	0.36	0.8

Table V. The occurrence index (stomach number with a /total stomach number) of American plaice in Div.3M in July 1988.

Food objects	A.plaice length (cm)							
	<21	21-26	27-32	33-38	39-44	45-50	51-56	>57
Polychaeta	-	-	-	0.035	0.016	-	-	-
Bivalva	0.04	-	0.03	0.045	0.13	0.07	0.14	-
Crustacea*	-	-	0.09	-	-	-	-	-
EchinoGermata								
Ophiuroidea	0.27	0.33	0.73	0.65	0.55	0.55	0.43	-
Echinoidea	-	-	-	0.023	0.016	0.04	0.4	-
Others Echino- Germata	-	-	-	-	0.016	0.02	-	-
Pisces	-	-	-	-	-	-	-	0.5
Other Feed	0.27	0.33	0.33	-	0.003	0.02	-	-
N stomachs	22	3	33	85	121	49	5	2
Empty stomach percentage	42	34	13	25	27	31	14	50

*Mainly decapods

Table VI. The Condition Factor of American plaice by length groups, in Div.3M in July 1988.

Length (cm)	FC(W*100/L ³)	N° stomachs
<21	0.85±0.12	22
21-26	0.98±0.05	3
27-32	1.03±0.18	33
33-38	1.04±0.11	85
39-44	1.10±0.10	121
45-50	1.09±0.09	49
51-56	1.12±0.13	5
>57	0.91±0.44	2
total	1.02±0.10	320

Table VII. Occurrence Index(stomachs numbers with a /total stomachs number) of Redfish, in Div.3M in July 1988.

Food objects	Redfish length (cm)						
	<21	21-26	27-32	33-38	39-44	45-50	>50
Crustacea							
Anhipoda	-	0.14	0.12	0.06	0.04	-	-
Copepoda	0.18	0.05	0.12	0.12	0.04	-	-
Other							
Crustacea	-	0.02	0.04	0.02	0.04	-	-
Pisces							
Sebastes spp.	-	-	0.07	0.02	0.04	0.14	0.20
Gadus morhua.	-	-	-	-	-	0.14	0.20
Other Pisces	-	0.02	0.05	0.04	0.04	0.14	-
Other Feed	0.09	-	0.04	0.04	0.11	-	-
N° stomachs	11	44	57	51	28	7	5
Empty stomach percentage	73	80	61	73	75	57	60

Table VIII. The Condition Factor of Redfish by length groups in Div.3M in July 1988.

Length	FC(W*100/L ³)	N° stomachs
<21	1.60±0.23	11
21-26	1.48±0.15	44
27-32	1.54±0.18	57
33-38	1.53±0.12	51
39-44	1.50±0.10	28
45-50	1.42±0.18	7
>50	1.41±0.14	5
Total	1.50±0.07	203

Table IX. The Diversity Index of Redfish by length groups in Div. 3M in July 1988.

<21	21-26	27-32	33-38	39-44	45-50	>50
0.67	0.64	0.81	0.81	0.89	0.33	0.00

Table X. The cannibalism of cod in the total stomachs by age groups in Div. 3M in July 1988.

Age	3	4	5	6	7
	0.6%	4.2%	9.4%	15.4%	4.5%
Average 3.8%					

Table XI. The Occurrence Index:(stomach number with a /total stomach number) of Cod, in Div. 3M in July 1988.

food objects	Cod age							
	1	2	3	4	5	6	7	8
Polychaeta	-	0.08	0.05	0.01	0.04	-	0.05	-
Cephalopoda	-	0.02	0.04	0.05	0.08	0.08	-	-
Crustacea								
Anphypoda	-	0.33	0.48	0.36	0.17	0.15	0.09	-
Decapoda*	-	0.14	0.11	0.14	0.11	0.15	0.27	-
Other crus- tacea	-	0.15	0.10	0.05	-	-	-	-
Pisces								
Sebastes spp	-	0.03	0.20	0.22	0.43	0.38	0.50	0.33
Gadus morhua	-	-	-	0.04	0.09	0.15	0.05	-
Other pisces	-	0.03	0.12	0.15	0.06	0.08	0.23	0.33
Other Feed	-	0.17	0.10	0.20	0.11	0.15	0.14	0.33
N° stomachs	3	66	164	144	53	13	22	3
Empty stomachs percentage	100	20	12	20	11	15	14	33

* Mainly Pandalus borealis

Table XII. The Condition Factor of cod by age groups in Div. 3M in July 1988.

