INTERNATIONAL COUNCIL FOR
THE EXPLORATION OF THE SEA

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Demersal Fish Committee

FEEDING OF NORTH SEA COD IN ROUNDFISH ARREA 6 IN 1980 -PRELIMINARY RESULTS

by

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Introduction

The large scale stomach sampling programme initiated in the North Sea in 1981 is supposed to yield the necessary information for the calibration of the food composition of five fish stocks against the year class strength of the different commercial fish species in that year.
In setting out the requirements for sampling intensity for this programme it became obvious that such a programme could not be continued on a routine basis, but at best could be repeated once or twice after a couple of years. Still, it would obviously be rather important to test the validity of the calibration procedure in one particular year against reliable information about the stomach contents in an independent year.

The information obtained for an earlier period by DAAN (1973) does not seem adequate in this respect because the sampling intensity was too low for analysing the data by individual years. Therefore, it was decided to start a sampling scheme for cod stomachs already in 1980 before the onset of the international programme. For the particular purpose of investigating annual variations in food composition and consumption it appeared appropriate to concentrate the effort in one particular area rather than spreading the limited effort over the entire North Sea. Therefore, in addition to the annual ICES Young Fish Survey in February, 3 GOV trawling cruises were carried out by the R.V. Tridens in roundfish area 6 in May, August and November 1980 respectively. This report deals with the results of these investigations.

Sampling intensity

Since Scotland and England cooperated in the collection of samples both during the IYFS and during standard trawl surveys in the third quarter of the year, stomach samples came in from a larger North Sea area than just area 6. Table I presents the number of samples and the number of cod stomachs investigated in 1980 by quarters, roundfish areas and by

predator size classes. In addition fig. 1 shows the spatial distribution of the collected stomachs by statistical rectangles.

Only for area 6 a high sampling intensity has been maintened during all seasons and this report deals only with the results for that area.

Methods

Sampling methods and the laboratory analysis of the contents were generally in accordance with the views expressed in the report of the ad hoc WG on Multispecies Assessment Model Testing (ICES, 1980) and of the Draft Manual for the Stomach Sampling Project *), except for minor amendments which were introduced in due course. Originally up to 25 fish per size class were opened but this number was later on reduced to 10. Fish showing signs of regurgitation were excluded from the sample and, whenever possible replaced by other individuals. (In 1981 it was decided to replace fish showing signs of regurgitation by feeding animals).

The stomach contents of all fish within a size class were emptied in jars and meanwhile inspected for obvious signs of having entered the stomach during the trawl haul. Such prey were also excluded from the sample.

Each trawl haul was further sampled for length distributions of the cod caught (as well as all the other fish species) in order to allow for a weighting factor for each sample during additive processes, based on the average abundance of the fish in the corresponding size class within each rectangle sampled.

The grouped samples were taken back in formalin and processed in the laboratory. The essential information contained the weights and numbers of each prey type by prey size category. In addition actual measurements were made of fish prey whenever possible.

The information was stored on magnetic disc for further analysis. For coding of the taxonomic units the NODC coding system was extended to include the relevant North Sea fauna.

Results

The stomach content data were combined with the relative abundance figures in each statistical rectangle to produce average figures of food composition of the total cod population in area 6 by quarter of the year. If N is the relative measure of density (number per hour fishing) and writing i for predator size class, j for prey and k for statistical rectangle, then the overall average weight ($\bar{w}$) of that prey in the stomach of an average predator in the area is:

$$\bar{w}_i^j = \frac{\sum_k N_k^i \times \bar{w}_{ik}^j}{\sum_k N_k^i}$$

*) Prepared during the stomach sampling meeting in IJmuiden, 13-15 January 1981. A limited number of copies is still available from the Netherlands Institute for Fishery Investigations, Haringkade 1, IJmuiden.

The output tables are rather voluminous due to the hundreds of prey types/size categories distinguished. Only global results will be given here but the basic tables are available upon request.

Fig. 2 provides the % weight composition by major taxa. The well established transition for cod from feeding on crustaceans to feeding on fish is apparent in all seasons but in detail considerable differences are exhibited. These variations will be partly caused by changes in absolute abundance of the prey types but they are also an effect of patterns of redistribution of the cod population over the area. As an example in fig. 3 the abundance of I-group cod over the area is shown for each of the four surveys. In winter these fish were particularly abundant in the inshore area, but they moved out rapidly and spread widely over the area during the summer. In autumn they were concentrating again along the continental coast.

Table II summarizes the information averaged over the four seasons. The mean weights of the stomach contents in individual quarters are plotted against predator length on a double logarithmic scale in fig. 4. For comparison the relationship obtained in an earlier study ($w_s = 0.000158 \times L^3$; DAAN, 1973) is also shown. The general agreement between the two data sets is striking. This is also true for the general trend in the nr of prey items per stomach with increasing predator size (fig. 5), although the present level is increased approximately by 1 item per stomach.

The weight % composition by commercial species given in the lower part of table II will be of later interest when comparable data for 1981 become available. In order to study the prey size preference of cod the frequency distributions of the different prey size classes by weight are given by predator size class in table III. In fig. 6 these data have been plotted, after a correction procedure based on log prey size class band width. (This was necessary because the division in size classes follows only approximately a logarithmic trend). The black part of the columns represents fish and the rest consists predominantly of crustaceans (and molluscs) since most annelids were not classified to size classes and appear at the right hand side of the figure. Because of their elongated format it did not seem appropriate to include annelids in an analysis of prey size class spectra. A general upward shift in prey size class is apparent which is associated with the transition from crustacean feeding to fish feeding. In fact in the larger size classes a bimodal distribution develops separating fish from crustaceans.

Fig. 7 provides similar information for the % composition in numbers in the stomachs by prey size classes. As could be expected the peaks have shifted to the left.

An interesting comparison can be made between the prey size preference of cod and of turbot (WETSTEIJN, 1981). The range of prey size classes within the food of turbot of a particular size is smaller and also the peaks are much more pronounced than for cod. This suggest that not only the cod is a less discriminate feeder in terms of the overall food spectrum but also in relation to the"optimal" prey size.

