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STOMACH CONTENTS OF MACKEREL, HORSE MACKEREL AND WHITING IN THE EASTERN PART OF THE NORTH SEA IN JULY 1985.

BY

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ABSTRACT

During a survey in the eastern part of the North Sea, along the Danish west coast, July 1985, stomachs of mackerel, horse mackerel and whiting were sampled. This report gives the preliminary results of the variation in food composition. The most important prey item for all predators was 0-group herring. For mackerel and horse mackerel the stomach contents were lowest at night and highest just before sunset indicating a diurnal feeding cyclus. The data

INTRODUCTION

In July 1985 an acoustic survey in the eastern part of the North Sea was undertaken by the Danish Institute for Fisheries and Marine Research. The primary aim of this survey was to estimate the number of 0-group herring along the west coast of Jutland. It was also planed to sample whiting stomachs to get an estimate of the predation on herring. During the International Stomach Sampling Programme in the North Sea in 1981 only a very few whiting stomachs were sampled in the area close to the Danish coast (Hislop et al.,1983), and knowing that especially 0-group herring are found in high concentration in this area it may have given an underestimate of the predation on herring.

During the survey very high numbers of mackerel and horse mackerel were found, and it was decided also to take stomach samples from these species, as a pilot experiment. Mackerel samples from the area are only present in very few numbers in the International Stomach Programme (Westgård & Mehl, in press).

This paper gives the preliminary results of the analysis of whiting, mackerel and horse mackerel stomachs.

MATERIAL AND METHODS

The stomach were sampled by R/V Dana, R/V Lars A. Kruse and R/V Havfisken during the Danish acoustic survey in the eastern part of the North Sea from 18/7 to 3/8 1985.

Totally 336 mackerel, 122 horse mackerel and 371 whiting stomachs were analysed. Details of all trawl catches taken during the survey are given in table 1 and Kirkegaard (1986).

The whiting stomachs were obtained from all trawl catches where the species were present (22 catches out of 48).
As it not originally was planed to collect mackerel and horse mackerel stomachs, there are only samples from a part of the catches containing the two species.

If possible, 10 stomachs were taken from each 5 cm size group and analysed in accordance with the guidelines outlined in the draft manual for the stomach sampling project (Anon., 1981) with the exception, that each stomach were handled individually. Prey wet weight was measured with 2 decimals, after a 2 minutes drying on paper. If possible the total length of fish found in the stomach were measured.

Number of collected stomachs by size and time are shown for mackerel, horse mackerel and whiting in table 4, 7 and 9.

RESULTS

Mackerel

Prey composition:

The relative prey weight composition by each predator size group is shown in table 3.

The proportion of fish in the stomachs increase with predator size from about 50% in the smallest to 90% in the largest mackerel. Herring makes out between 95 to 100% of all identifiable fish species, independent of mackerel size groups.

All the herring identified in the stomachs were 0-group fish. The mean length of herring found in the stomachs and in the trawl are given in table 2. There are no significant difference between the two observed mean lengths.

Diurnal variation in empty stomachs:

5 time intervals were established (01-06, 07-09, 11-12, 14-16 and 17-22), so that they contain approximately the same amount of fish. The distribution of empty stomachs by each time interval is shown in table 4. A chi-square test for homogenity between number of empty stomachs pr time interval (table 4) indicate a strong diurnal effect. The time interval 07-09, 14-16 and 17-22 are very similar and have a low frequency of empty stomachs, while the night observations 01-06 shows high frequencies of empty stomachs Time interval 11-12 seems to be some where in the middle.

Diurnal variation in mean stomach contents:

Mean stomach contents of fish found with food in the stomachs, seperated by time intervals and predator size-class (table 4), indicates the same diurnal variation as the distribution of empty stomachs. The mean weight per stomach is lower in the night than in the day observations

The material is too small for statistical analysis but the same picture is found for all sizegroups.

Predator length and stomach content:

The average weights of the stomach contents increase with fish length, and is assumed to be proportional to the fish length raised by a factor a :

$$S = h(t) \cdot L^a \qquad 1.$$

where S is weight of the stomach contents, h(t) is a time dependent stomach contents level and L is the total length of the fish.

