

**INTERNATIONAL COUNCIL FOR
THE EXPLORATION OF THE SEA**

ICES C.M. 1993/G:15
Demersal Fish Committee



**ANALYSIS OF THE RAY (*Raja spec.*) SAMPLES COLLECTED DURING
THE 1991 INTERNATIONAL STOMACH SAMPLING PROJECT**

by

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This project has been financed by the Commission of the European Communities within the frame of the EEC research programme in the Fisheries sector ("FAR", Fisheries and Aquaculture Research).





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ABSTRACT

This report provides a first analysis of the food and feeding of four species of rays (*Raja clavata*, *Raja montagui*, *Raja naevus* and *Raja radiata*) in the North Sea based on 3732 stomach samples taken during research vessel surveys in 1991. The largest fraction of these referred to *R. radiata* (3201), but the information for the other species was rather limited. The distribution patterns of the different species were rather different and so were the size distributions sampled. The mean weights of the stomach contents within comparable size classes differed considerably between species. *R. clavata* stomachs contained consistently larger amounts of food, followed by *R. montagui*, *R. radiata* and *R. naevus* in that order. In all species, there was a clear shift with predator size from feeding mainly on crustaceans to feeding mainly on fish. However, the size at which this shift took place varied considerably and ranged from 15 cm in *R. naevus* to 80 cm in *R. clavata*. Other prey taxa were relatively unimportant. Since fish prey in stomachs was difficult to identify to species, possibly due to the fact that rays chew their prey to a much larger extent than other fish predators do, the contribution of commercially important fish species to the total consumption is uncertain. Only for *R. radiata* a fairly consistent pattern of feeding predominantly on juvenile gadoids was apparent, whereas sandeels were found only infrequently. The data suggest that, given the relatively small size at which *R. radiata* shifts to feeding on fish (25 cm) in combination with its relatively high biomass, this species has a much higher impact on the fish fauna than the other three.

1. INTRODUCTION

During the planning of the 1991 International Stomach Sampling Project, it was realised that the extensive research vessel effort available for the routine collection of the five important commercial predator species offered an excellent opportunity to collect additional data on predator species of less economic importance, for which relatively few quantitative stomach content data have been collected in the past. However, since the required manpower for collecting and analysing these samples would put an additional burden on the participating countries, a request for additional funding was made to the EC in the frame of the "FAR" programme. This project, in which The Netherlands, Scotland, and Denmark participated was granted and the workload was split between these three countries.

This report presents the results of the data collected for the different ray species, which include *Raja clavata*, *Raja montagui*, *Raja naevus* and *Raja radiata*. Since Denmark had previously dealt with stomachs of rays, the analysis of the stomachs as well as the input of data in a data base was done by Denmark. Subsequently, the data were transferred in computerised format to the Netherlands, where a standard analysis of the results was made using the available software.

2. METHODS

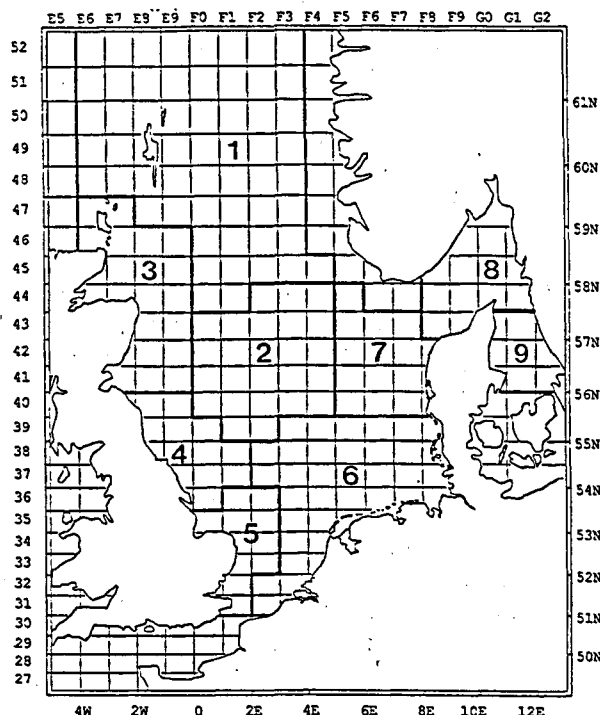
The methods used in sampling and analysing stomachs are well described in the Manual prepared before the project started (Anon., 1991) and a summary is given by De Gee & Kikkert (1993), which describe the results of the stomachs collected for grey gurnard.

3.RESULTS

3.1. Sampling intensity.

Tables 1a-d list the number of stomachs collected by size class, quarter and roundfish area (cf fig. 1) for the four different ray species. Research vessel catches of rays are seldomly very large and therefore the number of stomachs sampled is a fair measure of the number of specimens actually caught. It is evident from these tables that the samples were in most cases rather unevenly spread over the quarters and over the different areas. These differences have to be interpreted in terms of catchability in relation to distribution.

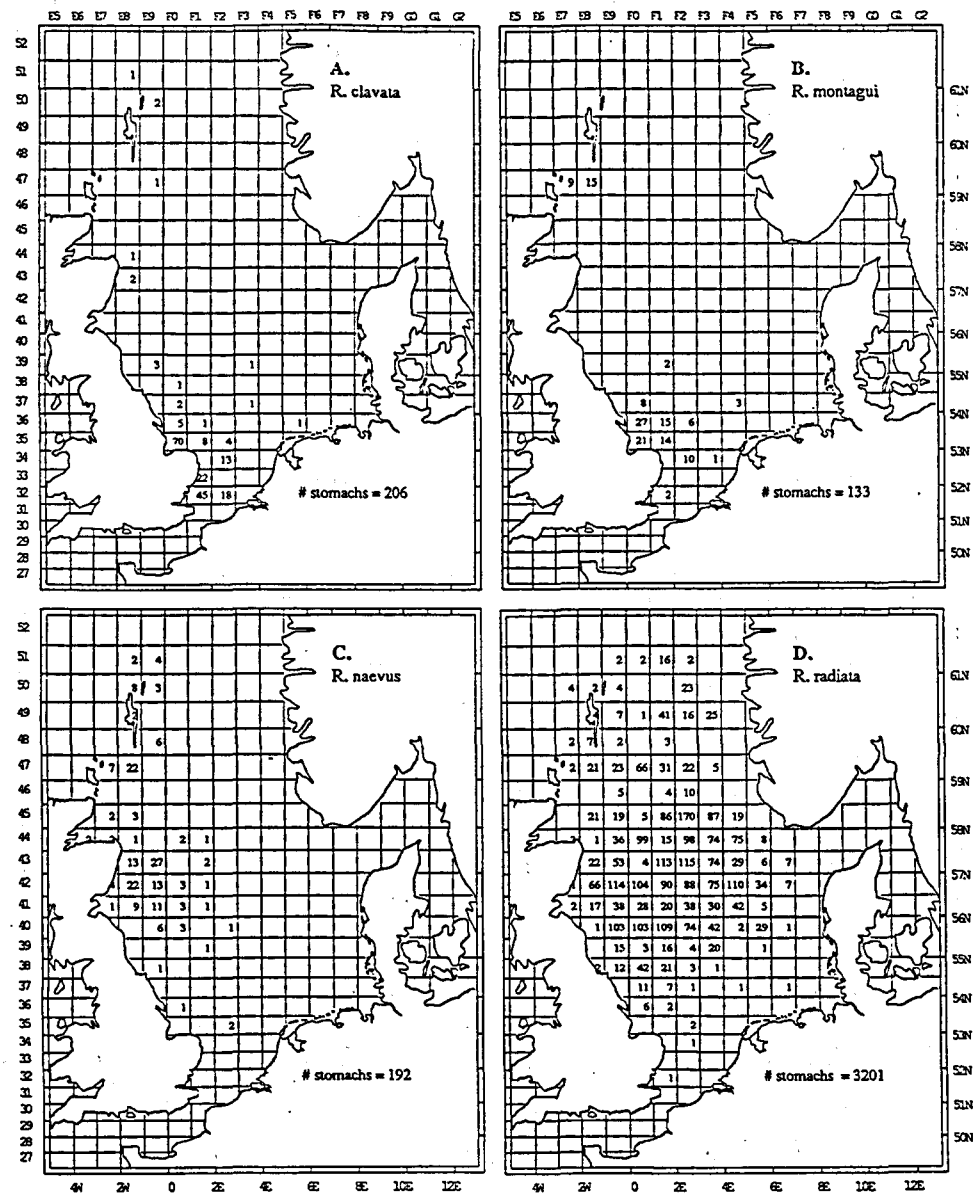
Fig 1. Subdivision of the North Sea by roundfish areas