References

DAAN, N., 1973 - A quantitative analysis of the food intake of North Sea Cod, Gadus morhua. Neth. J. Sea Res. 6(4): 479-517.

ICES, 1980 - Report of the ad hoc Working Group on multispecies Assessment Model Testing. ICES C.M. 1980/G:2.

WETSTEIJN, B., 1981 - Feeding of North Sea Turbot and Brill. ICES C.M. 1981/G:74.

Table I - Sampling intensity of cod stomachs in 1980 by quarters, roundfish areas and predator size classes (n = nr of samples; N = nr of stomachs).

		7 - 10		10 - 15		15 - 20		20 - 25		25 - 30		30 - 40		40 - 50		50 - 70		70 - 100		100 - 150		total	
		n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N	n	N
1st Quarter 1980																							
Rndf area	1	1	1					13	86		*)	21	120	19	67	19	90	19	62	3	4	95	430
	2			10	118	6	31	8	21		*)	5	63	4	42	3	24	3	18	2	5	41	322
	3					2	3	4	4		*)	6	7	2	2	4	13	7	20			25	49
	4			7	64	8	43	4	19		*)	5	31	3	38	4	36	5	11	1	2	37	244
	5					1	2	2	4		*)	1	2			1	2	4	21	2	2	11	33
	6	3	3	11	149	14	246	19	317		*)	17	141	13	165	11	102	13	57	7	21	108	1211
	7			9	74	9	83	10	73		*)	8	63	6	20	6	11	7	19			55	343
Sub-total		4	4	37	405	40	408	60	524		*)	68	427	47	334	48	278	58	218	14	34	372	2632
2nd Quarter 1980																							
Rndf area	1																						
	2																						
	3																						
	4			2	4	2	26	2	29	1	12			1	1	1	4	1	1	1	1	11	78
	5			3	22	4	55	3	67	4	36	4	8	3	3			1	1			22	191
	6			12	132	24	474	25	532	25	371	18	234	18	563	19	98	8	10			149	2414
	7			1	12	1	12	1	2													3	26
Sub-total				18	170	31	567	31	630	30	419	22	242	22	567	20	102	10	12	1	1	185	2709
3rd Quarter 1980																							
Rndf area	1							4	9	1	2	13	49	12	72	17	75	13	65	6	10	66	282
	2					2	4	5	34	5	35	5	42	5	28	4	21	4	20	2	3	32	187
	3					2	8	5	11	3	23	6	24	6	18	6	24	6	21	3	5	37	134
	4					1	10	2	24	2	30	2	29	2	17	2	16	1	2			12	128
	5					3	17	4	31	5	49	5	46	4	27	2	31	2	9			25	210
	6	7	76	12	139	10	51	23	227	26	309	27	326	16	113	16	91	3	8			140	1340
	7					1	4	6	53	6	60	6	60	6	44	6	43	5	16	1	1	37	281
Sub-total		7	76	12	139	19	94	49	389	48	508	64	576	51	319	53	301	34	141	12	19	349	2562
4th Quarter 1980																							
Rndf area	1																						
	2																						
	3																						
	4																						
	5					1	1			1	1			1	4	1	10	2	5			6	21
	6			7	12	14	96	15	89	16	156	19	268	16	201	11	57	9	38			107	917
	7																						
Sub-total				7	12	15	97	15	89	17	157	19	268	17	205	12	67	11	43			113	938
Total Years		11	80	74	726	105	1166	155	1632	95	1084	173	1513	137	1425	133	748	113	413	27	54	1019	8841

Table II - Summary cod stomach content data in roundfish area 6 in 1980 (Averaged over the quarters).
($\bar{W}s$ = mean weight stomach contents per fish; $\bar{N}s$ = mean nr of prey items per fish;
$\bar{W}p$ = mean weight per prey item in the stomach).

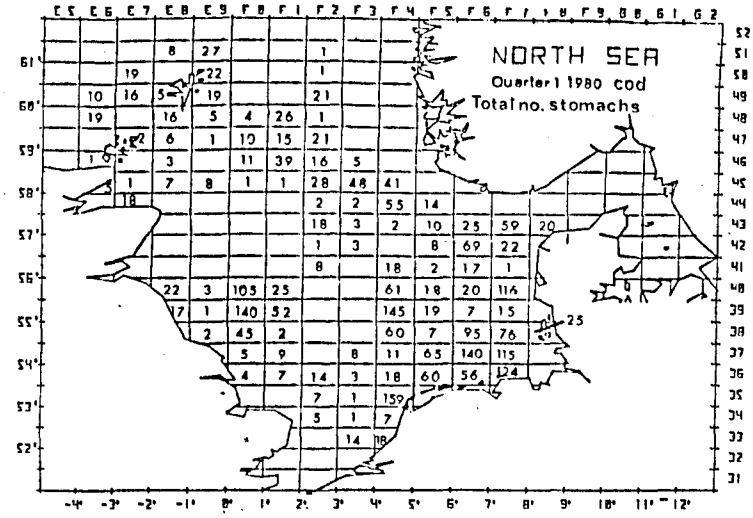
SIZE CLASS	7-10	10-15	15-20	20-25 *	25-30 *	30-40	40-50	50-70	70-100	100-150
Nr. of samples	10	42	62	82	86	81	63	57	33	7
Nr. of stomachs	79	432	867	1048	953	969	929	348	123	21
Percentage empty	10.2	26.7	23.8	19.5	12.5	15.1	11.6	11.2	21.7	13.8
Mean length	8.6	12.9	18.1	23.2	26.9	33.7	44.1	55.8	80.1	104.8
$\bar{W}a$	0.13	0.29	0.65	1.23	2.10	6.42	13.22	29.71	139.65	141.9
$\bar{N}a$	4.01	3.18	3.12	3.56	4.19	4.46	5.15	6.75	10.21	12.0
$\bar{W}p$	0.03	0.09	0.21	0.35	0.50	1.44	2.57	4.40	13.68	11.8
Stomach content composition in weight % by main taxa.										
Phaeophyta						0.03	0.04			
Porifera							0.01			
Cnidaria					0.05	0.30	0.08	0.04		
Ctenophora				0.00	0.01	0.07				
Rhynchocoela				0.01		0.00				
Annellida	6.48	9.66	22.47	28.71	28.61	15.34	13.01	10.12	1.06	0.68
Gastropoda		0.70	1.74	3.79	2.76	0.72	1.18	0.20	0.03	
Bivalvia			2.26	6.16	5.22	15.30	4.09	7.38	0.14	
Cephalopoda				0.00		0.00	0.02	0.03		
Crustacea	80.49	65.61	60.76	45.01	48.17	49.77	51.74	42.33	18.35	6.81
Priapulida				0.02	0.31		0.01			
Echinodermata			0.09	0.07	0.11	0.19	0.07	0.12	0.00	
Urochordata				0.87	0.03	0.03	0.01			
Cephalochordata				0.05	0.02	0.38	0.11			
Gnathostomata	13.04	24.03	12.69	15.32	14.71	17.80	29.66	39.79	80.43	92.51
Unknown										
Stomach content composition in weight % by commercial species										
Cod					0.08	0.33	0.70	2.92	2.03	
Haddock								0.49	7.98	
Whiting			0.02	1.05	0.25	0.28	4.14	4.11	26.77	2.64
Saithe						0.24				
Plaice			0.00	0.07		0.10	0.02	0.42	0.70	28.26
Sole			0.00	0.04	0.01	0.37	0.53	0.35	0.38	
Sandeel		14.44	2.42	2.99	5.52	6.26	9.91	3.28	0.52	0.19
Herring	11.76 **		0.00	0.49	0.04	0.20	1.22	4.65	0.76	0.23
Sprat		0.85	3.27	3.17	3.21	3.25	2.94	4.81	0.74	9.11
Norway Lobster				0.29		0.23	0.14	0.76		
Brown shrimp	30.06	33.16	30.28	12.02	12.14	5.71	3.97	2.62	0.05	

