

This paper not to be cited without prior reference to the authors

International Council for the
Exploration of the Sea



ICES CM 1983/G:59
Demersal Fish
Committee

A PRELIMINARY REPORT ON THE ANALYSIS OF THE WHITING
STOMACHS COLLECTED DURING THE 1981 NORTH SEA STOMACH SAMPLING PROJECT

by

J R G Hislop, A P Robb, M A Brown and D Armstrong
DAFS Marine Laboratory
Victoria Road, Aberdeen



Digitalization sponsored
by Thünen-Institut

ABSTRACT

The mean weight of each of several types of prey in the stomachs of whiting of age groups 0 to 6 has been estimated and preliminary estimates have been made of the annual consumption by whiting of seven commercially important fish species.

RESUME

On a estimé le poids moyen de chacun de plusieurs genres de proie dans les estomacs de merlan en groupes d'âge de 0 à 6 et on a fait des calculs approximatifs préliminaires du consommation annuel (par le merlan) de sept espèces de poisson qui sont d'une importance commerciale.

INTRODUCTION

As a consequence of the growing awareness of the limitations imposed by traditional single species VPA, the ad hoc Working Group on Multispecies Model Testing recommended (Anon, 1980) that an intensive cooperative programme to analyse the stomach contents of the major fish predator species (cod, haddock, whiting, saithe and mackerel) should be carried out in 1981. The ultimate aim of this programme was to provide input data for multispecies VPA in the form of mean numbers and mean weights of each prey age/size group eaten by each predator age/size group. To ensure that the results were internally consistent it was agreed that the task of working up the material should be shared in such a way that all stomachs from a particular predator would be analysed within a single laboratory. This paper gives the preliminary results of the analysis of the whiting stomachs which was undertaken at the Marine Laboratory, Aberdeen.

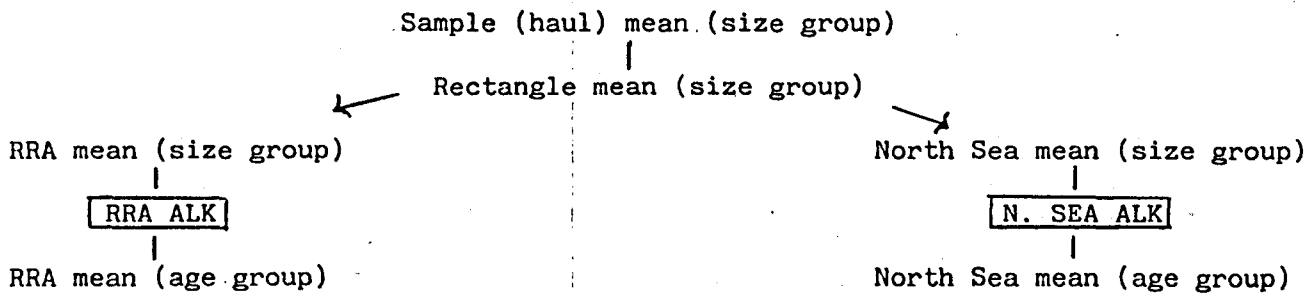
MATERIALS AND METHODS

The stomachs were collected in accordance with the guidelines outlined in the draft manual for the stomach sampling project (Anon, 1981). The objective was to sample a minimum of 10 stomachs per ICES statistical rectangle per whiting size group per quarter. The numbers of stomachs examined in each rectangle in each quarter are shown in Figure 1; Table 1 gives the numbers of full, empty and regurgitated stomachs examined in each quarter for whiting of each size group in each Roundfish Reporting Area (RRA). Good coverage of each RRA was achieved in most quarters but no samples were obtained from RRA 7 in quarter 2.

Data were stored and processed on a DEC PDP 11/70 computer using a set of programs written by one of the authors (DWA). The quality of information that could be obtained from the stomach contents depended on the type and state of digestion of the prey. The following four data types were recognised and these were filed and processed separately:

- Type 1 - Length and weight of an individual prey item
- Type 2 - Size group, weight and number of prey
- Type 3 - Weight and number of prey
- Type 4 - Weight of prey

The first objective was to provide details on a quarterly basis of the average stomach contents of whiting of each size group and each age group in each RRA and to give a value representative of the total North Sea population. There are a number of ways in which these values can be calculated; the pathways that were followed to work up the whiting data are outlined below and the methodology is described in detail in Appendices 1 and 2.



RESULTS

1: Composition of diet

Only a brief description of the results obtained for the individual RRAs will be given here, the main emphasis will be on the stomach contents averaged over the whole North Sea, for each whiting age group in each quarter of 1981.

The percentage weight of each major prey taxon, broken down by quarter and RRA, for each whiting size and age group are presented diagrammatically in Figures 2 and 3.

The greatest part of the food of whiting consists of fish and crustaceans. The proportion of fish in the diet, by weight, increased with predator size and represented about 50% of the diet of whiting in the 200-250mm size group and over 80% in whiting >300mm. There was some regional variation however. The diet of whiting in the southern North Sea (RRAs 5, 6 and 7) included a greater proportion of annelids, whilst molluscs (mainly cephalopods) were relatively important in the northern North Sea (RRAs 1, 2 and 3) in the first quarter of the year.

There were no obvious between-quarter differences in the weights of food in the stomachs. Average weights of the stomach contents increased exponentially with fish length over the range 100-500mm (Figure 4). The largest fish (> 500mm) had relatively small amounts of food in their stomachs but the means are based on a very small number of samples. If the data for the largest size group are excluded, the relationship between weight of stomach contents and fish length can

be described by the equation:

$$W_g = .00015 L_{cm}^{2.89}$$

1

and equation 2 describes the relationship between the mean weight of the stomach contents and the mean total weight of the predator:

$$W_g = .013 \text{ Fish Weight}^{.98}$$

2

Figure 5 gives the size composition of the prey of the whiting in each size group, averaged over the whole North Sea. The data are given as percentages by weight. There was an apparent increase in the importance of larger food items (mainly fish) with increasing predator size.

Details of the weights of the major types of non-fish prey in the stomachs are given in Table 2 by quarter and predator age group, averaged over the whole North Sea. The two main components of the crustacean prey were euphausiids and crangonids. Crangonids were relatively more important than euphausiids in the youngest whiting age groups but less important in the older fish.

In general molluscs made up only a small proportion of the stomach contents although appreciable quantities of squid were found in some of the quarter 1 samples. The only other invertebrate group found to make a major contribution to the weight of the stomach contents was polychaete worms.

Similar details are given in Table 3 for each type of fish prey. The greater part of the fish prey consisted of commercially exploited species, principally sandeels, sprats, herring, haddock, whiting, cod and Norway pout. Flatfish were not eaten to any great extent.

Table 4 gives the average weights of each size group of all fish prey in the stomachs of whiting of each age group in each quarter and in Tables 5a-d, the data are given separately for each species of fish. These data have been adjusted so that wherever possible the weight data relating to fish groups (unidentified gadidae, unidentified clupeoids, unidentified fish) have been allocated to particular species, using the proportions (by weight) of each named species in the stomach contents. A similar proportional method has been used to allocate fish whose size was not known to defined size groups.

2: Estimates of consumption

Estimates of daily ration were made by applying the method of Daan (1973) to the data in Tables 5a-d. This method assumes that evacuation of food from the stomach is rectilinear with respect to time. Daily ration is estimated from the equation:

$$\text{Ration} = \frac{2 \times \bar{W}}{D}$$

3

where \bar{W} = average weight of food in the stomach;
D = digestion time (days)

The simple rectilinear model proposed by Daan produces a lower estimate of daily ration than would be obtained by assuming that the rate of evacuation is proportional to the weight of food remaining in the stomach (Cohen and Grosslein, 1981). Daily intake was also determined using the method proposed by Jones (1974)

and gave values which were approximately 1.5 times greater than those obtained using the simple model. Initially, aquarium experiments were performed to estimate the times needed to digest meals of whole, previously frozen, sprat, sandeel and 0-group haddock. The results of these experiments are plotted in Figure 6.

There were no obvious differences in the times taken to digest the different prey species. Consequently, when calculating the daily consumption (in terms of weight of prey) for each age group of whiting, a digestion time of 2.5 days was applied to each prey species size class. The daily consumption figures were then raised (x 91), to a quarterly value. These total weights were converted to numbers of prey using the relevant mean weight at length data for each prey type (Harris and Hislop, 1978). Quarterly age/length group keys were applied to give the estimated numbers of prey of each age consumed by whiting of each age. These are shown in Table 6 for each quarter and summed to give an annual value. The data are expressed as the numbers of prey consumed per thousand whiting of each age.