For instance, approximately half of the *R. clavata* stomachs were collected during the winter survey and three quarters came from area 5. Samples of *R. montagui* were more evenly spread over the different quarters and relatively more were caught in the northern area. Very few *R. naevus* specimens were caught during the autumn and the Scottish east coast (area 3) was the most important area. During the winter also area 1 contributed significantly to the total. Compared to these three species, for which the total number of stomachs collected ranges from 133 to 206, *R. radiata* yielded over 3000 stomachs. Although all quarters appear to have been adequately sampled, almost half of the stomachs were collected during the summer.

Figure 2 provides the spatial distribution of all stomachs collected for each of the four species. It clearly shows the concentration of *R. clavata* and *R. montagui* off the southern English coast with a secondary concentration around Scotland. In contrast *R. naevus* was particularly abundant off Scotland, whereas *R. radiata* is distributed over a wide area in the central and northern North Sea with the highest abundance northeast of the Doggerbank.

Fig 2. Spatial distribution of ray stomachs collected by statistical rectangle.



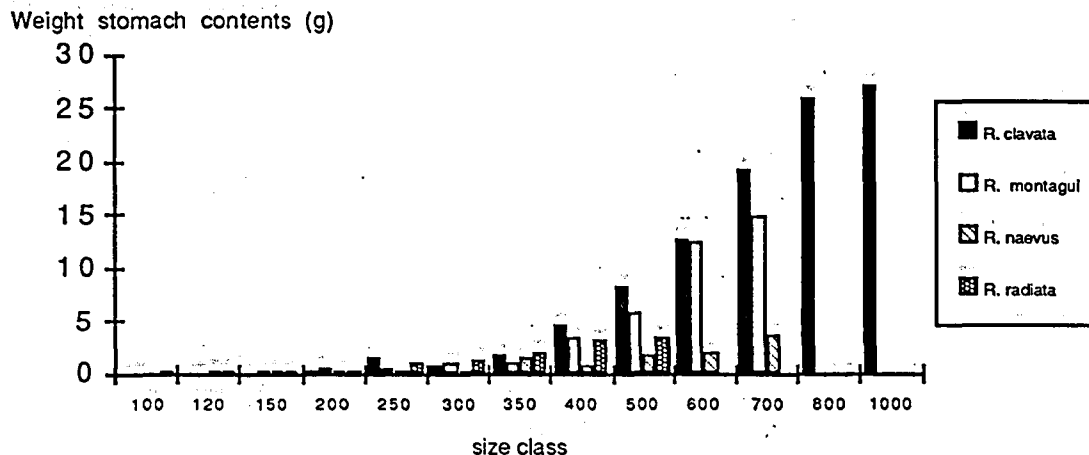
3.2 Feeding intensity

Tables 2a-d provide the percentage of empty stomachs by size class, quarter and area. Due to the low numbers per cell the estimated values are rather variable. Still, there are some interesting trends. Overall, *R. montagui* shows the lowest fraction empty (ca 4%), followed by *R. clavata* (ca 9%) and *R. radiata* (ca 20%). The real exception, however, is *R. naevus* with more than 40% of the stomachs being empty. In addition there is a clear seasonal trend within all species, highest fractions occurring in winter and lowest fractions during summer. Size specific and/or regional differences are less easily to detect, because of the variability in total number sampled in each category.

Table 3 provides the mean stomach content weight by size class and quarter. Although for *R. clavata* the winter values are obviously consistently lower than in other quarters in agreement

with the higher fraction of empty stomachs, this is less obvious for the other species. The differences between species for the same size are illustrated in fig 3.

Fig 3. Mean stomach content weight by size class (mm) and species.



Independent of the differences in the total size class spectrum, it appears that on average *R. clavata* of a certain size has more food in its stomach than *R. montagui*. Then follows *R. radiata* and *R. naevus* appears to have the lowest stomach content weight.

3.3 Food composition

Tables 4a-d summarise the data on the food composition by quarter for each sizeclass. Although more detailed data are available, only the weight percentages by major taxa and for the individual commercially important species are presented here. Fig 4 provides a graphical representation of the food composition by major taxa. In all four species crustaceans and fish represent by far the most important component of the food in all size classes. Annelids and molluscs are only a minor component in most size classes. Still, there appear to be significant differences between the ray species. *R. clavata* represents the largest species in this data set, but up to 80 cm they feed predominantly on crustacea. *R. montagui* feeds almost exclusively on crustaceans up to 50 cm, but has turned into an almost exclusive fish consumer at 70 cm. The food of *R. radiata* consisted for more than 50% of fish from 25 cm onwards and for *R. naevus* the corresponding size was even 15 cm.

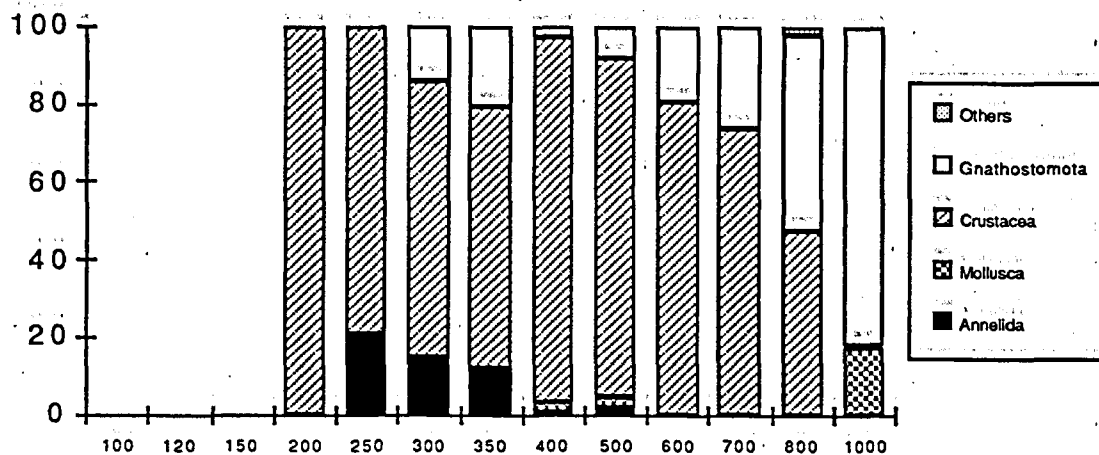
The component of commercially important fish species (table 4) was relatively low in most stomach samples. Also the different species occur rather scattered through different size categories indicating a high variability in the present results. This is particularly true for *R. clavata*, *R. montagui* and *R. naevus*, which in many quarters appeared not to have had eaten any commercial species at all. The species observed reflect what is available in their area of distribution. Thus, plaice, sole and brown shrimp appear in *R. clavata*, whereas Norway pout appears in *R. naevus*. Thanks to the larger number of stomachs investigated *R. radiata* shows a slightly more consistent pattern between neighbouring size classes and over the quarters. Gadoids appear to be the most important prey of this species. Apart from *R. clavata*, sandeels appear to be infrequently consumed by rays.