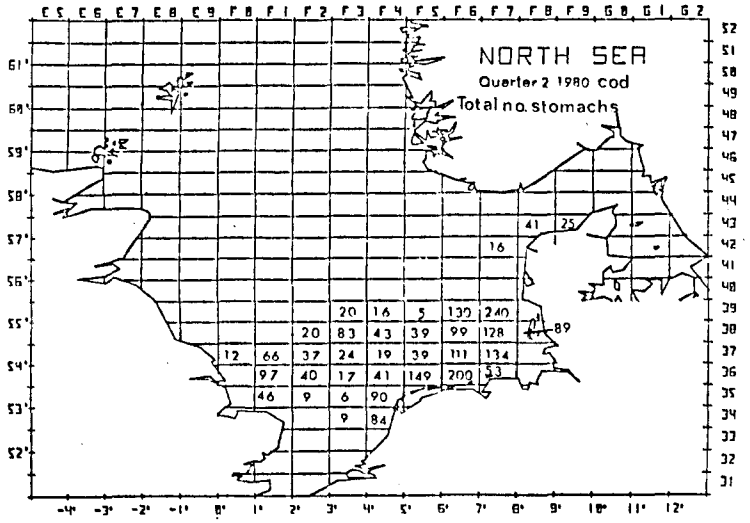
*) The data for the size class 20-30 cm from the first quarter have been included in both size classes for obtaining an annual average.

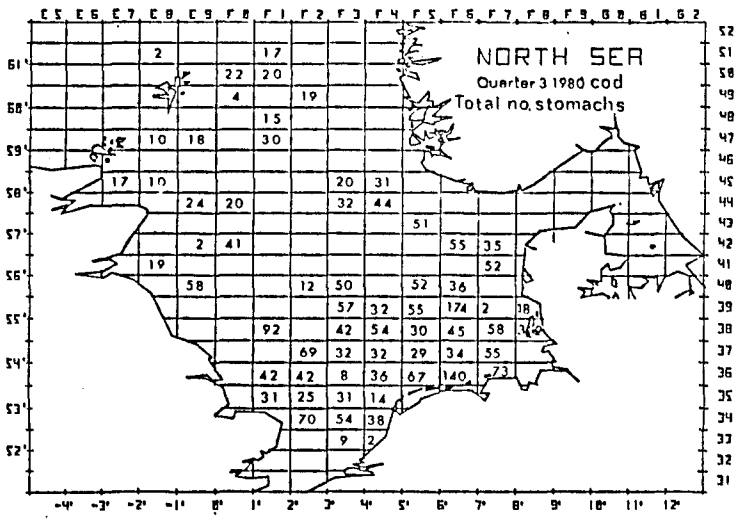
**) larvae

Table III - Size class distribution of prey items by predator size class (annual average).
Size class code represents lower limit in mm.