REFERENCES

- | | | |
|---------------------------|------|--|
| Anon. | 1980 | Report of the ad hoc Working Group on multi-species assessment model testing. ICES CM 1980/G:2. |
| Anon. | 1981 | Draft manual for the stomach sampling project. IJmuiden, January 1981. |
| Cohen, E and Grosslein, M | 1981 | Food consumption in five species of fish on Georges Bank. ICES CM 1981/G:68. |
| Daan, N | 1973 | A quantitative analysis of the food intake of North Sea cod, <u>Gadus morhua</u> . Neth. J. Sea. Res. 6(4), 479-517. |
| Jones, R | 1974 | Estimates of the food consumption of haddock (<u>Melanogrammus aeglefinus</u>) and cod (<u>Gadus morhua</u>). J. Cons. int. Explor. Mer, 38(1), 18-27. |
| Harris, M and Hislop, J | 1978 | The food of young puffins, <u>Fratercula artica</u> . J. Zool., Lond (1978), 185, 213-236. |

TABLE I - Number of stomachs collected per area and predator size group

Area	Size Gp	Total	QUARTER 1			Total	QUARTER 2			Total	QUARTER 3			Total	QUARTER 4		
			Full	Reg	Empty		Full	Reg	Empty		Full	Reg	Empty		Full	Reg	Empty
AREA 1	100	114	39	14	61	130	14	72	44	6	0	1	5	47	3	27	17
	150	214	87	16	111	213	21	136	56	32	9	5	18	44	7	10	27
	200	288	93	37	158	223	30	133	60	94	19	17	58	70	7	43	20
	250	415	138	39	238	428	41	308	79	315	49	56	210	141	11	73	57
	300	455	134	31	290	330	33	227	70	384	70	77	237	169	15	96	58
	400	125	37	16	72	10	1	5	4	117	24	27	66	64	2	37	25
	500	4	0	0	4	0	0	0	0	6	2	0	4	4	0	0	4
TOTAL	1615	528	153	934	1334	140	881	313	954	173	183	598	539	45	286	208	
AREA 2	100	309	78	36	195	15	8	0	7	17	5	0	12	59	11	12	36
	150	220	70	31	119	50	11	1	38	29	9	3	17	39	6	5	28
	200	178	62	23	93	51	21	1	29	106	27	24	55	158	48	14	96
	250	188	74	20	94	52	23	0	29	135	35	32	68	170	67	2	101
	300	45	35	1	9	42	14	0	28	98	18	25	55	127	55	4	68
	400	0	0	0	0	4	0	0	4	8	4	0	4	2	0	0	2
	500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	940	319	111	510	214	77	2	135	393	98	84	211	555	187	37	331	
AREA 3	100	334	26	185	123	133	3	61	69	21	12	0	9	51	8	3	40
	150	311	56	134	121	208	42	86	80	24	3	8	13	56	6	12	38
	200	409	115	124	170	241	39	83	119	148	35	58	55	99	13	46	40
	250	458	95	202	161	293	48	113	132	232	56	91	85	115	10	59	46
	300	340	74	171	95	227	23	145	59	170	58	63	49	109	11	63	35
	400	15	6	4	5	2	0	0	2	13	2	7	4	2	2	0	0
	500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1867	372	820	675	1104	155	488	461	608	166	227	215	432	50	183	199	
AREA 4	100	168	17	75	76	28	0	0	28	0	0	0	0	43	17	2	4
	150	139	15	66	58	49	3	3	43	36	11	2	23	41	12	3	26
	200	187	21	114	52	69	5	0	64	120	43	20	57	64	28	5	31
	250	139	21	75	43	72	10	3	59	104	49	8	47	60	23	13	24
	300	80	7	56	17	50	15	0	35	102	38	24	40	32	20	1	11
	400	0	0	0	0	9	1	0	8	1	1	0	0	3	2	0	1
	500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	713	81	386	246	277	34	6	237	363	142	54	167	243	102	24	117	
AREA 5	100	11	1	0	10	0	0	0	30	15	0	15	0	0	0	0	0
	150	31	7	4	20	21	8	0	13	34	13	0	21	3	0	0	3
	200	21	7	6	8	50	19	0	31	80	34	0	46	11	5	5	1
	250	24	4	7	13	50	26	0	24	74	36	0	38	11	0	5	6
	300	21	1	7	13	50	12	0	38	35	14	0	21	10	4	0	6
	400	0	0	0	0	13	4	0	9	5	0	0	5	3	0	0	3
	500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	108	20	24	64	184	69	0	115	258	112	0	146	38	9	10	19	
AREA 6	100	406	71	79	256	122	44	0	78	157	20	0	137	230	62	13	155
	150	536	118	162	256	215	93	0	122	161	37	0	124	249	51	22	176
	200	436	116	132	188	255	103	10	142	257	56	2	199	253	55	19	179
	250	355	119	85	151	266	105	11	150	249	65	5	179	244	42	28	174
	300	271	88	46	137	225	82	0	143	226	65	21	140	207	38	14	155
	400	31	5	5	21	15	8	0	7	16	12	0	4	30	0	2	28
	500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	2035	517	509	1009	1098	435	21	642	1066	255	28	783	1213	248	98	867	
AREA 7	100	183	50	102	99	0	0	0	0	0	0	0	0	94	17	14	63
	150	187	69	34	83	0	0	0	0	5	1	0	4	87	14	6	67
	200	104	33	35	50	0	0	0	0	38	17	4	17	74	20	1	53
	250	37	14	21	16	0	0	0	0	22	11	2	9	80	19	7	54
	300	38	14	7	21	0	0	0	0	17	9	0	8	86	14	10	62
	400	5	1	3	2	0	0	0	0	3	0	0	3	6	1	1	4
	500	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	554	181	102	271	0	0	0	0	85	38	6	41	427	85	39	303	

Table 2

Quarter 1 1981. Total North Sea. Weight, age, and percentage by weight of prey in whitling of each age group.

Species	AGE 0		AGE 1		AGE 2		AGE 3		AGE 4		AGE 5		AGE 6	
	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%
TOTAL FISH	187 144.42		463 152.91		1386 170.71		2427 180.27		3143 182.23		4463 187.54			
Copepoda		1 0.24												
Hyssida														
ICuacea														
Isopoda		1 0.24		1 0.11		3 1 0.24		8 1 0.26		8 1 0.21		9 1 0.17		
Ischiuroidea		2 0.48		2 0.23		1 0.05		1 0.03		1 0.03		1 0.02		
ICurhausiidae		58 113.78		200 122.86		338 117.75		344 115.89		341 116.92		291 115.51		
ICranchiidae		50 111.80		29 113.31		41 1 2.09		43 1 1.47		43 1 1.13		49 1 0.76		
IPandalidae		1 0.24		2 0.23		7 1 0.34		9 1 0.29		10 1 0.26		10 1 0.19		
IPræcessidae		4 1 0.75		3 1 0.37		3 1 0.15		3 1 0.10		3 1 0.09		4 1 0.09		
ICallinassidae		2 1 0.48		3 1 0.34		4 1 0.20		9 1 0.29		9 1 0.24		10 1 0.19		
ICalocaris		14 1 3.33		5 1 0.57		1 1 0.05								
IPleuron														
IPleuridae		1 0.24		2 1 0.23		2 1 0.10		3 1 0.10		3 1 0.13		8 1 0.15		
IPartunidae		1 0.24						1 0.03		6 1 0.16		14 1 0.27		
ICorvidae						2 1 0.10		27 1 0.88		135 1 3.57		344 1 6.32		
Unid.Brachura		4 1 0.75		12 1 1.37		23 1 1.17		15 1 0.47		11 0.29		1 0.04		
Unid.Crustacea		10 1 2.38		8 1 0.81		3 1 0.15		3 1 0.10		3 1 0.08		4 1 0.08		
TOTAL CRUSTACEA	148 135.15		271 130.97		430 121.94		499 135.99		574 135.07		740 114.02			
ILiaccina														
IBasteroidea						2 1 0.10		6 1 0.20		7 1 0.19		8 1 0.17		
ILamellibranchia				1 0.11		1 0.05		1 0.03						
ICephalopoda		58 113.78		99 111.31		89 1 4.54		58 1 1.90		47 1 1.23		23 1 0.44		
Unid.Mollusca		7 1 0.71		11 1 1.24		8 1 0.41		17 1 0.56		19 1 0.47		23 1 0.40		
TOTAL MOLLUSCA	61 114.47		111 112.49		101 1 5.15		82 1 2.48		72 1 1.88		52 1 0.99			
TECHINODERMATA														
IPLATHELMINTH						1 0.05		2 1 0.07		2 1 0.07		2 1 0.04		
IMEH														
IPOLYCHAETA		20 1 4.75		21 1 2.40		23 1 1.17		17 1 0.56		16 1 0.42		13 1 0.25		
IECHINUROIDA		1 0.24				1 0.05		3 1 0.10		3 1 0.08		3 1 0.06		
ICHIDARIA														
ICHANETOGMATHA		1 0.24												
ICTEMOPORA						1 0.05								
IAPPENDICULARIA		1 0.24		2 1 0.23		1 0.05								
IASCIDIACEA														
ISIPHONOPORA														
IPORIFERA														
Unid. PREY		2 1 0.59		5 1 0.41		20 1 1.02		13 1 0.43		19 1 0.26		3 1 0.06		
Unident. PREY		2 1 0.59		5 1 0.41		20 1 1.02		13 1 0.43		19 1 0.26		3 1 0.06		
GRAND TOTAL	421		875		1940		3041		3822		5279			

Quarter 3 1981. Total North Sea. Weight, age, and percentage by weight of prey in whitling of each age group.