4. DISCUSSION

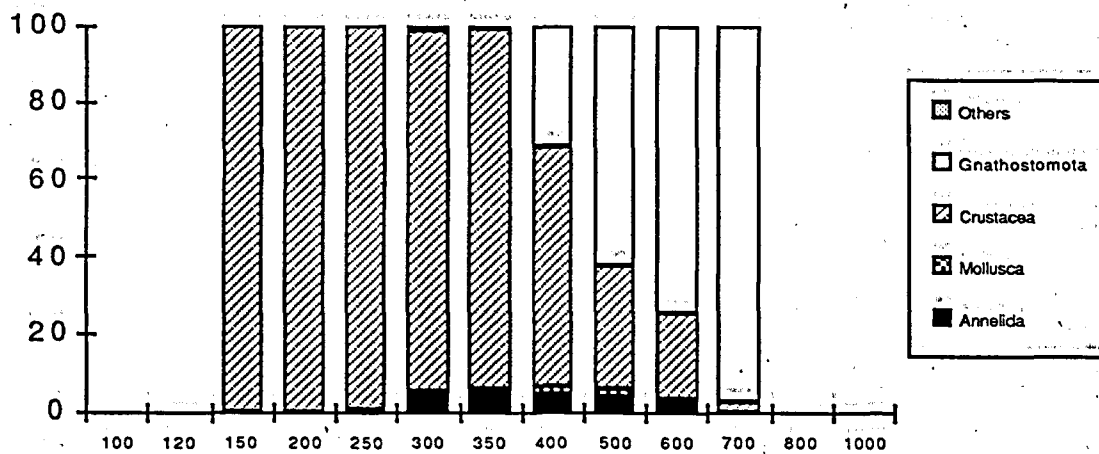
The present report covers only a first approach to analysing these data. In view of the relatively small number of stomachs investigated for 3 of the species, it would probably be appropriate to combine these data with scattered information from earlier years, which was not readily available at this stage. However, it is quite clear that there are species-specific differences in the amount and type of food eaten, which may be partly related to differences in distribution but also to differences in their general biology.

Fig 4 Food composition in % by major taxa of rays by size class (mm) for all quarters combined.

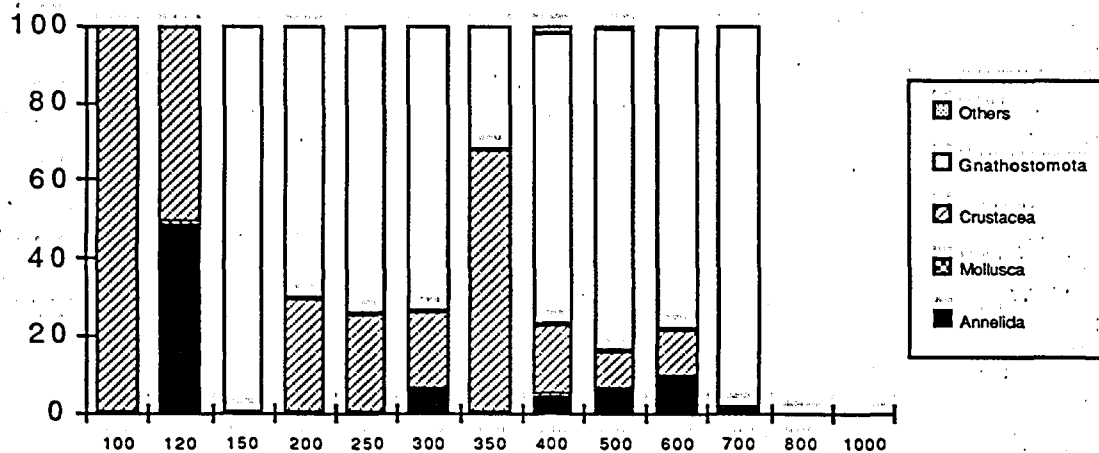
a. *Raja clavata*



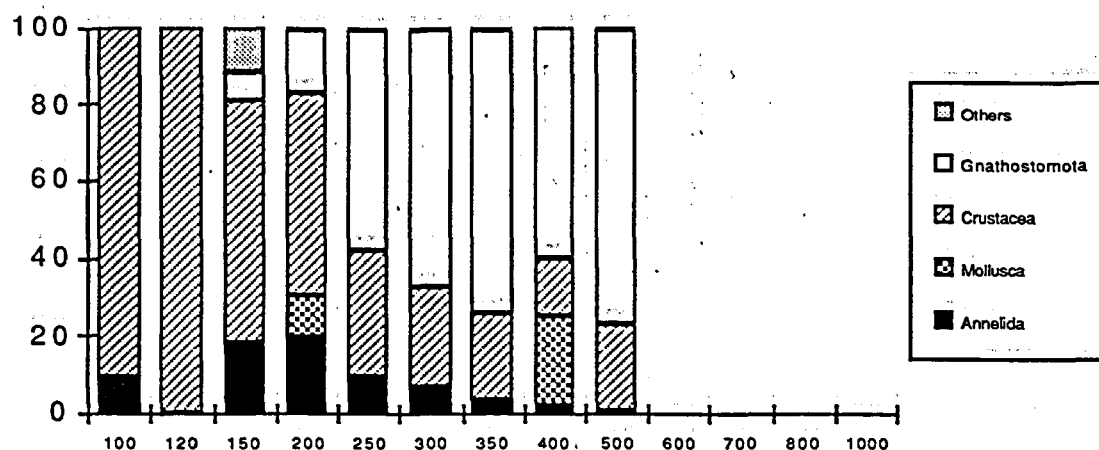
b. *Raja montagui*



c. *Raja naevus*



d. Raja radiata



The present observation that *R. naevus* feeds more intensively on fish, despite its smaller size, than *R. clavata* and *R. montagui* supports earlier evidence provided by Holden & Tucker (1974) on species specific differences, based on samples taken around the British isles. Also, Rae and Shelton (1982) found higher incidence frequencies of fish in *R. naevus* in Scottish waters, but their data are difficult to interpret because large size ranges were lumped and percentage occurrence does not provide a truly quantitative measure. For *R. radiata* earlier quantitative feeding information from the North Sea is available from Vinther (1989), but since his paper is in Danish it was not readily accessible. However, the mean stomach content by size class for this species observed by this author appears to be in agreement with the present results.