Age	FC(W*100/L ³)	N° stomachs
1	0.97±0.07	3
2	0.95±0.39	66
3	0.92±0.08	164
4	0.93±0.08	144
5	0.94±0.11	53
6	1.02±0.14	13
7	0.97±0.08	22
8	0.94±0.04	3

Table XIII. The Food Diversity Index of cod by age groups in Div. 3M in July 1988.

1	2	3	4	5	6	7	8
-	0.70	0.78	0.82	0.79	0.87	0.79	-

Table XIV.- Cod predation on redfish, in Div. 3M in July 1988. Relation between predator / prey size.

Redfish	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	totals	\bar{L} of Prey	
Cod																										
<33	1																							1	4	
33-38			1	3	2	3	1																		16	8
39-44				3	7	3	2	2	3	2				1											23	9.7
45-50					1		1	3	2	1															8	11
51-55										2	1														3	13
57-62					2	2	2	2	4	2							1								15	11.7
63-68					4	3		2	5	2															16	10.4
69-74							1	1	1	6	7		1				1								18	13.7
75-80										3															3	13
81-86																				1			1	2	25	
>86																1								1	1	
Total		1	6	16	11	7	10	15	13	8		2		1	2				1				1	100		

Table XV. The diet overlap index for American plaice, redfish and cod in July 1988 in Flemish Cap.: totals and by length groups.

Redfish < 38 cm. / Redfish > 38 cm.: $R_0 = 0.8325$

A. plaice < 44cm. / A. Plaice > 44 cm.: $R_0 = 0.94$

Cod < 38 cm. / Redfish < 38 cm.: $R_0 = 0.684$

Cod < 38 cm. / A. plaice < 38 cm.: $R_0 = 0.3055$

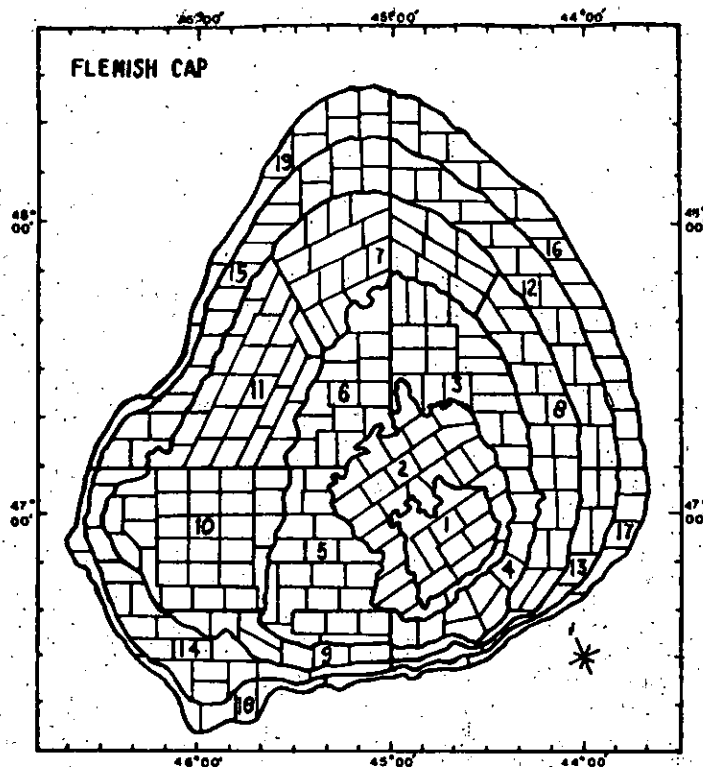
Cod < 44 cm. / A. plaice < 44 cm.: $R_0 = 0.2105$

Redfish < 38 cm. / A. plaice < 38 cm.: $R_0 = 0.5425$

Total Redfish / Total A. plaice : $R_0 = 0.4875$

Total Redfish / Total Cod : $R_0 = 0.7045$

Total Cod / Total A. plaice : $R_0 = 0.2735$



stratum	Depth range (Fathoms)	area (sq.miles)	rectangles	number of trawls carried out	
				valid	null
1	70-80	342	13	4	
2	81-100	333	25	10	
3	101-120	622	13	7	
4	101-120	343	10	4	
5	121-140	703	20	3	
6	101-120	490	15	6	
7	141-200	822	24	9	
8	141-200	646	19	7	
9	141-200	314	5	3	
10	141-200	951	23	0	2
11	141-200	386	24	9	
12	201-300	870	23	0	
13	201-300	249	7	3	
14	201-300	602	17	6	1
15	201-300	606	20	6	2
16	301-400	534	19	7	
17	301-400	216	6	2	
18	301-400	210	6	2	
19	301-400	414	12	5	
Total		10555	309	115	5

Figure 1.- Flemish Cap stratification with its main characteristics and number of trawls planned and carried out.