Size class		7-10	10-15	15-20	20-25	25-30	30-40	40-50	50-70	70-100	100-150
Weight %											
Code	0 Eggs		0.58		0.14	0.01		0.00	0.01		
	1	0.04	0.02	0.09	0.03						
	2										
	3	0.11	1.11		0.01	0.02					
	4	0.09	0.08	0.06		0.00					
	5	6.00	1.76	0.85	3.59	1.64	0.22	0.00	0.01		
	7	2.98	0.58	3.22	1.91	2.65	1.04	0.15	0.07	0.00	
	10	22.03	5.86	12.27	7.00	7.59	2.47	1.24	0.49	0.02	
	15	24.63	2.93	6.19	6.32	4.93	4.34	3.74	0.93	0.29	1.87
	20	17.02	14.32	5.83	7.42	9.29	11.40	10.22	6.27	1.44	0.69
	25	5.78	14.01	9.89	5.18	9.41	7.54	10.15	9.20	4.59	0.02
	30	13.47	28.56	14.10	15.07	6.96	20.93	18.51	16.52	8.28	3.75
	40		7.51	10.02	3.24	9.14	5.01	6.14	12.69	2.45	0.34
	50		10.32	8.34	11.57	9.72	20.98	13.22	9.55	1.27	2.28
	70		0.14	0.47	3.29	5.27	5.52	4.81	5.34	1.66	6.87
	100			0.13	3.38	3.13	5.91	16.88	18.37	12.73	9.84
	150					1.40	2.17	6.84	15.30	22.00	33.89
	200					0.33	0.32	1.60	1.35	31.97	16.07
	250									11.37	4.29
	300									0.07	19.07
	9999 Unclassified	7.92	12.24	28.56	31.89	28.58	12.14	6.51	3.94	1.87	0.83
Number %											
Code	0 Eggs		0.32		0.31	0.25		0.20	4.54		
	1	0.06	0.02	14.65	9.70						
	2										
	3	0.46	4.38		0.09	0.15					
	4	0.31	0.20	1.01		0.08					
	5	14.87	9.18	1.74	10.67	8.07	1.74	0.00	0.11		
	7	13.57	2.69	4.84	4.15	11.92	5.55	1.56	0.36	0.11	
	10	34.85	19.04	16.49	12.50	9.82	6.22	4.89	2.25	0.68	
	15	20.20	4.25	9.30	3.69	4.60	5.57	7.12	3.27	1.92	16.37
	20	6.54	9.12	6.52	8.08	6.26	11.65	10.73	9.43	7.49	8.54
	25	1.45	5.91	11.79	8.06	9.63	7.40	8.34	11.92	15.63	0.26
	30	3.85	12.83	8.38	7.85	6.52	14.05	19.51	16.27	17.84	7.57
	40		7.21	3.30	2.57	3.70	6.58	5.46	12.46	4.44	1.99
	50		7.32	1.62	3.09	3.29	9.99	5.96	10.46	2.25	16.95
	70		0.02	0.09	0.66	1.18	2.59	3.34	6.62	4.78	21.31
	100			0.01	0.33	0.44	2.50	9.31	9.52	16.43	9.44
	150					0.09	0.57	5.84	2.77	10.07	9.24
	200					0.01	0.03	1.72	0.08	7.17	3.92
	250									1.70	0.26
	300									0.01	1.35
	9999 Unclassified	4.27	17.54	20.28	28.30	34.25	24.63	6.47	9.8	8.35	2.82







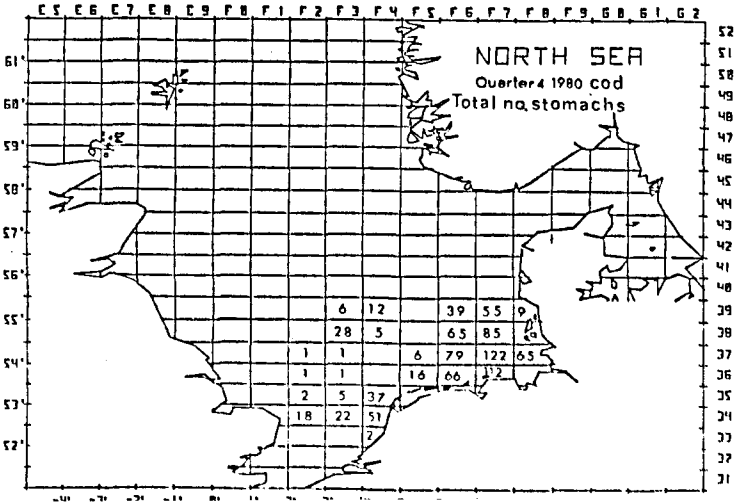


Figure 1 - Spatial distribution of cod stomach samples taken in 1980 by quarters and statistical rectangles. (Rapp. B. Vingerhoed, enclosure nr. 2).