The material is found too weak for an exact estimation of the constant a. A value of 2 seems reasonable assuming the food intake increase with L^2.

Taking the logarithm the model can be written as

$$\log S = \log h(t) + a \log L \qquad 2.$$

This model was analysed using two-way classification and the results are given in table 5. Empty stomachs were not included in the analysis.

The estimated value for a of 2.77 is not significant different at a 10 % level from the assumed value of 2. Mehl and Westergaard (1983) estimate a to be 2.21 in a feeding experiment.

From equation 1 it can be seen that $h(t) = S/L^2$ is independent of the fish length which means, that using h(t) it is possible to compare the stomach contents at different time of the day or from different areas using all size classes.

In fig. 1 the mean S/L^2 per trawl haul are plotted against time of the day. There is a clear diurnal pattern with increasing values of h from dawn until sunset where it begins to decrease.

The trawl haul at 14.00 GMT (station 46) is very different from the other. Table 1 shows that this is the only mackerel stomach station without herring caught in the trawl. No recognisabel herring prey was found among the prey species in this hauls mackerel stomachs.

The material is also found too weak for an estimation of daily consumption rate.

Horse mackerel

Prey composition:

The relativ prey composition by each predator size is shown in table 6.

There is a strong shift in prey composition from crustacean, goby and haddock in predator size group 20-24 towards only fish food with 0-group herring dominating from size group 25-29. No herring were observed in the stomachs of fish in size group 20-24.

In the two catches where it is possible to compare, the mean length of herring found in the stomachs are significant smaller then what is seen in the trawl (table 2).

Diurnal variation in feeding pattern:

As mentioned previously horse mackerel stomach were only collected from 4 trawl catches. This makes any conclutions on diurnal variation very uncertain, however in table 7 the same diurnal trend as was shown for mackerel can be seen for horse mackerel. The stomach contents of "not empty" is lowest during the night and the morning, as well as the percentage of empty stomachs is highest during night.

Whiting

Prey composition:

The relative prey composition for each whiting size group are presented in table 8.

The greatest part of the food consists of fish and bottom invertebrates. The proportion of fish in the diet increased with whiting size from 56 % in 10-15 cm size group to 99 % in the largest fish. Sand-eel is the only recognizable fish item in size group 10-15 cm, but its importance as food for whiting decline with predator size and is taken over by herring.

Diurnal variation in feeding pattern:

No variation in feeding pattern is seen, either in percent empty stomachs nor in mean stomach content of "not empty" fish (table 9).

DISCUSSION AND CONCLUSIONS

For mackerel and horse mackerel the greatest part of the food consists of fish and copepods, while whiting prefer bottom invertebrates and fish. The proportion of fish increases with predator size. In mackerel the only important fish prey species was 0-group herring. It looks as if horse mackerel's and whiting's in the smallest size group (20-24 and 10-14 cm) were unable to eat herring and the dominating fish prey species were in horse mackerel haddock and gobies (mainly Crystallogobis linearis) and in whiting sand eel. In the other size groups 0-group herring dominates.

The results for mackerel of the International Stomach Sampling Project 1981 are described in Westgård and Mehl (in press). They found a much lower proportion of fish in the stomachs sampled in the central North Sea in third quarter and did not find herring as an important prey species for mackerel.

The diet of whiting found here is in general agreement with the results for whiting of the International Stomach Sampling Project (Hislop et al, 1983). However we find 0-group herring as the dominating while Hislop et al (1983) also find sandeels, sprats and haddock in significant quantities.