The study indicates that both pelagic and demersal fish species are taken as prey. This is in agreement with Rae and Shelton (1982) and Vinther (1989) for *R. radiata*. In contrast with these authors the amount of sandeels observed during this study, however, was extremely low in all species. Sparholt and Vinther (1991) estimated the biomass of *R. radiata* in the North Sea in the mid-1980s and noted that commercial fish species and particularly sandeels contribute significantly to the diet of this species. This conclusion was based on the stomach analyses done by Vinther (1989), who found that sandeels constituted up to 30% in weight of the stomach contents. This suggests a major shift in food habits.

The main question underlying the present research was to fill in certain information gaps in the Multispecies models presently applied to quantify interactions between the important exploited North Sea species and other predators in the system. In the case of rays, this is clearly hampered by the fact that a relatively small component of the fish remains in the stomachs could be identified to the species level. This may be caused by the particular behaviour of rays. If they chew their food to a much larger extent than gadoid predators do, this would explain why ray stomachs are much more difficult to analyse. In any case, the percentages of the food which could be positively identified as belonging to a particular fish species is undoubtedly an underestimate of the actual consumption of that species. It is therefore necessary to determine the fraction identified at each species level in proportion to fractions estimated at the corresponding genus, family and class level in order to make an appropriate correction based on these proportions. Such an extensive analysis, however, fell beyond the scope of the present paper.

5. REFERENCES

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Table 1. Number of stomachs sampled by predator size class (mm), area and quarter.

a. Raja clavata

size class	100	120	150	200	250	300	350	400	500	600	700	800	1000	Total
QUARTER 1														
Area 1				1			2			1				4
Area 3									1					1
Area 5					3	12	17	20	13	13	10	10	1	99
Area 6				1	1		2	2						5
Total				1	4	12	21	22	14	14	10	10	1	109
QUARTER 2														
Area 3							2							2
Area 4						3				1		1		5
Area 5							1		1	2				6
Area 6								5						5
Total						3	3	7	1	3		1		18
QUARTER 3														
Area 4									1					1
Area 5				1		2	2	20	12	10	5	5		57
Area 6								8	4	2				14
Total				1		2	2	28	17	12	5	5		72
QUARTER 4														
Area 4								4	1					5
Area 5										1				1
Area 6									1					1
Total								4	2	1				7
TOTAL YEAR														
Area 1				1			2			1				4
Area 3							2							3
Area 4						3		4	2	1				11
Area 5				1	3	14	20	42	26	26	15	15	1	163
Area 6					1		2	15	5	2				25
Total				2	4	17	26	61	34	30	15	16	1	206

b. Raja montagui

size class	100	120	150	200	250	300	350	400	500	600	700	800	1000	Total
QUARTER 1														
Area 1					1	1	5		4	4				15
Area 3					1									1
Area 5				4	10	8	2	2	2					29
Total				4	12	9	7	2	6	4				45
QUARTER 2														
Area 1									1					1
Area 3				1										1
Area 4										4	1			5
Area 5						1		3	2					6
Total				1		1		3	3	4	1			13
QUARTER 3														
Area 3					4	2	1							7
Area 4								1	3	1				5
Area 5				1			4	7	2	3				17
Total				1	4	2	5	8	5	4				29
QUARTER 4														
Area 2								2						2
Area 4					1	2	5	13	1	2				24
Area 5						1	4	7	1	3				16
Area 6								1	3					4
Total					1	3	9	23	5	5				46
TOTAL YEAR														
Area 1					1	1	5		5	4				16
Area 2								2						2
Area 3				1	5	2	1							9
Area 4					1	2	5	14	4	7	1			34
Area 5				5	10	10	10	19	7	6				68
Area 6								1	3					4
Total				1	5	17	15	36	19	17	1			133

Table 1 ctd.

c. Raja naevus

size class	100	120	150	200	250	300	350	400	500	600	700	800	1000	Total
QUARTER 1														
Area 1				1		3	3	13	18	8				46
Area 2									3					3
Area 3			1		2	1		15	9	4				32
Area 5								1	1					2
Total			1	1	2	4	3	29	31	12				83
QUARTER 2														
Area 1									1					1
Area 2				1				2	2	1				6
Area 3					1	5	1	8	21	3				39
Area 4								2	4	1	1			8
Total			1	1	1	5	1	12	28	5	1			54
QUARTER 3														
Area 1								1	1	1				3
Area 2									3					3
Area 3	1	2	2	10	2	2	1	17	8					45
Total	1	2	2	10	2	2	1	18	12	1				51
QUARTER 4														
Area 2								1	1		1			3
Area 3							1							1
Total							1	1	1		1			4
TOTAL YEAR														
Area 1				1		3	3	14	20	9				50
Area 2				1				3	9	1	1			15
Area 3	1	2	3	10	5	8	3	40	38	7				117
Area 4								2	4	1	1			8
Area 5								1	1					2
Total	1	2	3	12	5	11	6	60	72	18	2			192

d. Raja radiata

size class	100	120	150	200	250	300	350	400	500	600	700	800	1000	Total
QUARTER 1														
Area 1			17	17	21	31	29	41	4					160
Area 2			22	37	62	53	44	124	12					354
Area 3				6	31	13	23	39	1					113
Area 4						1	3							4
Area 5								3						3
Area 6									1					1
Area 7					1				1					2
Total			39	60	115	98	99	207	19					637
QUARTER 2														
Area 1			2	4	11	15	19	31	3					85
Area 2			15	54	26	41	63	151	31					381
Area 3			2	4	15	12	13	38	1					85
Area 4			2		8	12	11	37	1					71
Area 6				1			1	2						4
Area 7			4	3		2		11	5					25
Total			25	66	60	82	107	270	41					651
QUARTER 3														
Area 1		2	26	78	81	113	127	83	13					523
Area 2			42	95	89	91	102	164	33					616
Area 3	2		2	14	33	39	35	56	1					182
Area 4			6	16	10	18	22	21						93
Area 6					1			1						2
Area 7			2	4	5	7	14	21	6					59
Total	2	2	78	207	219	268	300	346	53					1475
QUARTER 4														
Area 1		2	8	12	10	20	31	35	4					122
Area 2		2	6	10	25	32	45	82	5					207
Area 3				2	3	3	6	4	2					20
Area 4			2	2	10	24	3	12	2					55
Area 5							1	1						2
Area 6					1		3	15	2					21
Area 7					4	2	1	4						11
Total		4	16	26	53	81	90	153	15					438
TOTAL YEAR														
Area 1		4	53	111	123	179	206	190	24					890
Area 2		2	85	196	202	217	254	521	81					1558
Area 3	2		4	26	82	67	77	137	5					400
Area 4			10	18	28	55	39	70	3					223
Area 5							1	4						5
Area 6				1	2		4	18	3					28
Area 7			6	7	10	11	15	36	12					97
Total	2	6	158	359	447	529	596	976	128					3201

Table 2. Percentage of empty stomachs by predator size class (mm), area and quarter.