Species	AGE 0		AGE 1		AGE 2		AGE 3		AGE 4		AGE 5		AGE 6	
	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%
TOTAL FISH	30 1 7.81		478 167.20		2085 185.78		3128 188.99		4093 190.45		4797 191.72		5884 193.78	
Copepoda														
Hyssida														
ICuacea				2 1 0.20		1 0.04		2 1 0.04		3 1 0.07		4 1 0.08		3 1 0.05
Isopoda														
Ischiuroidea		1 1 0.26		1 0.10		4 1 0.16		6 1 0.17		7 1 0.16		7 1 0.13		4 0.10
ICurhausiidae		2 1 0.52		47 1 4.46		126 1 5.16		162 1 4.61		188 1 4.17		295 1 3.92		215 1 3.41
ICranchiidae		193 150.26		15 1 1.49		7 1 0.29		8 1 0.23		9 1 0.20		10 1 0.19		8 1 0.13
IPandalidae														
IPræcessidae		1 0.24												
ICallinassidae		4 1 1.04		17 1 1.48		2 1 0.08		2 1 0.06		2 1 0.04		1 0.02		1 0.02
IPleuridae														
IPartunidae														
ICorvidae		1 1 0.26		20 1 1.98		31 1 1.27		35 1 1.00		37 1 0.82		38 1 0.73		35 1 0.56
Unid.Brachura		4 1 1.04		4 1 0.40		7 1 0.29		20 1 0.57		32 1 0.71		46 1 0.78		33 1 0.52
Unid.Crustacea				11 1 1.07		4 1 0.16		5 1 0.14		8 1 0.18		10 1 0.19		8 1 0.13
Unid.Brachura														
Unid.Brachura		14 1 3.63		74 1 7.33		67 1 2.74		60 1 1.71		55 1 1.22		52 1 0.99		50 1 0.79
Unid.Crustacea		89 123.18		8 1 0.79		8 1 0.33		6 1 0.17		3 1 0.07		1 0.02		1 0.02
TOTAL CRUSTACEA	310 180.73		199 119.72		260 110.65		310 1 80.2		347 1 7.70		375 1 7.17		364 1 5.78	
ILiaccina				3 1 0.30		2 1 0.08		2 1 0.04		3 1 0.07		3 1 0.06		3 1 0.05
IBasteroidea														
ILamellibranchia														
ICephalopoda														
Unid.Mollusca				3 1 0.30		2 1 0.08		3 1 0.09		5 1 0.11		6 1 0.11		5 1 0.08
TOTAL MOLLUSCA				33 1 3.27		12 1 0.49		12 1 0.34		16 1 0.34		30 1 0.38		17 1 0.27
TECHINODERMATA														
IMEH														
IPOLYCHAETA		42 116.74		61 1 6.05		75 1 3.07		63 1 1.79		47 1 1.04		33 1 0.43		27 1 0.43
IECHINUROIDA		1 0.24		2 1 0.29		2 1 0.08		2 1 0.06		2 1 0.04		2 1 0.04		1 0.02
ICHIDARIA														
ICHANETOGMATHA														
ICTEMOPORA														
IAPPENDICULARIA														
ISALPINE														
Unid. PREY														
GRAND TOTAL	384		1009		2442		3515		4501		5230		6301	

Quarter 2 1981. Total North Sea. Weight, age, and percentage by weight of prey in whitling of each age group.

Species	AGE 0		AGE 1		AGE 2		AGE 3		AGE 4		AGE 5		AGE 6	
	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%
TOTAL FISH	175 151.78		475 158.21		1291 175.02		1921 180.44		2331 182.02		2798 182.88		2422 182.49	
Copepoda		3 1 0.89		2 1 0.25		1 1 0.06		1 1 0.04		1 1 0.04		1 1 0.03		1 1 0.03
Hyssida		1 1 0.30												
ICuacea														
Isopoda		1 1 0.30		1 1 0.12		2 1 0.12		1 1 0.04		1 1 0.04		1 1 0.03		1 1 0.03
Ischiuroidea		16 1 4.73		9 1 3.10		2 1 0.12		1 1 0.04		1 1 0.04		1 1 0.03		1 1 0.03
ICurhausiidae		89 126.33		262 132.11		297 137.26		225 112.42		179 112.30		145 110.89		165 112.20
ICranchiidae		17 1 5.03		8 1 0.98		18 1 1.05		37 1 1.53		46 1 1.42		35 1 1.43		52 1 1.44
IPandalidae														
IPræcessidae														
ICallinassidae														
ICalocaris														
IPleuron														
IPleuridae		1 1 0.30												
IPartunidae		1 1 0.30												
IGalatheidae														
Unid.Brachura		8 1 2.37		2 1 0.25		6 1 0.35		19 1 0.80		29 1 4.02		27 1 0.89		29 1 0.77
Unid.Crustacea		12 1 3.55		6 1 0.74		7 1 0.41		15 1 0.43		16 1 0.56		15 1 0.44		15 1 0.47
TOTAL CRUSTACEA	148 143.79		294 136.03		346 120									

Table 3. Quarter 1 1981. Total North Sea. Weight, as, and percentage by weight of each species of fish in whittins of each age group.

Species	AGE 0		AGE 1		AGE 2		AGE 3		AGE 4		AGE 5		AGE 6	
	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%
ICod			1	0.01	1	0.02	1	1						
IHaddock			3	0.76	2	0.18	22	1.11	62	2.01	81	2.13	120	2.26
IWhittins					3	0.30	48	2.46	190	6.21	504	13.21	1118	21.14
INorway pout			7	1.68	51	5.81	354	18.03	807	26.38	948	24.82	1218	23.02
ITrainutus					1	0.08	1	0.01						
IGadiculus			1	0.16	3	0.32	1	0.03						
IRocklins					15	1.76	40	2.07	37	1.23	37	0.97	36	0.67
IUnid.sadidae					1	0.01	1	0.06	3	0.10	3	0.09	4	0.07
IHerrins					55	6.25	268	110.61	331	110.82	388	110.16	494	9.34
ISprat			31	7.24	146	116.72	272	113.87	316	110.32	310	8.11	293	5.54
IUnid.clupeoids			15	3.51	101	111.51	192	9.80	175	5.72	173	4.01	107	2.03
ISandeels			107	125.43	47	5.38	87	4.42	129	4.22	149	3.89	187	3.52
IL.R.dab					2	0.20	16	0.82	38	1.26	45	1.17	57	1.07
ICoaron dab														
ILeon sole														
IUnid.flatfish														
IMaurolicus			1	0.20	4	0.44	10	0.49	14	0.47	14	0.38	14	0.27
IGasterosteus														
IArgentina														
ICallionus														
ITrisliidae														
IBlenniidae														
IGobiidae			6	1.38	1	0.11	5	0.24	11	0.37	12	0.32	14	0.26
IUnid.fish			15	3.55	32	3.66	115	5.91	294	9.61	404	10.58	614	11.60
TOTAL FISH			187	144.42	463	152.91	1396	170.71	2457	180.27	3143	182.23	4463	185.54

Table 3. Quarter 3 1981. Total North Sea. Weight, as, and percentage by weight of each species of fish in whittins of each age group.

Species	AGE 0		AGE 1		AGE 2		AGE 3		AGE 4		AGE 5		AGE 6	
	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%
ICod			1	0.01	1	0.01	1	1	1	1				
IHaddock			49	4.89	360	114.76	522	114.81	743	116.49	927	117.70	2024	132.18
IWhittins			41	4.07	103	4.24	131	3.73	168	3.74	200	3.82	386	6.14
INorway pout			27	2.63	130	5.35	194	5.50	251	5.57	286	5.47	427	6.79
IRocklins														
IUnid.sadidae			25	2.44	101	4.15	101	2.88	87	1.93	73	1.40	59	0.94
IHerrins			17	1.64	108	4.43	209	7.97	436	9.68	547	110.45	443	7.05
ISprat			6	0.62	81	3.32	389	111.05	686	115.23	903	117.25	748	111.89
IUnid.clupeoids			107	110.60	640	126.25	794	122.54	845	118.75	862	116.46	698	111.09
ISandeels			340	133.64	316	112.94	325	9.24	355	7.88	380	7.26	423	6.73
IMackerel														
IL.R.dab														
ICoaron dab														
ILeon sole														
IUnid.flatfish														
IMaurolicus														
ICallionus														
ITrisliidae														
IBlenniidae														
IGobiidae														
IEchiichthys														
ISmsnathus														
IUnid.fish			22	5.71	65	6.46	238	9.76	366	110.40	471	110.45	544	110.38
TOTAL FISH			30	7.81	678	167.20	2085	185.38	3128	188.99	4093	190.85	4797	191.72

Table 3. Quarter 2 1981. Total North Sea. Weight, as, and percentage by weight of each species of fish in whittins of each age group.