The strength of the North Sea herring year class 1984 is the highest on record, and is about 2 to 3 times the 1980 and 1981 year classes. This may explain some of the differences between the International Stomach Sampling Project 1981 and our results. However, especially for mackerel the results are more likely to reflect the distribution of 0-group herring. In third quarter a major part of young herring are found along the Danish west coast. In Westgård and Mehl's work only very few samples were collected in this area. Depending on the distribution of mackerel it may give an underestimate of the predation on 0-group herring. In 1985 very high concentrations of mackerel and horse mackerel were found in the eastern part of the North Sea and in Skagerrak (Kirkegaard, 1986)

Even though the number of stomachs are small and the variation between samples from the same trawl haul is high, the mackerel data shows a clear diurnal variation in both the relative porportion of empty stomachs and the average wet weight of the stomach content (excluding empty

stomachs). This indicates a diurnal feeding cyclus, where mackerel are feeding only during the day. No diurnal variation is observed in the diet. The horse mackerel data are too small to draw any conclusions on diurnal variation, but they show the same tendency as found for mackerel. There are no clear diurnal trend in the whiting data.

In the calculation of mackerel's consumption Westgård and Mehl (in press) assume that the feeding rate is constant within 24 hours intervals. From our data this is not always true. A diurnal feeding rhythm may result in an over-or underestimation of the consumption if the data are not sampled at all time of the day or at least weighted by the time period.

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TABLE 1. trawl station number, time for trawling (GMT), depth in meter, gear type (B = bottomtrawl and F = pelagic trawl), number of whiting, mackerel and horse mackerel stomachs sampled and finaly stations with herring in the catch.

Station nr.	Time (GMT)	Depth m.	Gear type	Whiting	Macke-rel	Horse macker.	Herring present
1	10.45	25	B	21			+
6	11.25	29	B	1			+
8	05.25	33	B	33			+
14	07.20	35	B	34			
18	11.10	27	B	33	13		+
26	05.35	13	B		20		+
30	07.00	24	B	27			+
35	18.05	13	B	1			+
36	08.10	11	B	4	1		+
38	13.06	18	B	4			+
40	06.10	17	B	5			
41	08.10	18	B	11			+
42	17.10	25	B	14			+
45	22.20	32	F	2	6		+
46	14.00	30	F	1	23		
48	15.20	31	F	4	12		+
49	07.00	48	F	38	36		+
50	17.40	27	F	30	29		+
51	01.40	39	F	20	26		+
53	07.50	27	F	1	32		+
54	17.20	38	F	36	24		+
57	11.00	25	B		40	39	+
58	05.50	33	F		30	36	+
59	11.00	41	F	35	16	28	+
62	02.30	37	F	16		19	+
64	14.00	25	B		28		+
Total				371	336	122	

TABLE 2. Mean length in mm of 0-group herring in the stomachs and in the trawl catches. Only data where the number of measured fish is more then 5 are included in the table.

haul no	mean length in trawl	mackerel mean length	mackerel no of fish	horse mackerel mean length	horse mackerel no of fish	whiting mean length	whiting no of fish
18	91.9	95.2	5	-	-	-	-
48	94.8	91.7	6	-	-	-	-
49	95.9	93.3	23	-	-	-	-
54	105.6	97.7	15	-	-	95.4	12
57	95.3	92.4	16	85.2	17	-	-
59	104.5	-	-	95.4	7	-	-
64	89.1	88.4	9	-	-	-	-

TABLE 3. Average mackerel stomach content composition in percent wet weight of the main food items, by time period and predator size group.

		time interval					TOTAL
		01_to_06	07_to_09	11_to_12	14_to_16	17_to_22	
predator size group	prey catagories						
20-24	CRUSTACE	15.12	46.72	10.09	100.00	60.01	46.70
	HERRING	62.28		61.73		39.99	39.48
	OTHER FISH	0.63					0.12
	UNIDEN. FISH	11.72	47.09	25.60			10.84
	UNIDENTIFIED	10.26	6.19	2.58			2.86
25-29	CRUSTACE	42.21	36.11	10.80	64.74	27.48	37.25
	HERRING	1.27	20.09	31.14	29.80	31.42	28.24
	OTHER FISH	12.08					0.64
	UNIDEN. FISH	28.26	43.80	57.44	5.46	41.10	32.90
	UNIDENTIFIED	16.18		0.62			0.97
30-34	CRUSTACE	77.39	4.07	14.31	26.83	62.85	26.40
	HERRING	1.01	75.58	73.98	49.94	19.34	55.68
	OTHER FISH	1.01	6.41				1.40
	SPRAT				4.80		1.21
	UNIDEN. FISH	1.64	13.41	11.70	18.43	17.81	14.43
	UNIDENTIFIED	18.95	0.52				0.88
35-39	CRUSTACE	74.52	2.22	3.66	15.15	4.86	10.83
	HERRING	23.91	84.77	85.44	56.93	73.82	71.65
	OTHER FISH			0.02			0.00
	UNIDEN. FISH		13.00	10.67	27.91	21.32	17.38
	UNIDENTIFIED	1.57		0.20			0.13
40-44	HERRING			56.42			11.33
	UNIDEN. FISH			43.58		100.00	88.67