a. Raja clavata

size class	100	120	150	200	250	300	350	400	500	600	700	800	1000	Total
QUARTER 1														
Area 1				100.00			100.00			0.00				75.00
Area 3									0.00					0.00
Area 5					0.00	8.33	17.65	20.00	7.69	23.08	0.00	30.00	0.00	15.15
Area 6					0.00		0.00	0.00						0.00
Total				100.00	0.00	8.33	23.81	18.18	7.14	21.43	0.00	30.00	0.00	16.51
QUARTER 2														
Area 3							0.00							0.00
Area 4						33.33				0.00		0.00		20.00
Area 5							0.00	0.00	0.00	0.00				0.00
Area 6								0.00						0.00
Total						33.33	0.00	0.00	0.00	0.00		0.00		5.56
QUARTER 3														
Area 4									0.00					0.00
Area 5				0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
Area 6								0.00	0.00	0.00				0.00
Total				0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
QUARTER 4														
Area 4								0.00	0.00					0.00
Area 5										0.00				0.00
Area 6									0.00					0.00
Total								0.00	0.00	0.00				0.00
TOTAL YEAR														
Area 1				100.00			100.00			0.00				75.00
Area 3							0.00		0.00					0.00
Area 4						33.33		0.00	0.00	0.00	0.00			9.09
Area 5				0.00	0.00	7.14	15.00	9.52	3.85	11.54	0.00	20.00	0.00	9.20
Area 6						0.00		0.00	0.00	0.00	0.00			0.00
Total				50.00	0.00	11.76	19.23	6.56	2.94	10.00	0.00	18.75	0.00	9.22

b. Raja montagui

size class	100	120	150	200	250	300	350	400	500	600	700	800	1000	Total
QUARTER 1														
Area 1					0.00	0.00	40.00		0.00	0.00				13.33
Area 3					0.00									0.00
Area 5				0.00	0.00	12.50	0.00	0.00	0.00					3.45
Total				0.00	0.00	11.11	28.57	0.00	0.00	0.00				6.67
QUARTER 2														
Area 1									0.00					0.00
Area 3			0.00											0.00
Area 4										0.00	0.00			0.00
Area 5						0.00		0.00	0.00					0.00
Total			0.00			0.00		0.00	0.00	0.00	0.00			0.00
QUARTER 3														
Area 3					25.00	0.00	0.00							14.29
Area 4								0.00	0.00	0.00				0.00
Area 5				0.00			0.00	14.29	0.00	0.00				5.88
Total				0.00	25.00	0.00	0.00	12.50	0.00	0.00				6.90
QUARTER 4														
Area 2								0.00						0.00
Area 4					0.00	0.00	0.00	0.00	0.00	0.00				0.00
Area 5						0.00	0.00	0.00	0.00	0.00				0.00
Area 6								0.00	0.00					0.00
Total					0.00	0.00	0.00	0.00	0.00	0.00				0.00
TOTAL YEAR														
Area 1					0.00	0.00	40.00		0.00	0.00				12.50
Area 2								0.00						0.00
Area 3			0.00		20.00	0.00	0.00	0.00	0.00	0.00	0.00			11.11
Area 4					0.00	0.00	0.00	0.00	0.00	0.00		0.00		0.00
Area 5				0.00	0.00	10.00	0.00	5.26	0.00	0.00				2.94
Area 6								0.00	0.00					0.00
Total			0.00	0.00	5.88	6.67	9.52	2.78	0.00	0.00	0.00			3.76

Table 2 ctd.

c. Raja naevus

size class	100	120	150	200	250	300	350	400	500	600	700	800	1000	Total
QUARTER 1														
Area 1				100.00		33.33	0.00	46.15	61.11	50.00				50.00
Area 2									100.00					100.00
Area 3			0.00		50.00	0.00		93.33	44.44	100.00				71.88
Area 5								100.00	100.00					100.00
Total			0.00	100.00	50.00	25.00	0.00	72.41	61.29	66.67				61.45
QUARTER 2														
Area 1									0.00					0.00
Area 2				0.00				100.00	0.00	100.00				50.00
Area 3					0.00	20.00	0.00	25.00	28.57	33.33				25.64
Area 4								100.00	50.00	0.00	100.00			62.50
Total			0.00	0.00	20.00	0.00	50.00	28.57	40.00	100.00				33.33
QUARTER 3														
Area 1								0.00	0.00	0.00				0.00
Area 2									66.67					66.67
Area 3	0.00	0.00	50.00	20.00	0.00	0.00	100.00	23.53	25.00					22.22
Total	0.00	0.00	50.00	20.00	0.00	0.00	100.00	22.22	33.33	0.00				23.33
QUARTER 4														
Area 2								100.00	100.00		0.00			66.67
Area 3								0.00						0.00
Total								0.00	100.00	100.00	0.00			50.00
TOTAL YEAR														
Area 1				100.00		33.33	0.00	42.86	55.00	44.44				46.00
Area 2				0.00				100.00	66.67	100.00	0.00			66.67
Area 3	0.00	0.00	33.33	20.00	20.00	12.50	33.33	50.00	31.58	71.43				36.75
Area 4								100.00	50.00	0.00	100.00			62.50
Area 5								100.00	100.00					100.00
Total	0.00	0.00	33.33	25.00	20.00	18.18	16.67	33.33	44.44	55.56	50.00			43.23

d. Raja radiata

QUARTER 1														
Area 1			0.00	0.00	14.29	25.81	13.79	31.71	25.00					18.13
Area 2			0.00	0.00	17.74	26.42	38.64	31.45	58.33					24.86
Area 3				0.00	58.06	46.15	39.13	71.79	100.00					54.87
Area 4						100.00	0.00							25.00
Area 5								66.67						66.67
Area 6									0.00					0.00
Area 7					0.00			0.00						0.00
Total			0.00	0.00	27.83	29.59	30.30	39.61	47.37					28.57
QUARTER 2														
Area 1			50.00	25.00	9.09	46.67	10.53	35.48	33.33					28.24
Area 2			0.00	12.96	19.23	26.83	31.75	28.48	38.71					25.72
Area 3			0.00	0.00	13.33	16.67	53.85	28.95	0.00					25.88
Area 4			0.00		50.00	16.67	9.09	27.03	0.00					23.94
Area 6				100.00			0.00	0.00						25.00
Area 7			0.00	0.00		50.00		45.45	40.00					32.00
Total			4.00	13.64	20.00	28.05	28.04	29.63	36.59					26.11
QUARTER 3														
Area 1		0.00	0.00	7.69	8.64	10.62	8.66	10.84	30.77					9.37
Area 2			0.00	0.00	8.99	8.79	18.63	25.61	39.39					14.61
Area 3	0.00		0.00	7.14	21.21	12.82	5.71	8.93	0.00					10.99
Area 4			0.00	6.25	10.00	33.33	13.64	23.81						17.20
Area 6					0.00			0.00						0.00
Area 7			0.00	25.00	20.00	0.00	14.29	33.33	66.67					25.42
Total	0.00	0.00	0.00	4.35	10.96	11.57	12.33	19.65	39.62					12.87
QUARTER 4														
Area 1		0.00	0.00	25.00	40.00	15.00	6.45	14.29	0.00					13.93
Area 2		0.00	0.00	20.00	16.00	18.75	22.22	26.83	40.00					22.22
Area 3				0.00	33.33	33.33	50.00	0.00	0.00					25.00
Area 4			0.00	0.00	10.00	16.67	33.33	16.67	0.00					14.55
Area 5							100.00	0.00						50.00
Area 6					0.00		33.33	20.00	50.00					23.81
Area 7					0.00	0.00	0.00	25.00						9.09
Total	0.00	0.00	0.00	19.23	18.87	17.28	20.00	21.57	20.00					18.91
TOTAL YEAR														
Area 1		0.00	1.89	9.01	12.20	16.76	9.22	20.00	25.00					13.37
Area 2		0.00		4.59	13.86	17.97	25.98	28.02	41.98					20.67
Area 3	0.00		0.00	3.85	34.15	20.90	27.27	32.12	20.00					27.25
Area 4			0.00	5.56	21.43	23.64	12.82	24.29	0.00					18.83
Area 5							100.00	50.00						50.00
Area 6				100.00	0.00		25.00	16.67	33.33					21.43
Area 7			0.00	14.29	10.00	9.09	13.33	36.11	50.00					24.74
Total	0.00	0.00	0.63	6.41	17.45	18.34	19.30	26.95	37.50					19.51