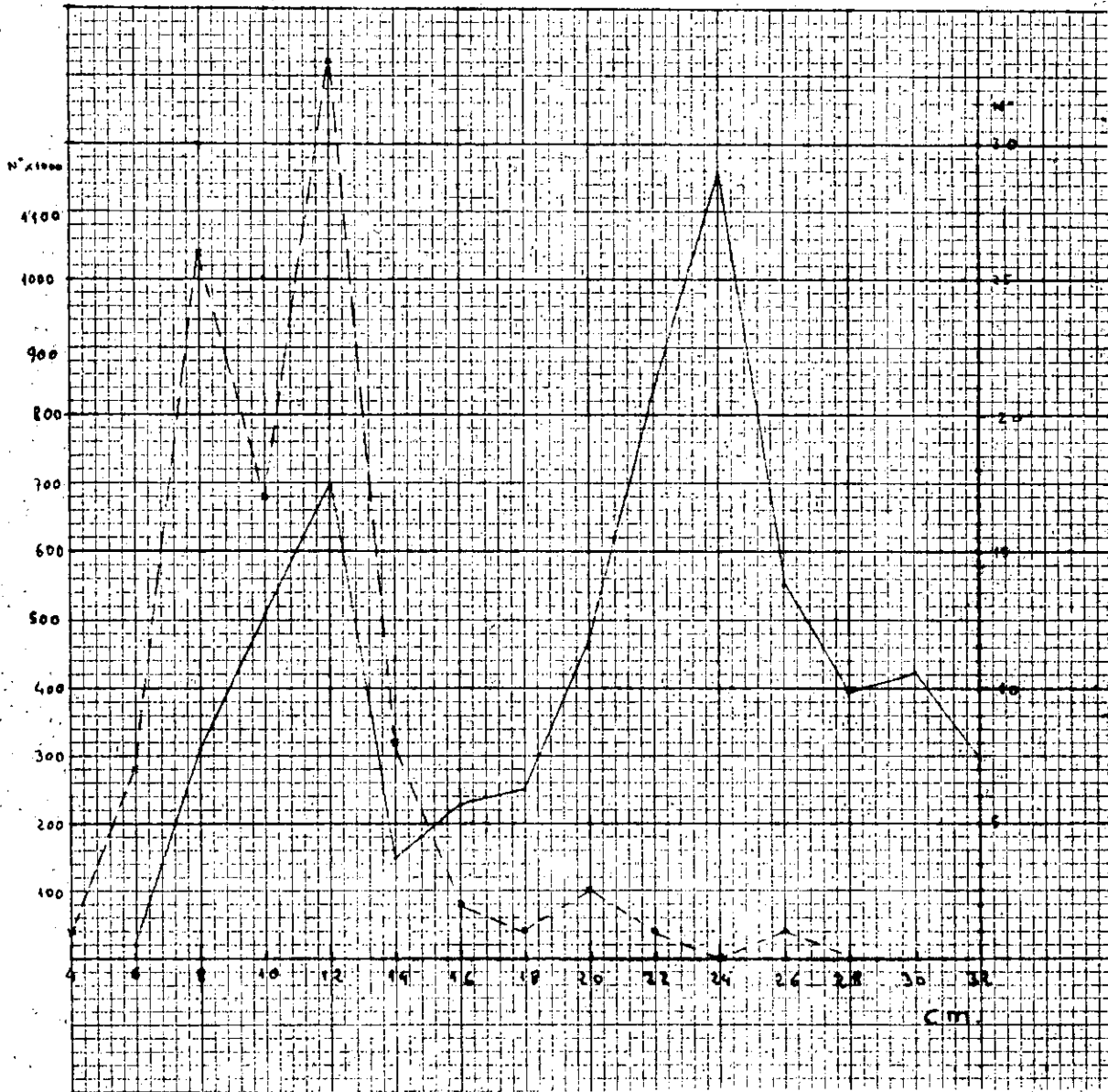


Fig. 2. Length distribution of redfish (*S. marinus*) in the surveys (full line) and in the cod stomach (dashed line) during Flemish Cap, 1988.