Species	AGE 0		AGE 1		AGE 2		AGE 3		AGE 4		AGE 5		AGE 6	
	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%
ICod					1	0.09	3	0.18	6	0.27	5	0.18	5	0.15
IHaddock					1	0.02	12	0.72	76	3.20	158	5.55	143	4.22
IWhittins					1	0.04	7	0.42	44	1.84	93	3.29	89	2.64
INorway pout					17	2.11	110	6.41	281	11.76	427	115.01	385	111.39
ITrainutus														
IGadiculus														
IRocklins														
IUnid.sadidae			17	4.91	4	0.52	1	0.07	7	0.30	17	0.59	15	0.45
IHerrins			4	1.23	6	0.76	7	0.43	13	0.54	6	0.22	6	0.17
ISprat														
IUnid.clupeoids														
ISandeels			143	142.26	421	151.62	1045	160.74	1267	153.11	1148	140.40	1048	131.03
IMackerel														
IL.R.dab														
ICoaron dab														
IUnid.flatfish														
IManrichus														
IMaurolicus														
IArgentina														
ICallionus														
IGobiidae														
IUnid.fish			10	3.09	17	2.13	53	3.06	90	3.77	139	4.89	299	8.83
TOTAL FISH			175	151.78	475	158.21	1291	175.02	1921	180.44	2331	182.02	2798	182.88

Table 3. Quarter 4 1981. Total North Sea. Weight, as, and percentage by weight of each species of fish in whittins of each age group.

Species	AGE 0		AGE 1		AGE 2		AGE 3		AGE 4		AGE 5		AGE 6	
	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%
ICod			1	0.04	1	0.14	5	0.27	17	0.58	20	0.47	29	0.50
IHaddock			1	0.30	38	3.75	190	9.64	401	113.52	773	117.85	1275	121.93
IWhittins			4	1.17	23	2.26	44	2.23	86	2.90	130	3.01	175	2.67
INorway pout			11	3.50	99	9.86	365	118.56	733	124.71	1199	127.67	1545	128.29
ITrainutus														
IRocklins														
IUnid.sadidae			1	0.19	13	1.33	41	2.08	54	1.81	61	1.42	61	1.05
IHerrins			1	0.30	11	1.05	47	2.37	108	3.63	173	4.00	213	3.66
ISprat			7	2.19	68	6.78	107	5.42	129	4.05	129	2.95	129	2.22
IUnid.clupeoids			16	4.86	105	110.44	161	9.21	184	6.20	156	3.64	143	2.46
ISandeels			39	111.87	239	123.81	284	114.42	310	110.44	321	7.42	392	5.20
IL.R.dab			1	0.05	1	0.08	2	0.12	12	0.39	52	1.29	135	2.32
ICoaron dab														
ILeon sole														
IUnid.flatfish														
IMaurolicus														
ICallionus														
ITrisliidae														
IBlenniidae														
IGobiidae			10	3.03	15	1.48	22	1.14	30	1.02	36	0.84	38	0.65
IEchiichthys														
ISmsnathus														
IUnid.fish			46	114.22	141	114.03	414	121.03	609	120.52	813	118.77	983	116.91
TOTAL FISH			138	142.46	760	175.62	1715	187.10	2679	190.23	3925	190.67	5232	189.77

TABLE 4

Total North Sea. Adjusted weight, mg, of all fish prey of each size group in whiting of each age group in each quarter of 1981 + Less than .5mg

Quarter	Whiting age gp.	Prey size group														Total
		7	10	15	20	25	30	40	50	70	100	150	200	250	999	
1	1		+		+	9	5	40	95	37	+				+	186
	2		+	+	1	1	3	3	36	170	238	10	1		+	463
	3		+	+	4	2	10	2	56	294	844	155	19		+	1386
	4			+	8	2	19	2	58	408	1428	480	54		+	2459
	5			+	8	1	20	2	57	413	1680	888	78		+	3147
	6			+	8	1	21	2	56	419	2156	1680	123		+	4467
2	0			16	2	2	8	44	20	82						174
	1	+		3	1	11	17	54	191	140	50	9			+	476
	2	+	+	+	1	1	23	43	314	400	357	150		+	1	1291
	3		+	1	+	6	12	23	207	438	916	315		2	1	1922
	4		+	1	+	14	15	14	164	356	1330	430		5	1	2329
	5		+	1	+	13	14	13	149	438	1270	898		4	1	2800
6		+	1	+	14	15	12	150	386	1346	691		5	+	2621	
3	0			25	+	+	+	+	2	1					1	30
	1	+		6	+	1	3	3	94	404	148	20			1	678
	2	+		+	+	5	15	18	307	548	1062	129			+	2085
	3	+		+	+	4	20	31	585	948	1436	105			2	3131
	4	+		+	+	2	22	41	846	1380	1721	68			12	4093
	5			+	+	+	24	49	1037	1705	1921	39			21	4796
6			+	+	+	19	50	1103	1988	2496	130			98	5884	
4	0			+	9	6	15	27	24	49	7	1				138
	1			+	5	3	33	38	108	400	122	51				760
	2			+	1	2	19	35	105	967	402	185				1716
	3			+		2	27	35	89	1608	666	253				2681
	4			+		3	37	33	69	2281	1137	365				3926
	5					3	40	30	52	2732	1823	544				5224
6					2	32	24	42	2600	2331	635				5666	

Quarter 1 1981. Total North Sea. Adjusted weights, mg. of fish prey of each size group in whiting of each age group.

Prey	Whiting age gp.	Prey size group													Tot.
		10	15	20	25	30	40	50	70	100	150	200	999		
COD	1									+					+
	2									1					1
	3									+					+
	4														
	5														
	6+														
HADDOCK	1								+	3					3
	2								+	+	+	+			2
	3								+	5	9	10	+		24
	4									14	25	28	+		68
	5									15	37	37	1		90
	6+									17	58	53	3		132
WHITING	1														
	2								+	2	1				3
	3								4	20	29				53
	4								9	72	135				218
	5								10	179	404				593
	6+								11	385	928				1324
NORWAY POUT	1								3	4	2				9
	2		+						+	13	41	4			58
	3		+						2	58	261	81			403
	4								5	112	594	227			937
	5								5	118	684	294			1101
	6+								6	131	855	422			1413
HERRING	1														
	2								+	1	69	1			71
	3								+	28	236	12			277
	4								+	77	335	33			446
	5								+	83	386	36			505
	6+								+	95	480	41			617
SPRAT	1								7	4	19	17	5		51
	2								+	3	33	127	84		248
	3								1	2	47	174	218		443
	4								3	2	42	156	278		481
	5								3	2	41	144	267		457
	6+								4	2	39	119	242		406
SANDEEL	1								+	12	70	31	+		113
	2								+	2	23	24	4	1	53
	3								+	4	13	42	14	19	91
	4								3	2	42	156	278		481
	5								+	3	12	42	22	77	155
	6+								+	2	11	39	22	120	193
HAKE	1										1				1
	2										3				3
	3										1				1
	4														
	5														
	6+														
T. MINUTUS	1										+				+
	2										1				1
	3										+				+
	4														
	5														
	6+														
GADICULUS	1														
	2								+	+	16				16
	3								1	5	35				42
	4								2	15	22				39
	5								2	16	20				38
	6+								2	18	16				36
LONG ROUGH DAB	1										+				+
	2										+				2
	3										1	1			21
	4										13	38			52
	5										14	45			59
	6+										16	58			74
COMMON DAB	1														
	2										+				+
	3										+				+
	4										+				+
	5										+				+
	6+										+				+
LEMON SOLE	1										+				+
	2										+				+
	3														
	4														
	5														
	6+														

Prey	Whiting age gp.	Prey size group													Total	
		10	15	20	25	30	40	50	70	100	150	200	999			
UNIDENT. FLATFISH	1														+	+
	2														+	+
	3														+	+
	4															
	5															
	6+															
MAUROLICUS	1															1
	2									+	1	1	2	+	+	4
	3									+	4	2	3	+	+	11
	4									+	8	2	3	+	5	17
	5									+	8	1	2	+	5	17
	6+									+	8	1	1	+	6	17
ARGENTINA	1															+
	2															+
	3														7	7
	4														25	25
	5														48	48
	6+														93	93
CALLIONYMUS	1															+
	2															+
	3															+
	4														1	10
	5														47	47
	6+														121	121
GASTEROSTEUS	1															
	2															+
	3															+
	4															+
	5															+
	6+															+
BLENNIES	1															+
	2															
	3															
	4															
	5															
	6+															
GOBIES	1															8
	2															1
	3															6
	4															14
	5															15
	6+															17
GURNARDS	1															
	2															+
	3															7
	4														20	20
	5														21	21
	6+														24	24

Table 5a

Table C Estimated Numbers of Prey of Each Age Consumed Per Thousand Whiting of Each Age in 1981

Quarter 1		Whiting Prey	Age	0	1	2	3	4	5	6+
Cod	1				1	5	1			
Haddock	1				52	15	136	352	436	582
	2					.07	3	8	11	17
	3						.002	.002	.01	.02
	4						.0004	.0001	.002	.004
Whiting	1					14	126	676	1608	3377
	2					1	3	16	48	110
N. Pout	0				958	958	958			
	1				259	543	3000	6437	7138	8569
	2				2	47	453	1146	1412	1916
	3					.48	9	26	34	49
Herring	1					594	2659	4706	5363	6439
	2					2	27	73	80	90
Sprat	1				2357	3516	4820	4777	4574	4366
	2				86	907	1811	2020	1976	1750
	3				.4	2	5	6	7	5
Sandeel	All Ages				4832	1756	1812	17673	1794	1674