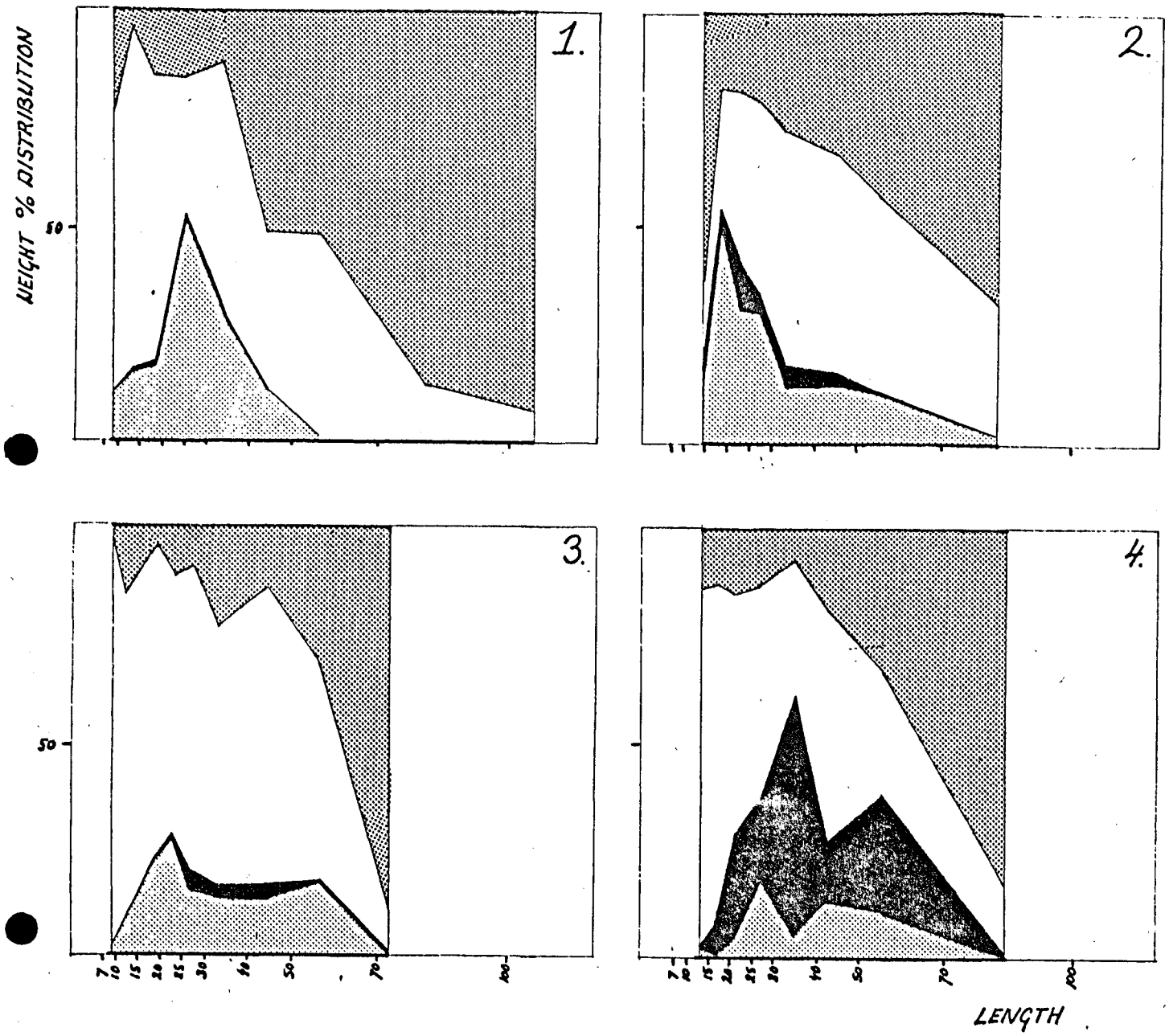
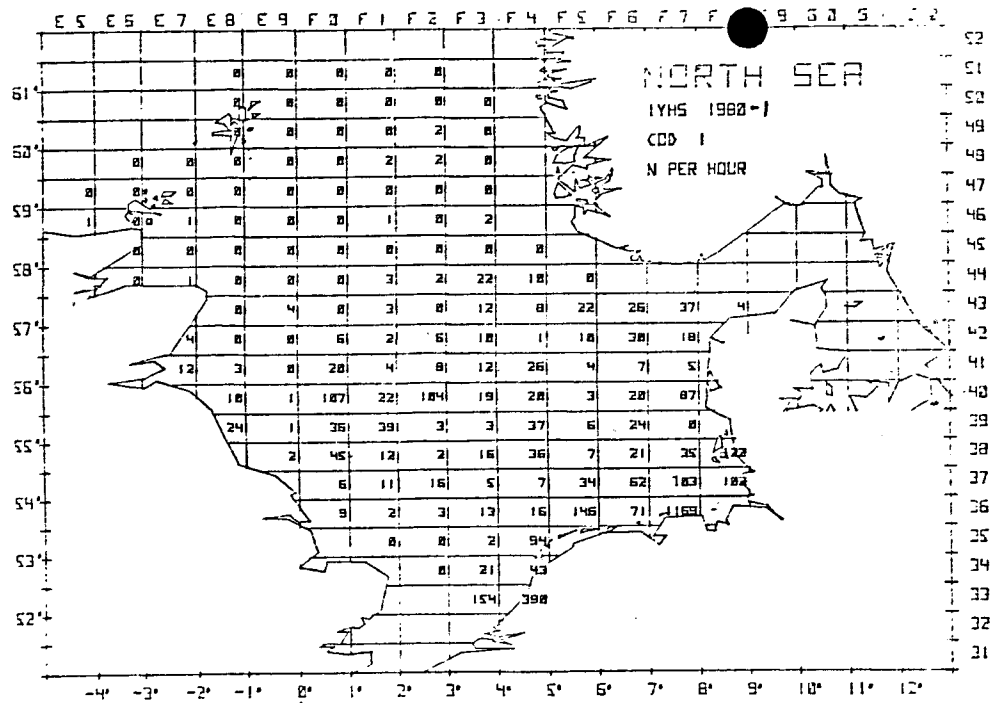
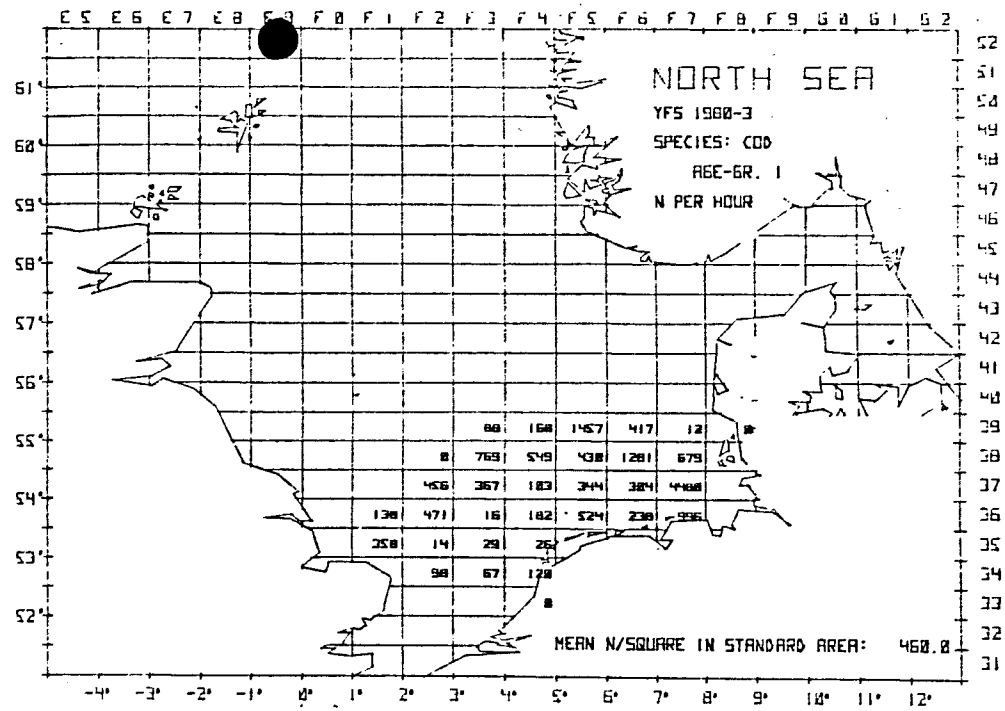
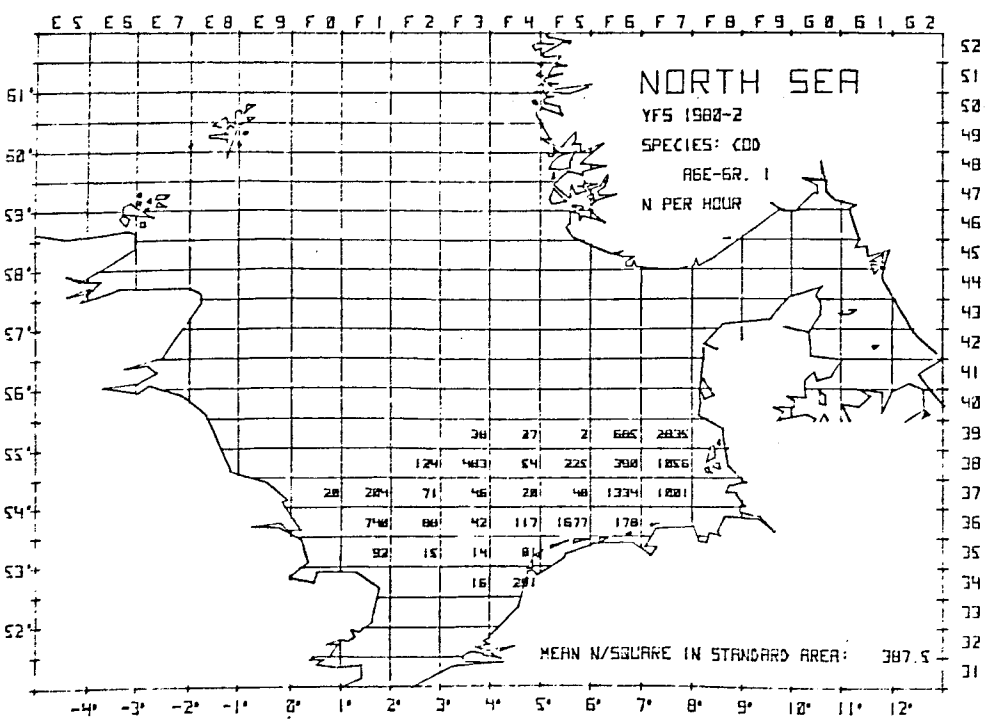