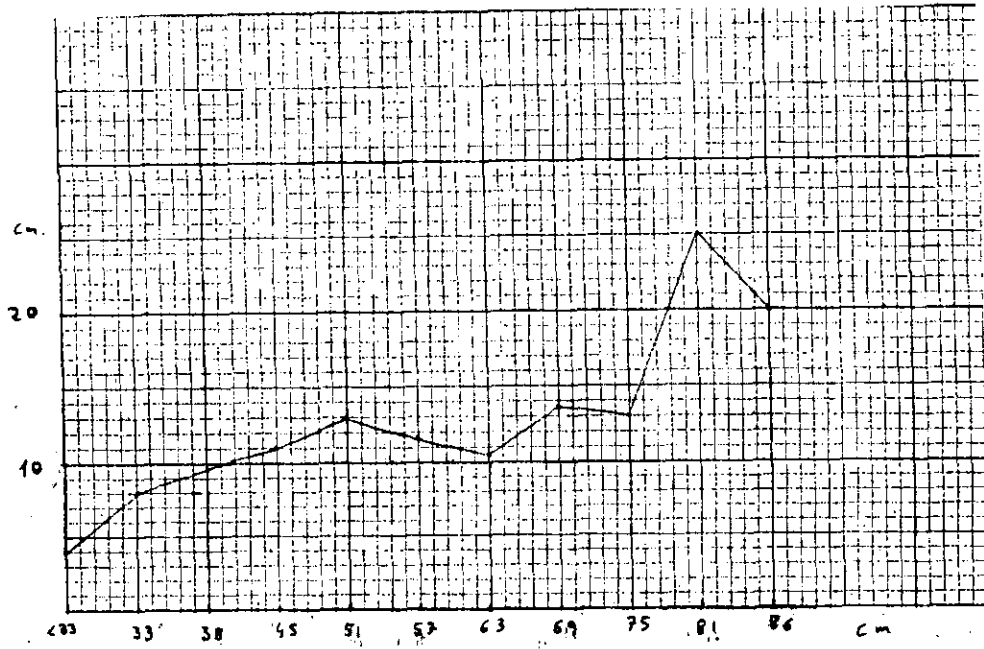


Figure 3. Mean length of *S. marinus* (prey) plotted against length class of cod (depredator).

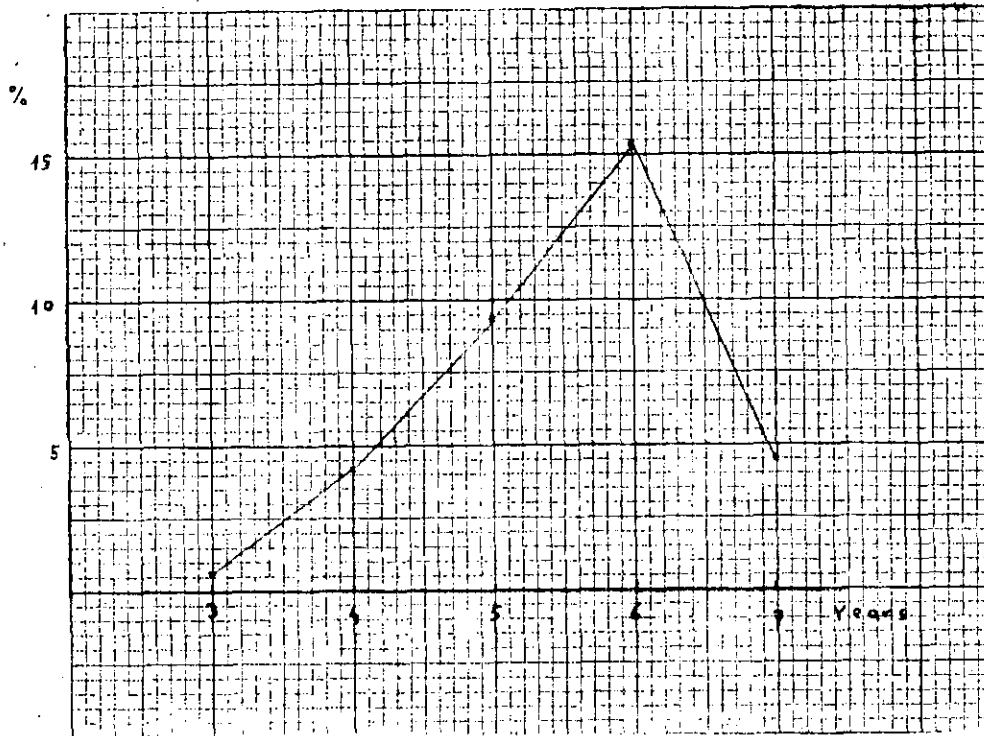


Figure 4. Occurrence index of cannibalism plotted against year-class.