Quarter 2			Age	0	1	2	3	4	5	6+
Cod	0				1343	1231	4255	8355	7507	8354
Haddock	0				47	47	47			
	1					28	271	632	573	650
	2					5	13	16	14	15
Whiting	0				.003	.26	2	3	3	4
	1				.97	33	296	428	397	441
	2					.01		.02	.1	.07
N. Pout	0				1300	3499	410	173	173	173
	1				42	722	1956	2540	2284	2458
	2					80	321	545	492	545
	3					1	6	12	10	12
Herring	0				333	1065	1569	1484	1186	1101
Sprat	1				176	761	1331	1495	1351	1438
	2				12	92	303	536	484	531
	3				1	3	12	29	30	33
	4				.22	.66	3	7	7	7
Sandeel	All Ages				29609	64971	73346	53212	44020	42197

Quarter 3			Age	0	1	2	3	4	5	6+
Cod	0				15	23	8	8		
Haddock	0				4	607	4456	8758	14151	18472
	1					4	29	31	34	38
Whiting	0				10	1567	5541	6443	7106	6760
N. Pout	0				102	2639	13137	20231	24847	27662
	1					2	7	51	102	139
Herring	0				1001	4150	7343	9935	11756	9528
	1				482	3322	3491	3105	2716	2197
Sprat	1				350	1875	4888	7589	9567	7770
	2				32	371	1695	2962	3890	3217
	3				1	20	104	184	243	201
Sandeel	All Ages				412	17903	13326	26593	40477	51060

Quarter 4			Age	0	1	2	3	4	5	6+
Cod	0				5	20	57	114	216	345
Haddock	0				32	648	3135	730	8964	11520
	1				.23	3	7	13	42	104
	2				.01	.12	.32	.57	2	5
Whiting	0				172	271	361	733	933	1113
	1					.13	1	3	5	5
N. Pout	0				424	3022	10833	19674	29829	38355
	1				1	6	23	64	126	208
Herring	0				55	639	3045	6390	9483	10559
	1					.24	3	11	37	83
Sprat	0				593	2723	795	439	328	297
	1				49	566	1223	1135	159	846
	2				3	65	136	184	16	136
Sandeel	All Ages				3303	19747	18946	13407	6845	3886

Annual Totals		Whiting Prey	Age	0	1	2	3	4	5	6+
Cod	0				20	1336	1296	4377	8579	7852
	1					1	5	1		
Haddock	0				34	1302	7639	9595	23115	30292
	1				.23	59	79	451	1060	1151
	2				.01	.12	5	16	26	30
	3						.002	.002	.01	.02
	4						.0004	.0004	.002	.004
Whiting	0				182	1837	5901	7183	8097	7876
	1					1.17	48	405	1109	2011
	2						1.01	3	16	48
N. Pout	0				526	8519	28483	41273	54849	66190
	1				1	309	1305	5071	9205	9767
	2					2	127	774	1693	1904
	3					1.43	15	33	44	61
Herring	0				393	2795	8764	16368	20902	23501
	1					482	3916	6151	7939	8167
	2						2	27	73	80
Sprat	0				593	2723	795	439	328	297
	1				49	4043	7375	12274	14050	16338
	2				3	195	1556	3973	5574	6486
	3					2.4	25	121	219	239
	4					2.2	.66	3	7	7
Sandeel	All Ages				33329	107458	107474	95114	108240	100760

APPENDIX 1

Procedure for working up quarterly stomach contents data in terms of predator
SIZE GROUP

A : Calculation of sample (haul) mean weight; \bar{W}_S

If W = total weight of prey in valid stomachs from an individual haul, then

$$\bar{W}_S = \frac{W}{N_F} \times \frac{(N_F + N_R)}{(N_F + N_R + N_E)}$$

where N_F = Number of stomachs in sample with 'valid' contents

N_R = Number of stomachs in sample showing evidence of regurgitation

N_E = Number of stomachs in sample classified as empty

B : Calculation of rectangle mean weight; \bar{W}_R

\bar{W}_R = arithmetic mean of sample means

C : Calculation of roundfish reporting area mean weight; \bar{W}_{RRA}

Rectangle means within RRA are weighted by mean catch rates of the appropriate predator size class:

$$\bar{W}_{RRA} = \frac{[(\bar{W}_{R1} \times CR_{R1}) + (\bar{W}_{R2} \times CR_{R2}) + (\bar{W}_{R3} \times CR_{R3}) \dots]}{(CR_{R1} + CR_{R2} + CR_{R3} \dots)}$$

D : Calculation of total North Sea mean weight; \bar{W}_{NS}

As in C, using data from each rectangle sampled in the quarter.

APPENDIX 2

Procedure for working up quarterly stomach contents data in terms of predator
AGE GROUP

E : Calculation of roundfish reporting area mean weight:

Quarterly RRA age length key in the form:

Age \ Size gp.	100-150	150-200	200-250
1	1.0			
2	0.4	0.6		
3	0.1	0.8	0.1	
.				
.				
.				

is applied to the RRA contents by size group data calculated in C. Thus the average weight of the stomach contents of predator of age 2 in RRA X is:

$$\bar{W}_{2(RRA_X)} = [0.4 \times \bar{W}_{RRA_X (100-150mm)}] + [0.6 \times \bar{W}_{RRA_X (150-200mm)}]$$

F : Calculation of total North Sea mean weight

Step 1: Total North Sea ALK prepared by weighting the RRA ALKs by
(i) RRA catch rates by age group
(ii) RRA size (number of rectangles with water depth < 200m)*
Thus, assuming that only three RRAs were sampled in the quarter the total North Sea age/size group composition for age group 2 is derived as follows:

Age	Area	Size group		
		100-150	150-200	200-250
2	1 Proportion Catch rate Size	.4	.4	.2
	2 Proportion Catch rate Size	.3	.7	-
	3 Proportion Catch rate Size	.3	.6	.1
			10 45	
			20 25	
			50 19	



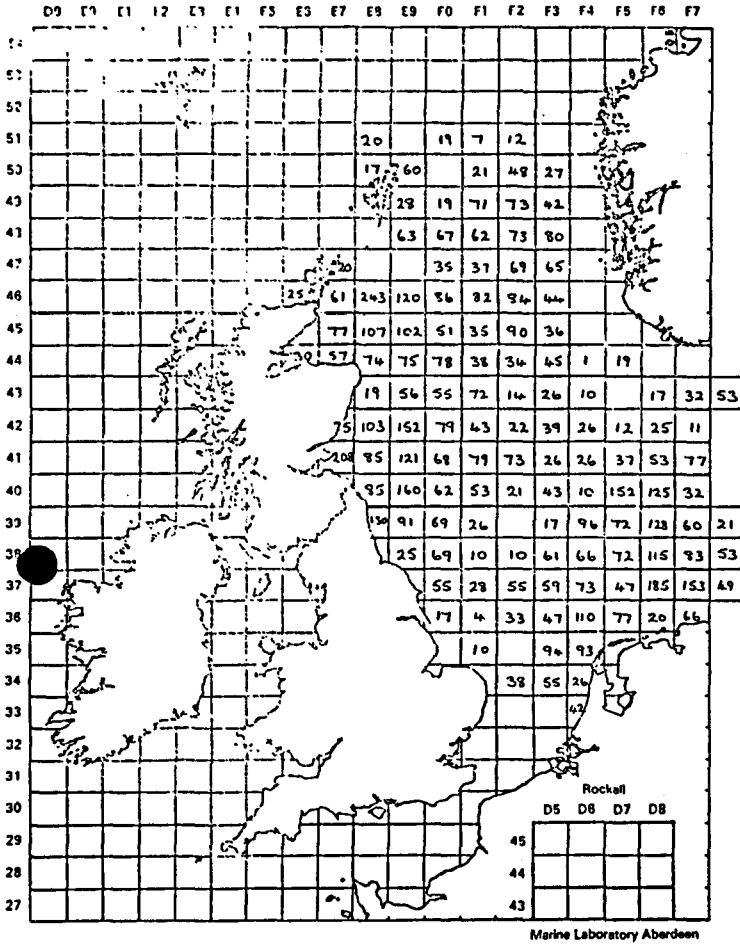
Age	Area	100-150	150-200	200-250
2	Total North Sea	.32	.58	.10

Step 2: Total North Sea ALK applied to total North Sea contents by size group data calculated in D.