Figure 2 - Percentage weight distribution by major taxa against cod size for different quarters of 1980.







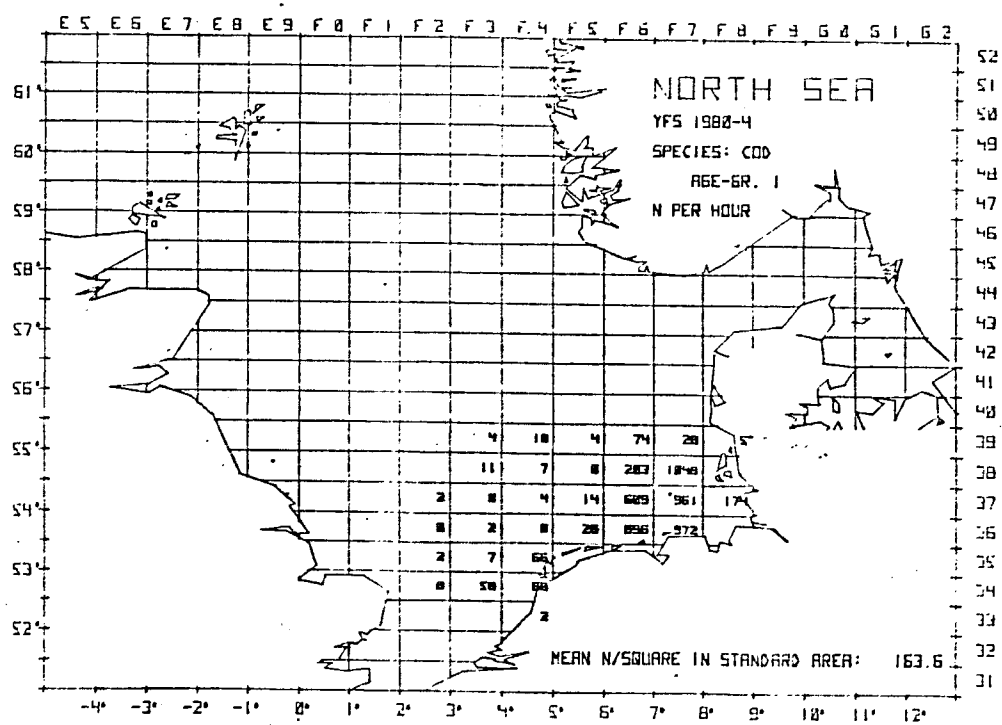


Figure 3 - Spatial distribution of I-group cod according to G.O.V. trawling surveys in different quarters of 1980.