Table 3. Average stomach content weight (g) by size class (mm) and quarter.

a. *Raja clavata*

size class	100	120	150	200	250	300	350	400	500	600	700	800	1000	Total
Q 1				0.00	1.56	0.53	1.31	2.13	5.45	9.35	14.20	22.35	27.10	6.30
Q 2						1.10	4.63	6.94	16.39	14.63		12.32		7.69
Q 3				0.43		0.59	2.22	5.38	10.34	17.08	29.66	35.51		11.99
Q 4								7.51	8.53	1.79				6.99
Total				0.22	1.56	0.64	1.76	4.53	8.39	12.72	19.36	25.83	27.10	8.43

b. *Raja montagui*

size class	100	120	150	200	250	300	350	400	500	600	700	800	1000	Total
Q 1				0.50	0.44	0.75	0.73	3.79	2.79	12.50				2.08
Q 2			0.12			0.47		2.97	6.74	25.91	14.87			11.40
Q 3				0.47	0.12	0.17	0.29	3.08	10.63	10.04				4.16
Q 4					0.75	1.90	1.79	3.73	4.21	3.44				3.19
Total			0.12	0.49	0.39	0.88	1.08	3.52	5.85	12.41	14.87			3.83

c. *Raja naevus*

size class	100	120	150	200	250	300	350	400	500	600	700	800	1000	Total
Q 1				0.00	0.13	0.22	3.00	0.13	0.86	1.23				0.67
Q 2				0.00	0.11	0.03	0.22	0.43	2.85	3.69	0.00			1.92
Q 3	0.02	0.14	0.20	0.19	0.57	1.16	0.00	2.01	1.70	0.60				1.24
Q 4							0.23	0.00	0.00		7.46			1.92
Total	0.02	0.14	0.14	0.16	0.30	0.30	1.57	0.75	1.76	1.88	3.73			1.20

d. *Raja radiata*

size class	100	120	150	200	250	300	350	400	500	600	700	800	1000	Total
Q 1			0.36	0.30	1.14	1.69	1.60	3.10	3.24					1.87
Q 2			0.22	0.21	0.93	1.18	1.81	3.79	3.73					2.37
Q 3	0.14	0.06	0.17	0.37	0.87	1.35	2.43	2.47	2.62					1.62
Q 4		0.29	0.22	0.12	0.93	1.01	1.62	3.23	4.91					1.94
Total	0.14	0.22	0.23	0.31	0.95	1.33	2.06	3.09	3.34					1.86

Table 4a. Summary of *Raja clavata* stomach contents by predator size class (mm) and quarter.

Quarter 1											
size class	150	200	250	300	350	400	500	600	700	800	1000
Nr of samples		1	2	2	5	4	3	4	3	1	1
Nr of stomachs sampled		1	4	12	21	22	14	14	10	10	1
Nr of empty stomachs		1	0	1	5	4	1	3	0	3	0
% empty stomachs		100.00	0.00	8.33	23.81	18.18	7.14	21.43	0.00	30.00	0.00
Mean st content wght(g)			0.95	0.48	0.95	1.55	5.49	9.49	14.96	22.35	27.10
Mean nr of prey items			15.85	13.52	13.87	6.91	7.09	7.42	11.35	6.30	3.00
Mean weight per prey(g)			0.06	0.04	0.07	0.22	0.77	1.28	1.32	3.55	9.03
WEIGHT % by major TAXA											
PHAEOPHYTA										2.08	
ANNELIDA			20.66	16.87	20.71	1.69	1.28	0.11			
CEPHALOPODA						0.64	5.45				
CRUSTACEA			79.34	83.13	61.01	86.19	80.90	67.78	74.31	31.76	0.96
GNATHOSTOMATA					18.29	9.83	12.37	32.10	25.69	66.16	99.04
UNKNOWN						1.65					
WEIGHT % COMMERCIAL SPEC.											
MERLANGIUS MERLANGUS										11.69	
CLUPEA HARENGUS						4.22		1.16	20.30		
SPRATTUS SPRATTUS									4.19		38.04
AMMODYTIDAE						2.10	4.20				
PLEURONECTES PLATessa								16.62			
SOLEA SOLEA					10.04						
CRANGON CRANGON						1.83		0.10	2.14		
Quarter 2											
Nr of samples			1	2	2	1	3			1	
Nr of stomachs sampled			3	3	7	1	3			1	
Nr of empty stomachs			1	0	0	0	0			0	
% empty stomachs			33.33	0.00	0.00	0.00	0.00			0.00	
Mean st content wght(g)			1.10	4.57	7.14	16.39	14.63			12.32	
Mean nr of prey items			1.67	14.00	27.87	15.00	6.00			7.00	
Mean weight per prey(g)			0.66	0.33	0.26	1.09	2.44			1.76	
WEIGHT % by major TAXA											
ANNELIDA			13.30	1.34	1.02	0.02					
CRUSTACEA			44.14	69.96	98.49	74.31	99.95			100.00	
GNATHOSTOMATA			42.56	28.70	0.50	25.67					
UNKNOWN							0.05				
WEIGHT % COMMERCIAL SPEC.											
Quarter 3											
Nr of samples		1	1	1	4	4	3	1		2	
Nr of stomachs sampled		1	2	2	28	17	12	5		5	
Nr of empty stomachs		0	0	0	0	0	0	0		0	
% empty stomachs		0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	
Mean st content wght(g)		0.43	0.59	2.22	5.99	9.58	15.56	29.66		35.24	
Mean nr of prey items		3.00	2.00	13.00	4.20	7.14	10.24	9.80		14.00	
Mean weight per prey(g)		0.14	0.29	0.17	1.42	1.34	1.52	3.03		2.52	
WEIGHT % by major TAXA											
ANNELIDA				0.90							
CEPHALOPODA							0.11				
CRUSTACEA		100.00	100.00	99.10	100.00	100.00	96.16	72.14		89.49	
GNATHOSTOMATA							3.73	27.86		6.11	
UNKNOWN										4.40	
WEIGHT % COMMERCIAL SPEC.											
Quarter 4											
Nr of samples					2	2	1				
Nr of stomachs sampled					4	2	1				
Nr of empty stomachs					0	0	0				
% empty stomachs					0.00	0.00	0.00				
Mean st content wght(g)					8.00	8.53	1.79				
Mean nr of prey items					34.78	9.00	4.00				
Mean weight per prey(g)					0.23	0.95	0.45				
WEIGHT % by major TAXA											
ANNELIDA					0.07	7.03					
CEPHALOPODA					9.22						
CRUSTACEA					90.71	91.33	100.00				
GNATHOSTOMATA					1.53						
WEIGHT % COMMERCIAL SPEC.											
CRANGON CRANGON								0.62			

Table 4b. Summary of *Raja montagui* stomach contents by predator size class (mm) and quarter.