TABLE 4. Number of analysed mackerel stomachs, the percent empty stomachs and the mean wet weight stomach content of "not empty" fish, by time period and predator size group.

		time interval					total
		01_to_06	07_to_09	11_to_12	14_to_16	17_to_22	
predator size group							
20-24	number of sample	25	19	15	11	16	86
	procent empty	28.00	21.05	26.67	9.09	25.00	23.3
	mean weight	1.14	0.55	2.08	1.71	3.61	1.71
25-29	number of sample	34	20	23	18	23	118
	procent empty	44.12	5.00	17.39	0.00	8.70	18.6
	mean weight	0.71	1.24	2.45	4.26	4.47	2.41
30-34	number of sample	14	22	18	20	14	88
	procent empty	42.86	4.55	22.22	5.00	7.14	14.8
	mean weight	1.99	3.95	8.92	5.19	5.30	5.15
35-39	number of sample	3	8	12	14	5	42
	procent empty	0.00	12.50	33.33	21.43	0.00	19.1
	mean weight	4.66	9.57	5.54	5.68	8.89	6.69
40-45	number of sample			1		1	2
	procent empty			0.00		0.00	0.0
	mean weight			8.33		33.14	20.74
total number of sample		76	69	69	63	59	336
total percent empty		36.84	10.14	23.19	7.94	11.86	18.75

TABEL 5. The results of the two-way classification. Df is the degree of freedom and SSQ is sum of squares. The dependent variable is log(wet weight of stomach content).

	df	SSQ	F-value	R-square
Model	15	48.72	4.39	0.64
Error	37	27.36		
Type 3 ss				
log L	1	17.07	23.08	
log L	1	17.07	23.08	
log h(t)	14	29.02	2.08	

TABLE 6. Average horse mackerel stomach content composition in percent wet weight of the main food items, by time and predator size group.

predator size group	prey catagories	time interval 02.3	05.5	11.0	TOTAL
20-24	CRUSTACE	100.00	80.70	13.40	33.43
	GOBY			28.25	20.63
	HADDOCK			58.35	42.62
	UNIDENTIFIED		19.30		3.31
25-29	CRUSTACE	100.00	67.14		2.08
	GOBY			1.46	1.41
	HADDOCK			16.47	16.00
	HERRING			68.57	66.62
	UNIDEN. FISH		11.43	13.51	13.39
	UNIDENTIFIED		21.43		0.49
30-34	CRUSTACE		27.06		0.42
	HADDOCK			4.45	4.38
	HERRING			75.74	74.55
	MACKEREL			12.28	12.09
	OTHER FISH		19.27		0.30
	UNIDEN. FISH		25.69	7.53	7.82
	UNIDENTIFIED		27.98		0.44
35-39	HADDOCK			26.76	26.76
	HERRING			58.43	58.43
	UNIDEN. FISH			14.81	14.81
40-44	HADDOCK			100.00	100.00

TABLE 7. Number of analysed horsemackerel stomachs, the percent empty stomachs and the mean wet weight stomach content of "not empty" fish, by time and predator size group.