* Area size weightings: 1 : 45, 5 : 10,
2 : 25 6 : 33
3 : 19 7 : 13
4 : 11

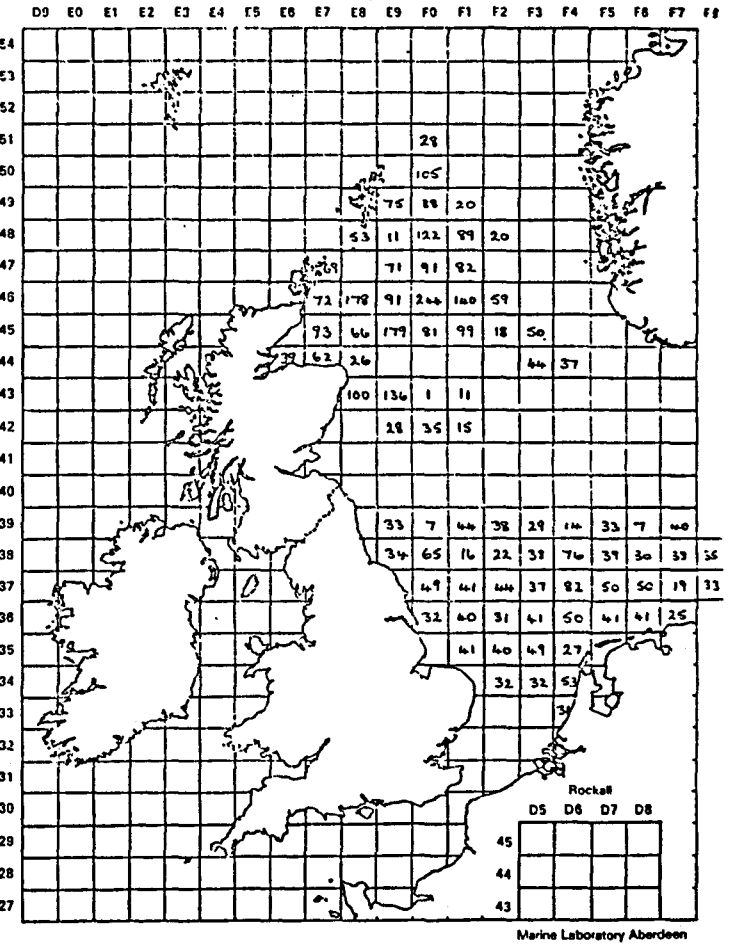
Figure 1
 Numbers of stomachs examined in each statistical
 rectangle in each quarter