Quarter 1											
size class	100	120	150	200	250	300	350	400	500	600	700
Nr of samples				1	3	4	2	1	3	1	
Nr of stomachs sampled				4	12	9	7	2	6	4	
Nr of empty stomachs				0	0	1	2	0	0	0	
% empty stomachs				0.00	0.00	11.11	28.57	0.00	0.00	0.00	
Mean st content wght(g)				0.50	0.45	0.76	1.14	3.79	3.07	12.50	
Mean nr of prey items				5.00	3.94	8.71	9.25	31.50	8.92	4.75	
Mean weight per prey(g)				0.10	0.11	0.09	0.12	0.12	0.34	2.63	
WEIGHT % by major TAXA											
ANNELIDA					1.07	7.00	3.84		18.66	13.28	
CRUSTACEA				100.00	98.93	91.02	96.16	100.00	79.28	17.24	
GNATHOSTOMATA						1.98			2.06	69.48	
WEIGHT % COMMERCIAL SPEC.											
Quarter 2											
Nr of samples			1			1		3	3	1	1
Nr of stomachs sampled			1			1		3	3	4	1
Nr of empty stomachs			0			0		0	0	0	0
% empty stomachs			0.00			0.00		0.00	0.00	0.00	0.00
Mean st content wght(g)			0.12			0.47		2.97	6.74	25.91	14.87
Mean nr of prey items			16.00			31.00		12.673	6.67	4.00	6.00
Mean weight per prey(g)			0.01			0.02		0.23	0.18	6.48	2.48
WEIGHT % by major TAXA											
ANNELIDA						17.26		6.74	1.72		
BIVALVIA									9.91		
CRUSTACEA			100.00			82.74		50.49	9.08	4.83	27.87
GNATHOSTOMATA								40.48	78.34	95.17	71.96
UNKNOWN								2.29	0.96		0.17
WEIGHT % COMMERCIAL SPEC.											
SPRATTUS SPRATTUS										64.94	71.82
AMMODYTIDAE									2.37		
Quarter 3											
Nr of samples			1	1	1	2	3	3		2	
Nr of stomachs sampled			1	4	2	5	8	5		4	
Nr of empty stomachs			0	1	0	0	1	0		0	
% empty stomachs			0.00	25.00	0.00	0.00	12.50	0.00		0.00	
Mean st content wght(g)			0.47	0.12	0.17	0.20	2.88	12.85		8.38	
Mean nr of prey items			1.00	0.75	1.00	2.00	2.97	1.67		1.50	
Mean weight per prey(g)			0.47	0.17	0.17	0.10	0.97	7.71		5.59	
WEIGHT % by major TAXA											
ANNELIDA							20.00	4.14	0.30	1.16	
CRUSTACEA			100.00	100.00	85.38	64.88	39.17	6.89		43.36	
GNATHOSTOMATA					14.62		56.69	92.81		55.49	
UNKNOWN						15.12					
WEIGHT % COMMERCIAL SPEC.											
Quarter 4											
Nr of samples				1	2	4	7	3	3		
Nr of stomachs sampled				1	3	9	23	5	5		
Nr of empty stomachs				0	0	0	0	0	0		
% empty stomachs				0.00	0.00	0.00	0.00	0.00	0.00		
Mean st content wght(g)				0.75	1.96	1.55	3.98	4.42	3.76		
Mean nr of prey items				24.00	54.00	16.19	15.43	11.22	5.50		
Mean weight per prey(g)				0.03	0.04	0.10	0.26	0.39	0.68		
WEIGHT % by major TAXA											
ANNELIDA						2.65	6.05	5.81	6.74		
BIVALVIA							0.46				
CEPHALOPODA								2.26			
CRUSTACEA				100.00	97.11	93.49	64.70	84.56	91.93		
GNATHOSTOMATA							27.22	8.70	8.07		
UNKNOWN					0.24		0.02				
WEIGHT % COMMERCIAL SPEC.											
SPRATTUS SPRATTUS							20.98				
CRANGON CRANGON							0.01	1.37			

Table 4c. Summary of *Raja naevus* stomach contents by predator size class (mm) and quarter.

Quarter 1											
size class	100	120	150	200	250	300	350	400	500	600	700
Nr of samples				1	2	4	2	11	13	7	
Nr of stomachs sampled				1	2	4	3	29	31	12	
Nr of empty stomachs				1	1	1	0	21	19	8	
% empty stomachs				100.00	50.00	25.00	0.00	72.41	61.29	66.67	
Mean st content wght(g)					0.13	0.22	2.26	0.23	0.67	1.81	
Mean nr of prey items					1.00	4.50	2.75	1.27	0.93	1.17	
Mean weight per prey(g)					0.13	0.05	0.82	0.18	0.72	1.55	
WEIGHT % by major TAXA											
ANNELIDA						12.73		5.32	8.131	6.90	
CRUSTACEA					12.74	48.62	68.96	64.89	28.08	23.73	
GNATHOSTOMATA					87.26	38.65	31.04	29.79	63.79	59.37	
WEIGHT % COMMERCIAL SPEC.											
MERLANGIUS MERLANGUS									6.67		
AMMODYTIDAE								2.43			

Quarter 2											
Nr of samples					1	4	1	6	10	5	1
Nr of stomachs sampled					1	5	1	12	28	5	1
Nr of empty stomachs					0	1	0	6	8	2	1
% empty stomachs					0.00	20.00	0.00	50.00	28.57	40.00	100.0
Mean st content wght(g)					0.11	0.02	0.22	0.33	3.01	3.69	
Mean nr of prey items					2.00	0.50	1.00	0.79	1.59	0.80	
Mean weight per prey(g)					0.05	0.04	0.22	0.42	1.89	4.61	
WEIGHT % by major TAXA											
ANNELIDA						74.07		25.06	0.08		
BIVALVIA									0.12		
CRUSTACEA					100.00	25.93		19.19	9.85		
GNATHOSTOMATA							100.00	55.75	88.83	100.00	
UNKNOWN									1.12		
WEIGHT % COMMERCIAL SPEC.											
TRISOPTERUS ESMARKI								5.52			
SOLEA SOLEA										41.36	

Quarter 3											
Nr of samples	1	1	2	4	2	1	1	6	6	1	
Nr of stomachs sampled	1	2	2	10	2	2	1	18	12	1	
Nr of empty stomachs	0	0	1	2	0	0	1	4	4	0	
% empty stomachs	0.00	0.00	50.00	20.00	0.00	0.00	100.00	22.22	33.33	0.00	
Mean st content wght(g)	0.02	0.14	0.20	0.14	0.57	1.16		2.88	2.85	0.60	
Mean nr of prey items	1.00	1.00	0.50	0.99	1.00	1.00		1.81	1.74	1.00	
Mean weight per prey(g)	0.02	0.14	0.41	0.15	0.57	1.16		1.59	1.63	0.60	
WEIGHT % by major TAXA											
ANNELIDA		48.79						3.27	1.89		
CRUSTACEA	100.00	51.21		29.67	21.43	8.97		11.44	2.02		
GNATHOSTOMATA			100.00	70.33	78.57	91.03		82.38	95.96	100.00	
UNKNOWN								2.92	0.13		
WEIGHT % COMMERCIAL SPEC.											
TRISOPTERUS ESMARKI									76.12		

Quarter 4											
Nr of samples							1	1	1		1
Nr of stomachs sampled							1	1	1		1
Nr of empty stomachs							0	1	1		0
% empty stomachs							0.00	100.00	100.00		0.00
Mean st content wght(g)							0.23				7.46
Mean nr of prey items							1.00				2.00
Mean weight per prey(g)							0.23				3.73
WEIGHT % by major TAXA											
CRUSTACEA							100.00				1.48
GNATHOSTOMATA											98.52
WEIGHT % COMMERCIAL SPEC.											