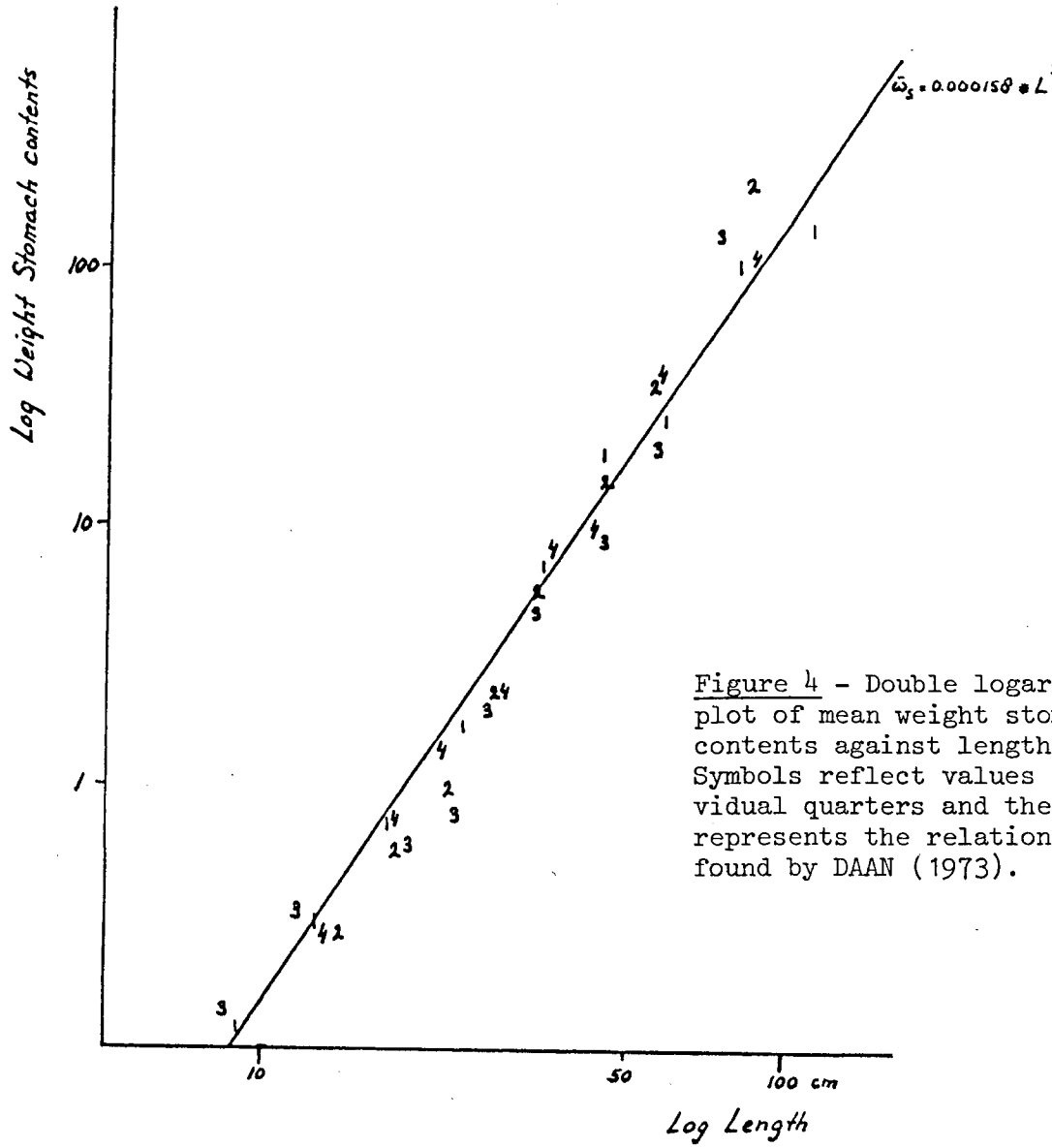


Figure 4 - Double logarithmic plot of mean weight stomach contents against length of cod. Symbols reflect values in individual quarters and the line represents the relationship found by DAAN (1973).

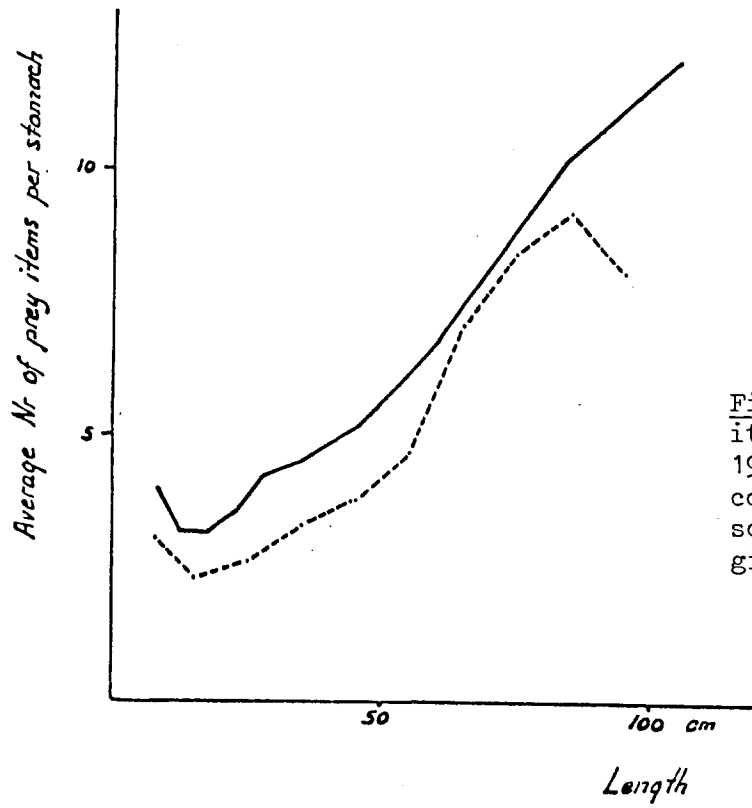


Figure 5 - Average nr. of prey items per stomach in area 6 in 1980 against cod length and the corresponding values for the southern North Sea (broken line) given by DAAN (1973).