QUARTER 1



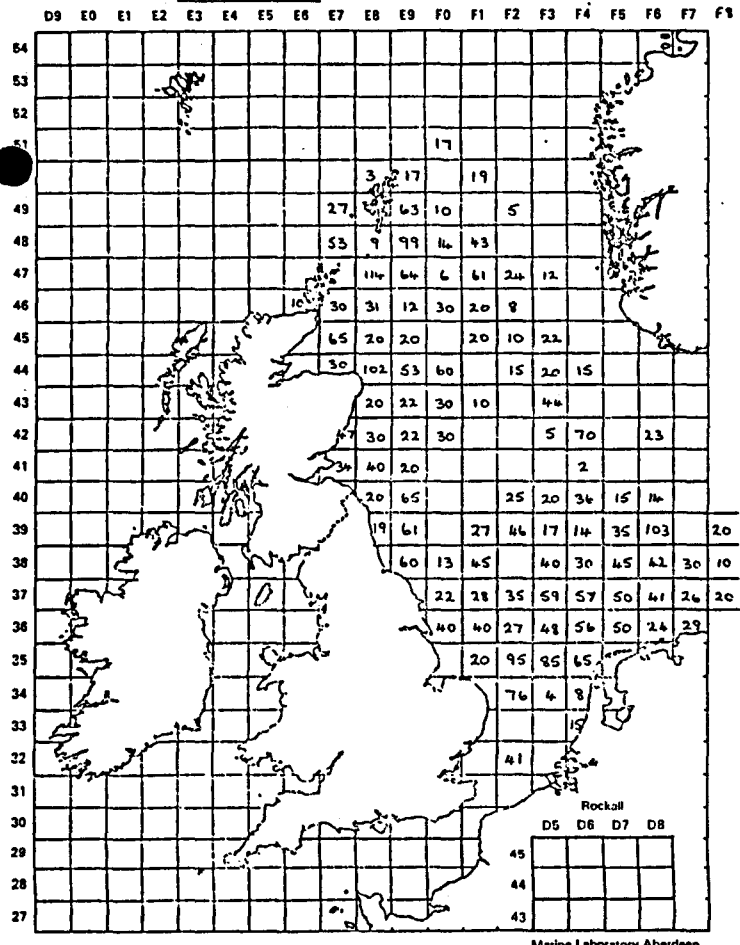
Marine Laboratory Aberdeen

QUARTER 2



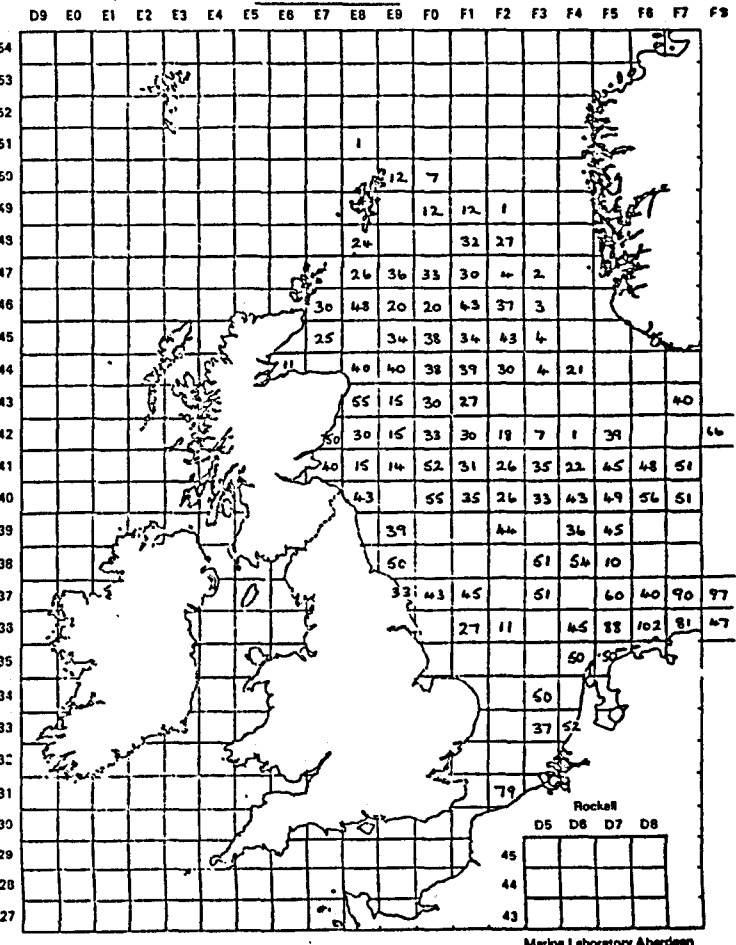
Marine Laboratory Aberdeen

QUARTER 3



Marine Laboratory Aberdeen

QUARTER 4



Marine Laboratory Aberdeen

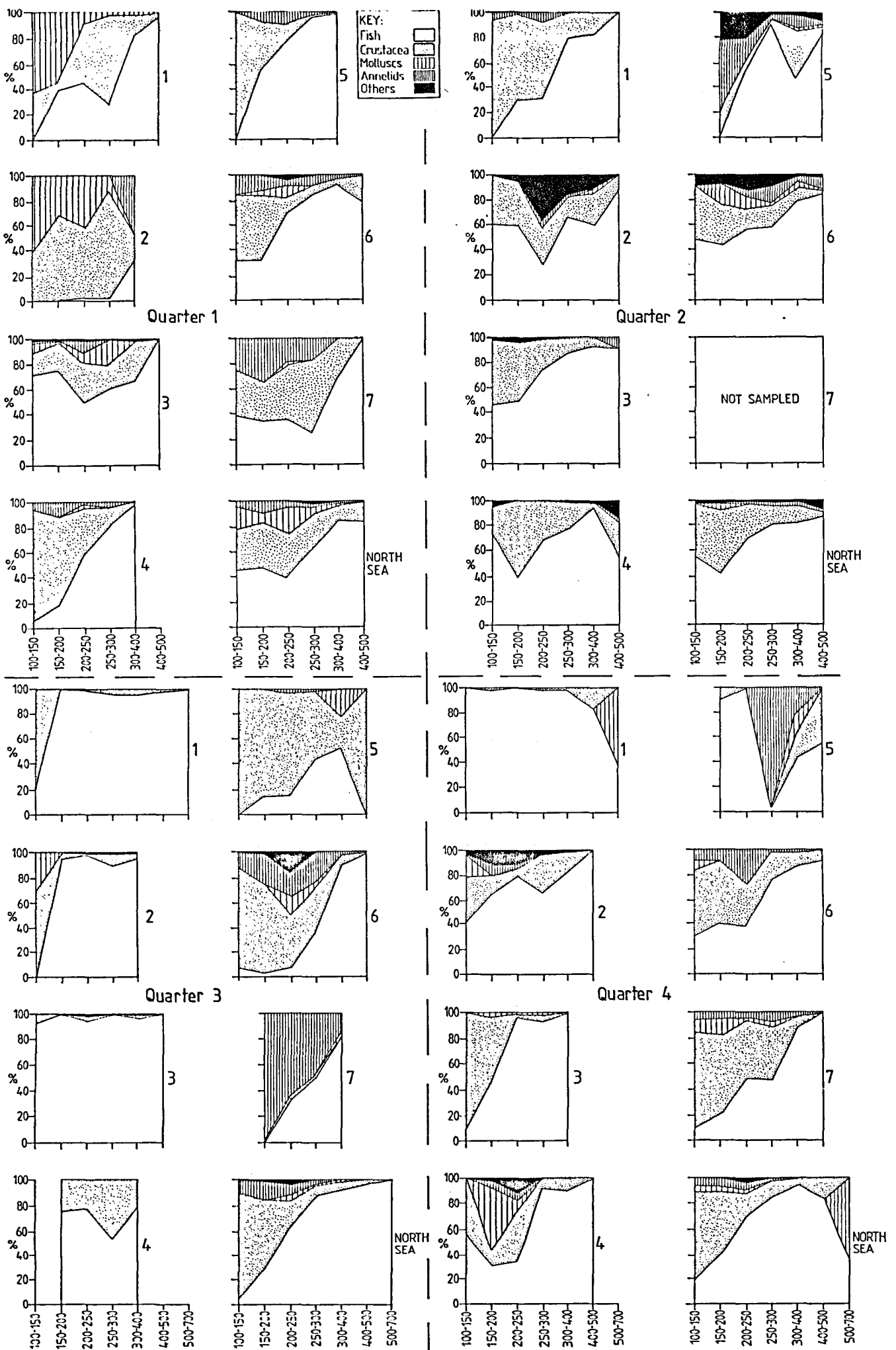


Fig 2 Percentages by weight of each major prey group in each whiting length group in each area

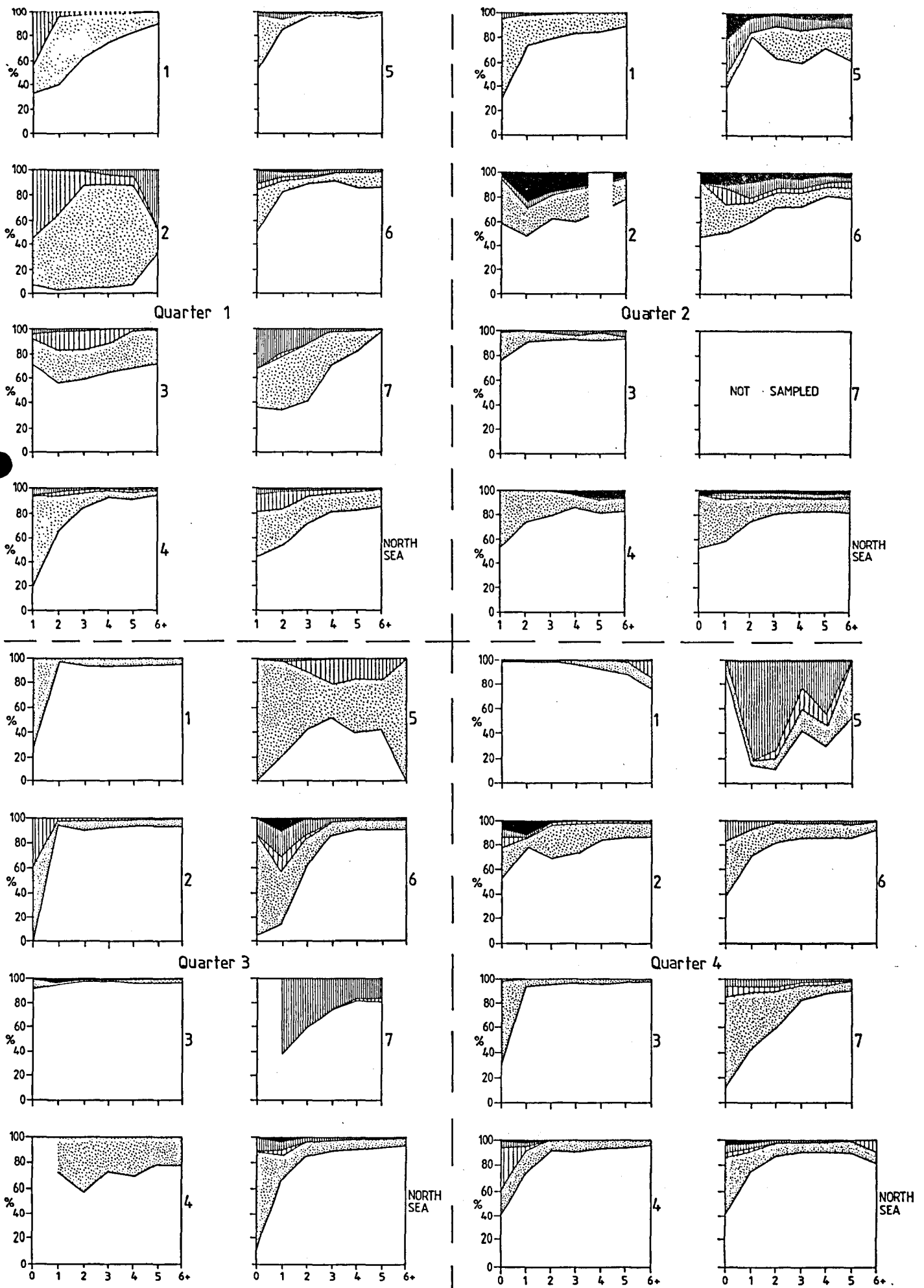


Fig 3 Percentage by weight of each major prey group in each whiting age group in each area

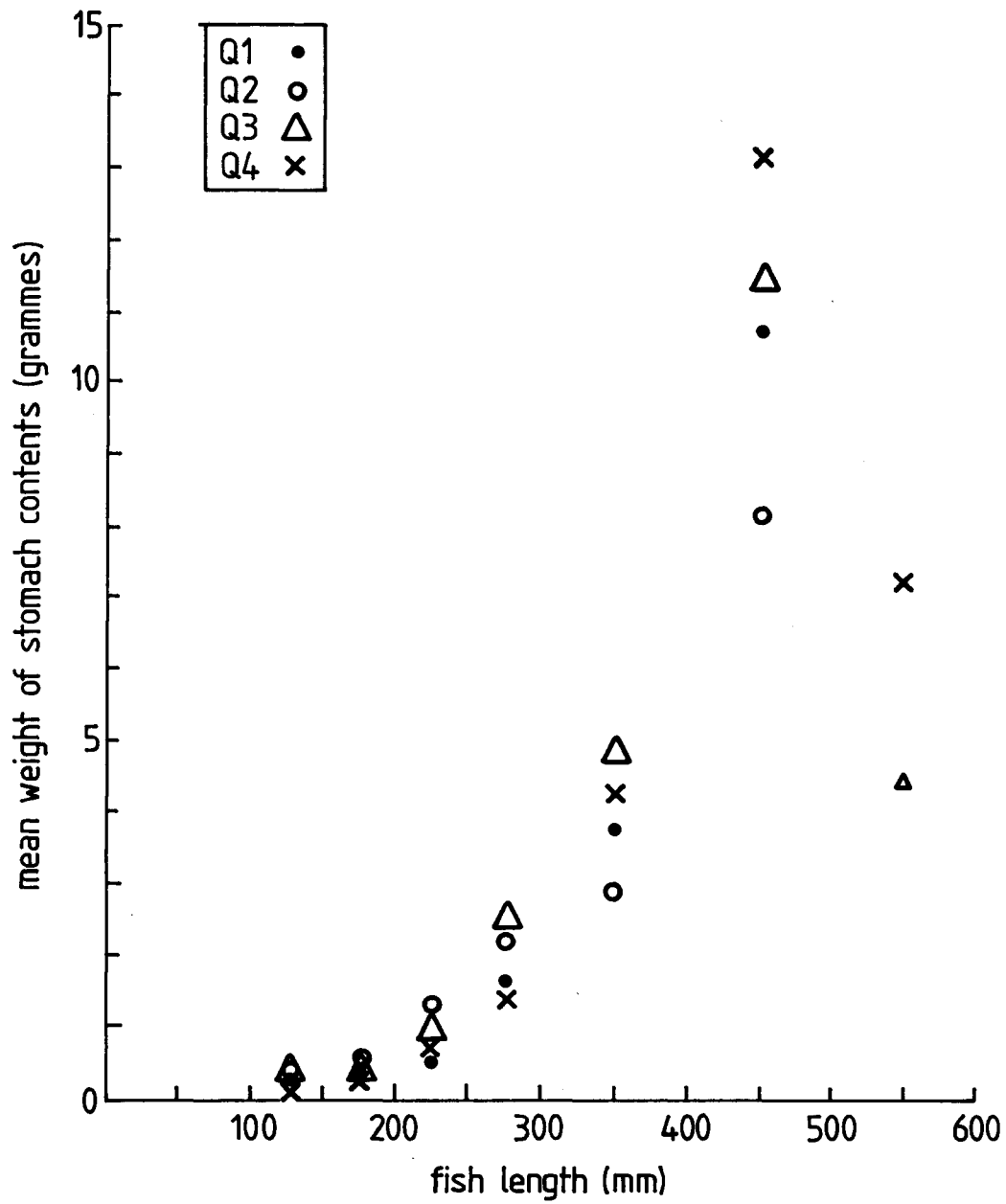


Fig 4. Total North Sea. Mean weight, g, of stomach contents of whiting in each size group in each quarter.

