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THE DIET AND CONSUMPTION OF MACKEREL IN THE NORTH SEA
(A preliminary report)

by

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ABSTRACT

The contents of 3674 mackerel stomachs sampled during 1981 and 1982 are analysed and presented. The samples were taken by five countries at 270 different stations as a part of The International Stomach Sampling Programme in the North Sea. The gears used were trawl, hook and line, gill net and purse seine. The most important prey items in percent wet weight were copepods, euphausiids and fish. The fish prey items were sandeel, Norway pout, herring, sprat, pearl side, cod, haddock, horse mackerel, pipe-fish, dragonet, weever and dab. An attempt was made to calculate the North Sea mackerel stock's annual food consumption.

INTRODUCTION

This paper is a contribution to the International Stomach Sampling Programme 1981. The project is described in Anon. (1980) and Anon. (1982), and aims at producing data which makes it possible to run a multispecies virtual population analysis for the fish stocks in the North Sea, which are assessed by ICES today. Mackerel was one of the five predator species to

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be included and the Institute of Marine Research, Bergen was rendered the responsibility to analyse and present the diet of mackerel sampled by the participants in the project.

The general feeding ecology and diet of Atlantic mackerel Scomber scombrus is described by Allen (1897), Bullen (1908, 1912), Nilsson (1914), Ehrenbaum (1923), Steven (1949), Sette (1950), Bolster (1971, 1974), Moores, Winters and Parsons (1975), Maurer (1976), Grave (1978), MacKay (1979), Walsh and Rankine (1979) and Vinogradov (1981). Mackerel consume zooplankton such as copepods and euphausiids and fish in the size-range 1-20 cm. Only a few authors have estimated the relative proportions of the food items over an extended area and time-period (Jones and Richards, 1976, Walsh and Rankine, 1979).

We will present data on the diet of mackerel gathered in various parts of the North Sea throughout the years 1981 and 1982.

MATERIALS AND METHODS

Samples have been collected onboard research vessels from Denmark, England, Scotland, The Netherlands and Norway. In addition, samples from Norwegian commercial catches were included. The aim was to collect ten stomachs per ICES statistical rectangle per quarter for the length groups 10-14, 15-19, 20-24, 15-29, 30-39, and 40-49 cm during 1981. This was not possible with the available resources and additional samples have been taken in 1982 and 1983. In the Norwegian samples the length groups 30-39 cm and 40-49 cm are split into four length groups.

Stomachs of fish which had regurgitated were not included in the sample. All stomachs in a length group were put into one jar and preserved in 4% formalin.

Fish prey was identified to species level if possible, other prey was identified to species level when practical.

Each recognizable prey species, genus or family were split into size categories. Numbers and total wet weight, measured to the nearest milligram, were recorded for each of these size categories. The results were then filed in the computer.

The number of stomachs collected in each quarter in 1981 and 1982 is given in the text table below.

Year	Q1	Q2	Q3	Q4	Sum
1981	28	556	1008	214	1806
1982	53	298	1048	469	1868
Sum	81	854	2056	683	3674

The distribution of samples by time and area is shown in Fig. 1 and 2. The stomachs were sampled from mackerel caught by five different gears, 1996 were taken by bottom trawl, 538 by pelagic trawl, 185 by purse seine, 565 by drift net and 390 by hand line.

Details of the methods for sampling, preservation, computer filing and output of the data is given in Anon. (1981) and Westgård (1982).

RESULTS

Distribution of samples by gear, time and area

The sampling is fairly well distributed throughout the area, with a slight concentration in the south (Fig. 1).

In the first quarter of the years 1981 and 1982 81 stomachs were collected, mostly in the central and north-eastern North Sea, (Fig. 2 and Table 1). In the second quarter 845 stomachs were collected and the samples were more evenly distributed by area and gear. The third quarter had the highest sampling

intensity and the contents of 2056 stomachs were analysed. In the fourth quarter 683 stomachs were collected. In this time period the north-eastern North Sea was underrepresented and only 38 stomachs were collected in that area.

The gears used for collection of samples were bottom trawl and pelagic trawl in the north-western North Sea, hand line, drift net and purse seine in the north-eastern North Sea and bottom trawl, drift net, hand line and pelagic trawl in the central North Sea. In the southern North Sea only bottom trawl was used. The areas referred to as north-western, north-eastern, central and southern North Sea are defined in Fig. 1.

Average wet weight of stomach content

In the first quarter (Q1) of the years 1981 and 1982 the average stomach content was only 0.11-0.72 grams (Table 2a). About 30% of the stomachs were empty and the few samples show no significant differences in stomach content weight between areas and between predator size groups.