Table 4d. Summary of *Raja radiata* stomach contents by predator size class (mm) and quarter.

Quarter 1											
size class	100	120	150	200	250	300	350	400	500	600	700
Nr of samples			7	9	27	23	27	34	14		
Nr of stomachs sampled			39	60	115	98	99	207	19		
Nr of empty stomachs			0	0	32	29	30	82	9		
% empty stomachs			0.00	0.00	27.83	29.59	30.30	39.61	47.37		
Mean st content wght(g)			0.38	0.33	1.00	1.15	1.40	3.02	2.67		
Mean nr of prey items			9.94	6.14	3.29	1.65	2.51	2.56	1.71		
Mean weight per prey(g)			0.04	0.05	0.30	0.70	0.56	1.18	1.57		
WEIGHT % by major TAXA											
ANNELIDA			9.62	30.00	8.01	3.37	4.01	3.17	0.29		
GASTROPODA								0.05			
BIVALVIA						2.91					
CEPHALOPODA				0.75				0.28			
CRUSTACEA			65.58	55.62	25.14	35.33	34.01	12.30	4.86		
GNATHOSTOMATA			2.79	12.01	66.59	57.94	57.94	83.89	94.84		
UNKNOWN			22.00	1.62	0.26	0.44	4.05	0.31	0.01		
WEIGHT % COMMERCIAL SPEC.											
TRISOPTERUS ESMARKI					3.25			4.44			
SPRATTUS SPRATTUS							0.70				
AMMODYTIDAE						0.79	5.91	0.61			
CRANGON CRANGON			1.16	1.29							
Quarter 2											
size class	100	120	150	200	250	300	350	400	500	600	700
Nr of samples			9	22	25	31	35	47	17		
Nr of stomachs sampled			25	66	60	82	107	270	41		
Nr of empty stomachs			1	9	12	23	30	80	15		
% empty stomachs			4.00	13.64	20.00	28.05	28.04	29.63	36.59		
Mean st content wght(g)			0.29	0.18	0.70	1.07	1.97	3.92	2.74		
Mean nr of prey items			5.59	3.41	3.42	2.46	1.87	1.58	1.25		
Mean weight per prey(g)			0.05	0.05	0.21	0.44	1.05	2.49	2.19		
WEIGHT % by major TAXA											
ANNELIDA			32.36	26.61	14.17	9.02	2.45	1.67	0.91		
GASTROPODA						0.11					
BIVALVIA					0.18						
CEPHALOPODA						0.86		0.84			
CRUSTACEA			40.66	44.83	51.77	31.51	25.77	22.15	22.04		
ECHINODERMATA			4.40					0.00			
GNATHOSTOMATA			12.77	17.95	31.95	57.74	70.84	74.09	75.26		
UNKNOWN			9.82	10.61	1.93	0.75	0.94	1.25	1.78		
WEIGHT % COMMERCIAL SPEC.											
MELANOGRAMMUS AEGLEFINUS								13.42			
MERLANGIUS MERLANGUS								6.17	12.08		
TRISOPTERUS ESMARKI						13.98	6.45	3.30			
CLUPEA HARENGUS									8.35		
LIMANDA LIMANDA									7.93		
Quarter 3											
size class	100	120	150	200	250	300	350	400	500	600	700
Nr of samples	1	1	24	29	43	44	48	52	13		
Nr of stomachs sampled	2	2	78	207	219	268	300	346	53		
Nr of empty stomachs	0	0	0	9	24	31	37	68	21		
% empty stomachs	0.00	0.00	0.00	4.35	10.96	11.57	12.33	19.65	39.62		
Mean st content wght(g)	0.14	0.06	0.17	0.36	0.89	1.49	2.45	2.34	2.99		
Mean nr of prey items	4.00	1.00	3.64	2.69	2.10	1.84	2.17	1.72	0.88		
Mean weight per prey(g)	0.04	0.06	0.05	0.13	0.43	0.81	1.13	1.36	3.39		
WEIGHT % by major TAXA											
PHAEOPHYTA								0.00			
ANNELIDA	9.09		18.42	24.96	8.17	3.79	2.42	3.62	0.20		
BIVALVIA				0.69	0.11	0.17	0.08	0.04	0.10		
CEPHALOPODA				0.03		0.18					
CRUSTACEA	90.91	100.00	68.03	49.36	25.00	19.63	20.19	22.99	21.54		
PRIAPULIDA					0.77						
ECHINODERMATA				0.02		0.02	0.00				
GNATHOSTOMATA			11.33	24.84	65.95	75.70	77.09	72.68	78.05		
UNKNOWN			2.22	0.09		0.50	0.22	0.67	0.10		
WEIGHT % COMMERCIAL SPEC.											
GADUS MORHUA					0.53		1.11	0.33	31.04		
MERLANGIUS MERLANGUS							0.91		4.32		
TRISOPTERUS ESMARKI					3.06	5.81	10.76	16.42	4.07		
CLUPEA HARENGUS							4.00				
LIMANDA LIMANDA					1.79	0.63	0.29				

Table 4d ctd

Quarter 4

size class	100	120	150	200	250	300	350	400	500	600	700
Nr of samples		2	5	11	20	26	31	32	8		
Nr of stomachs sampled		4	16	26	53	81	90	153	15		
Nr of empty stomachs		0	0	5	10	14	18	33	3		
% empty stomachs		0.00	0.00	19.23	18.87	17.28	20.00	21.57	20.00		
Mean st content wght(g)		0.24	0.20	0.11	0.87	0.96	1.66	3.47	4.84		
Mean nr of prey items		1.33	2.92	2.30	2.97	3.44	2.16	2.15	1.36		
Mean weight per prey(g)		0.18	0.07	0.05	0.29	0.28	0.77	1.61	3.55		
WEIGHT % by major TAXA											
ANNELIDA			21.40	14.52	12.32	13.43	5.44	1.85	0.12		
GASTROPODA			1.88								
BIVALVIA				0.68				0.01			
CEPHALOPODA					0.13	0.80	0.05				
CRUSTACEA	100.00	74.57	76.59	63.79	37.04	20.89	16.29	36.75			
GNATHOSTOMATA		2.15	8.21	23.19	46.12	71.39	81.43	62.12			
UNKNOWN				0.58	2.61	2.24	0.44	1.02			
WEIGHT % COMMERCIAL SPEC.											
GADUS MORHUA				1.75							
MELANOGRAMMUS AEGLEFINUS								0.56	4.25		
MERLANGIUS MERLANGUS								6.36			
TRISOPTERUS ESMARKI					1.16	1.87	20.23	29.55			
CLUPEA HARENGUS									44.88		
SOLEA SOLEA						16.62					
LIMANDA LIMANDA								0.56			
CRANGON CRANGON						0.12					