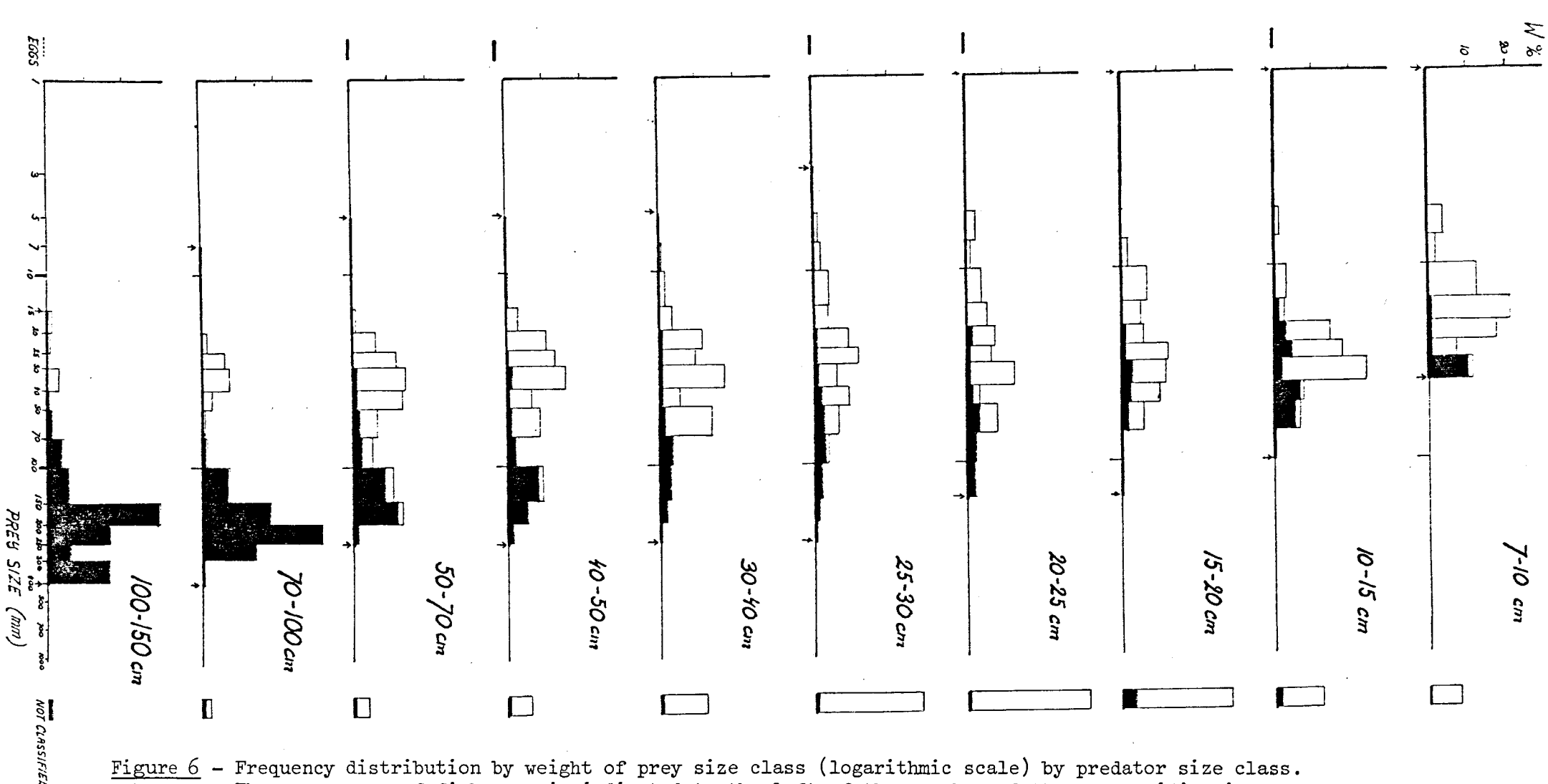


Figure 6 - Frequency distribution by weight of prey size class (logarithmic scale) by predator size class.
The occurrence of fish eggs is indicated to the left of the graphs and the unclassified items are given on the right hand side.
The black part of the columns represents fish.

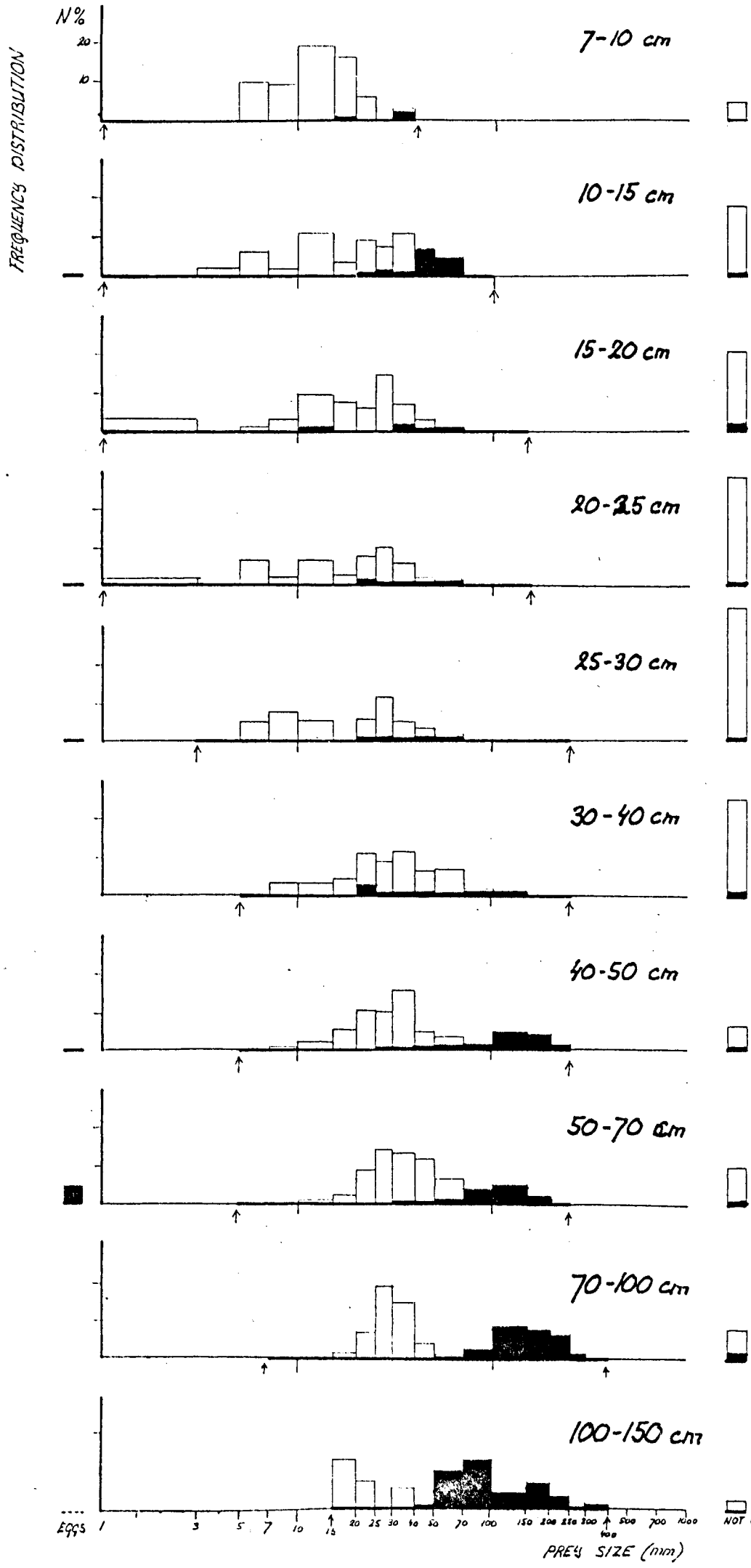


Figure 7 - Frequency distribution by numbers of prey size class (logarithmic scale) by predator size class. For other details see figure 6.