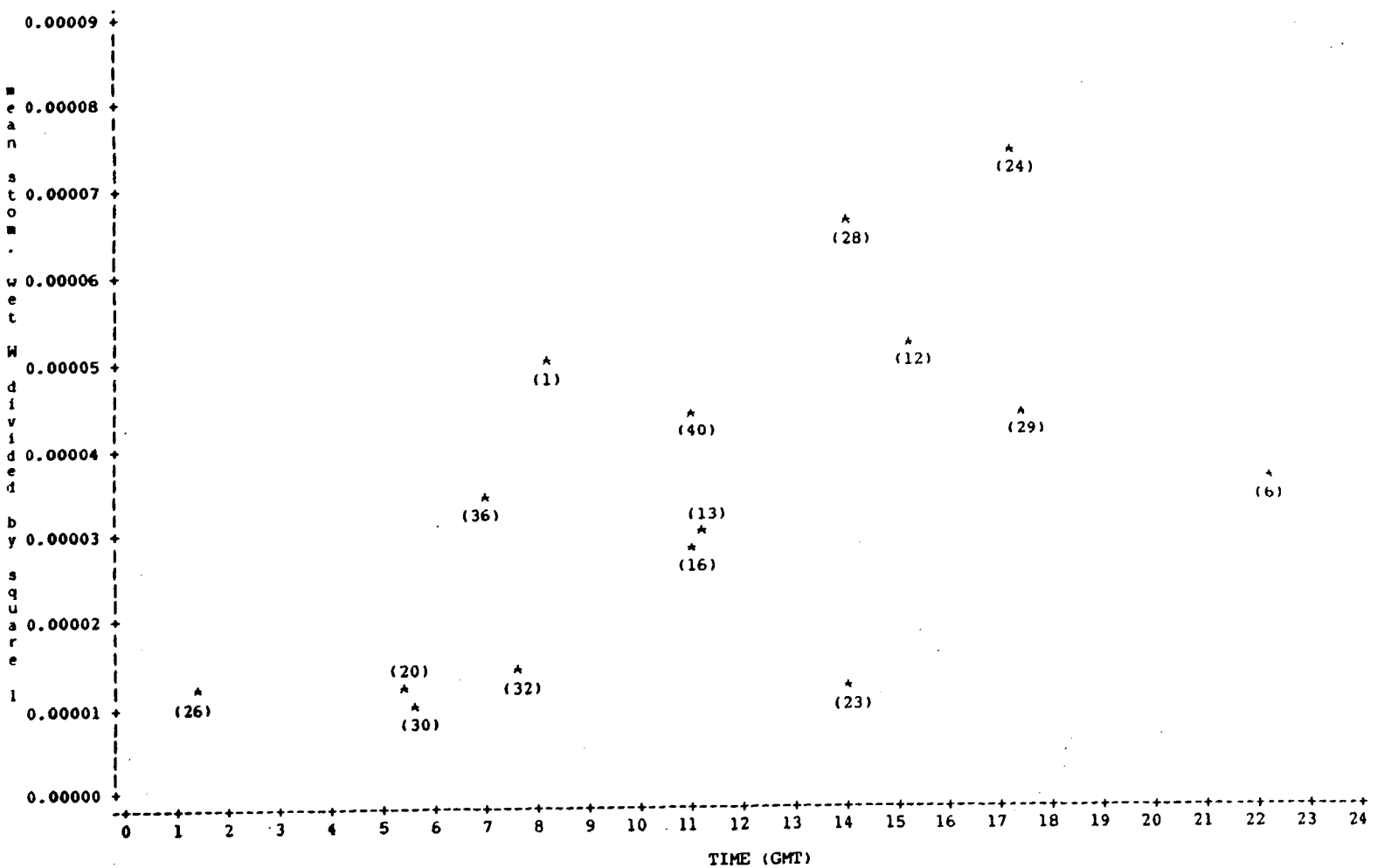
predator size group		time interval			total
		02_to_03	05_to_06	10_to_11	
20-24	number of sample	10	8	11	29
	procent empty	70.00	25.00	36.36	44.8
	mean weight	0.22	0.19	0.69	0.43
25-29	number of sample	9	21	24	54
	procent empty	66.67	61.90	37.50	51.9
	mean weight	0.16	0.26	6.33	2.86
30-34	number of sample		7	23	30
	procent empty		0.00	43.48	33.3
	mean weight		0.31	9.81	7.48
35-39	number of sample			7	7
	procent empty			42.86	42.9
	mean weight			5.59	4.79
40-44	number of sample			2	2
	procent empty			50.00	50.0
	mean weight			18.89	18.89
total number of samples		19	36	67	122
total procent empty		68.4	41.7	40.3	45.1