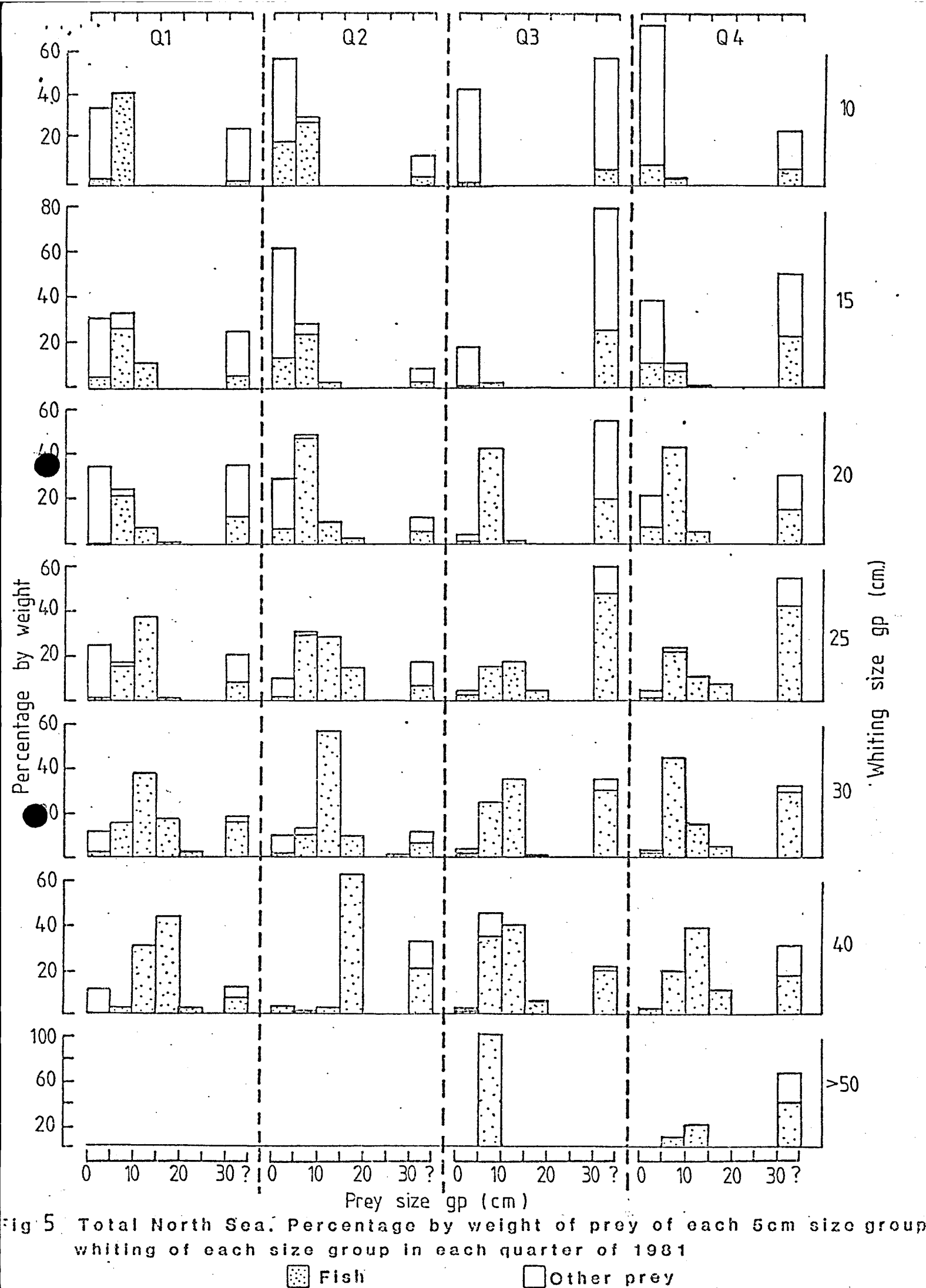


Fig 5 Total North Sea. Percentage by weight of prey of each 5cm size group whiting of each size group in each quarter of 1981

● Fish

□ Other prey

WHITING DIGESTION RATE EXPERIMENTS

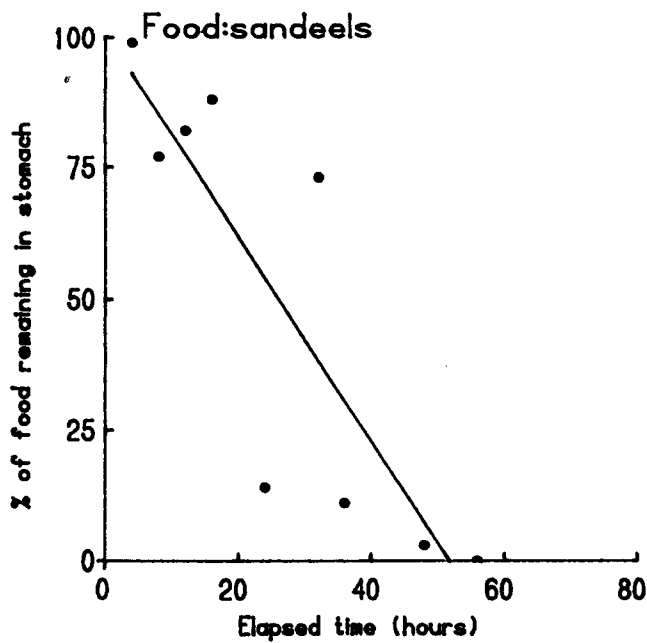
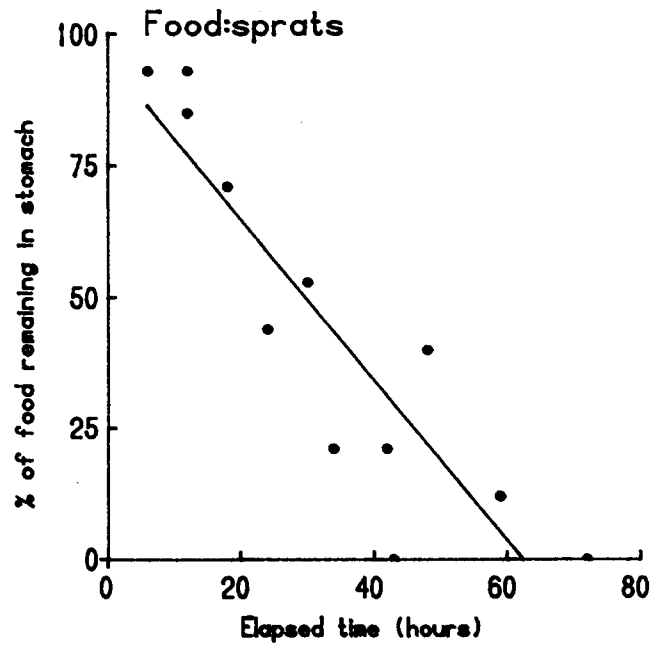
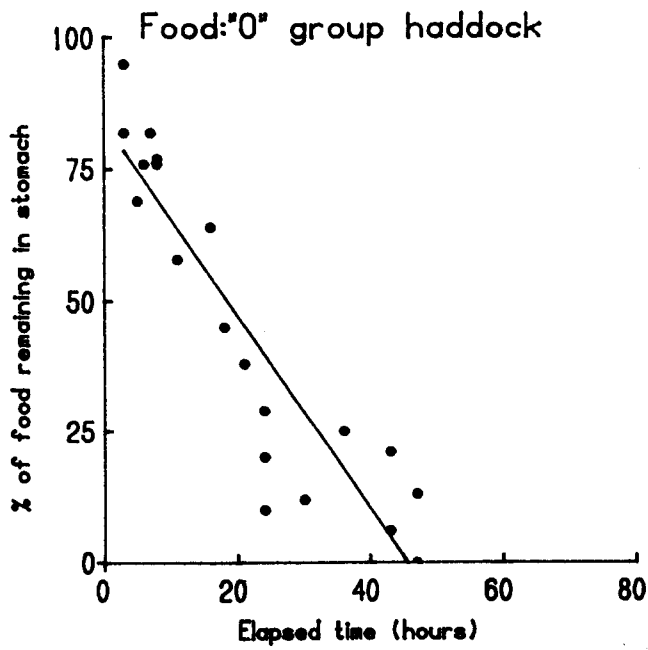


Figure 6 Rates of elimination of haddock (6-12 cm, 2.7-16.4 g) sprats (6-10 cm, 1.4-6.8 g) and sandeels (5-10 cm, 0.5-1.5 g) from the stomachs of whiting of 27-40 cm. Range of experimental temperatures: 9-14°C