TABLE 8. Average whiting stomach content composition in percent wet weight of the main food items, by time period and predator size group.

predator size group	prey catagories	time interval				TOTAL
		01_to_06	07_to_09	11_to_16	17_to_22	
10-14	BIVALVIA		6.13		19.62	7.01
	CRAP		7.81		30.69	10.16
	ECHINODERM		20.97		36.33	17.35
	GREATER SANDEEL			68.91		21.62
	OTHER CRUSTAC.		0.59			0.27
	OTHER FISH		1.78			0.81
	SCHRIMP		10.98	4.01	5.64	7.46
	UIDEN. FISH	100.00	51.73	27.08	2.30	34.16
	UNIDENTIFIED				5.43	1.17
15-19	ECHINODERM		6.69			1.47
	GREATER SANDEEL		2.49	11.74	14.91	7.05
	HERRING		33.08	47.50		28.93
	OTHER CRUSTA.		3.57		0.91	0.86
	OTHER FISH	15.59	1.08	0.71		4.41
	SCHRIMP	7.68	1.59			2.25
	UIDEN. FISH	76.72	51.50	40.04	84.18	55.03
20-24	GREATER SANDEEL			4.26		1.31
	HERRING		15.75	51.47	87.99	55.82
	OTHER CRUSTA.				0.08	0.04
	OTHER FISH	18.58	4.88	3.10		3.94
	SCHRIMP	18.97	9.50	2.40		4.41
	UIDEN. FISH	62.45	69.86	38.78	11.92	34.49
25-29	CRAP				1.35	0.46
	ECHINODERM		0.65			0.12
	GREATER SANDEEL	0.86				0.13
	HERRING	47.65	48.10	76.84	52.14	58.60
	OTHER FISH	37.70			1.66	6.25
	SCHRIMP	2.39				0.36
	UIDEN. FISH	11.41	51.25	23.16	44.85	34.08
30-34	HERRING		52.59		88.98	74.47
	OTHER FISH	100.00		78.04		10.53
	SCHRIMP		3.86			0.38
	UIDEN. FISH		43.55	21.96	11.02	14.63
35-39	SCHRIMP	100.00				17.45
	UIDEN. FISH		100.00			82.55

TABLE 9. Number of analysed whiting stomachs, the percent empty stomachs and the mean wet weight stomach content of "not eating" fish, by time period and predator size group.

predator size group		time interval				TOTAL
		01_to_06	07_to_09	11_to_16	17_to_22	
10-14	number of sample	4	24	13	15	56
	procent empty	0.00	37.50	30.77	6.67	25.0
	mean weight	0.37	0.67	0.78	0.48	0.64
15-19	number of sample	20	37	32	20	109
	procent empty	30.00	54.05	37.50	55.00	45.0
	mean weight	1.26	0.92	1.62	0.61	1.12
20-24	number of sample	29	25	28	16	98
	procent empty	55.17	44.00	57.14	43.75	51.0
	mean weight	0.80	0.83	2.15	4.02	1.72
25-29	number of sample	17	16	19	21	73
	procent empty	52.94	43.75	47.37	42.86	46.6
	mean weight	3.35	3.77	5.69	5.01	4.53
30-34	number of sample	2	10	7	11	30
	procent empty	50.00	50.00	71.43	45.45	53.3
	mean weight	4.02	1.81	3.58	11.83	6.05
35-39	number of sample	2	3			5
	procent empty	50.00	66.67			60.0
	mean weight	0.41	1.94			1.33
Total number of sample		74	115	99	83	371
total percent empty		44.6	47.0	46.5	39.8	44.7



FIGUR 1. Mean mackerel stomach wet weight content (W) divided by the square fish length (l), plotted against time for each start of trawling. The number ( ) indicate the sample size.