The average wet weight of the stomach content was 6.56 grams in the second quarter (Q2) and this was the highest during the year (Table 2b). In this period only 5% of the stomachs sampled were empty. The average stomach content for the length group 40-49 cm was as much as 9.1 grams. The mean weight of stomach content for the length group 20-49 cm varied between 3.22 grams in the north-western North Sea and 8.87 grams in the central North Sea.

In the third quarter (Q3) (Table 2c) the average stomach content was half of the content in the second quarter and 10% of the stomachs were empty. The samples from the north-western North Sea had the highest stomach content weight.

In the last quarter (Q4) (Table 2d) the average stomach content was about the same as in the third quarter. 15% of the stomachs were empty and the stomach content weight was highest in the northern part of the North Sea.

In Fig. 3 the average stomach content weight for the total North Sea for the length groups 20-29 cm, 30-39 cm, 40-49 cm and 20-49 cm is summarized. The stomach content is clearly highest in Q2 for all predator size groups.

The mackerel's prey size preference

As earlier described the samples of mackerel is taken by several gears and it is a difficult task to weight these samples to get a correct picture of the total North Sea mackerel stock's prey size preference. Since the fish caught by bottom trawl had the most diverse diet we used these samples to describe the prey size preference of mackerel of different lengths. The fish were split into the length groups 20-29, 30-39 and 40-49 cm. The result is given in Table 3a, b, c and d for Q1, Q2, Q3 and Q4 respectively.

Apart from Q1 when only 27 fish were sampled we see that the length group 40-49 cm eats more and bigger fish than the 20-29 and 30-39 cm length groups. This is especially evident in Q3 (Table 3d and Fig. 4) when fish constitutes about 20 and 60% of the diet for the 20-29 and 40-49 cm length group respectively. The mean fish prey size for the 40-49 cm length group is larger than for the 20-29 and 30-39 cm length groups.

Stomach contents composition

The average compositions of the stomach content in weight percent for the main food items in different areas and quarters are given in Table 4, and more detailed in Table 5a, b, c and d. The columns labeled demersal and pelagic in Table 5 refers to fish caught by bottom trawl and other gears respectively.

The main food items were copepods (mainly Calanus finmarchicus), euphausiids, where Meganyctiphanes norvegica was the most important, and fish. On a yearly basis fish constituted about 1/3 of the stomach content and about 90% of the fish prey were herring, sprat, sand eel and Norway pout.

In the north-eastern North Sea the stomach contents examined were dominated by euphausiids and copepods, in the north-western North Sea fish was most abundant but also euphausiids made up a large part. In the central North Sea copepods, euphausiids and fish contributed with about the same proportion, while in the southern North Sea fish dominated the diet of the mackerel.

There are also some seasonal variations in the diet. In Q1, the mackerel had almost no stomach content, the main item of diet appears to be euphausiids. In Q2, copepods make an increasing contribution to the diet in the north-eastern and central North Sea, while the stomach contents were totally dominated by fish in the north-western and southern North Sea. In Q3 the contents composition is more complex. Fish still dominates the diet in north-west and south, copepods and euphausiids in north-east and euphausiids and fish in the central North Sea. In addition, there is a considerable amount of appendicularians in the diet in the north-eastern and central North Sea and appendicularians and crab larvae in the southern North Sea.

In Q4, euphausiids were most abundant in the diet in northern and fish in southern North Sea. In the central North Sea euphausiids, copepods, appendicularians, cephalopods and fish were the main food items for the mackerel examined.

We cannot draw any firm conclusions about differences in the mackerel's diet caught demersal or pelagic from Table 5.

A complete list of all prey species found in the mackerel stomachs is listed in Appendix I.

The North Sea mackerel stock's consumption

Quantitative distribution

We have tried to form a rough sketch of the North Sea mackerel stock's quantitative distribution throughout the year from the

few sources available (Table 6). The general pattern of migration is given by Anon. (1981).

It should be noted that the pattern outlined above is mainly derived from quantitative information on the distribution of adult mackerel and may not be representative for juveniles. In the first quarter of the year the North Sea mackerel stock stays in the north-eastern and north-western North Sea and to the north-west of the British Isles. Tentatively we place 50% in the north-eastern and 10% in the north-western North Sea, while 40% of the stock is outside the area defined by Fig. 1. At this time of the year the over-wintering mackerel stays near the bottom or in deep water. In the second quarter of the year the mackerel spawns and most of the stock is supposed to stay pelagic. Most of the stock is now distributed in the central and north-eastern North Sea. Judging from the Norwegian egg surveys in the period 1976-1980 (Iversen, 1981) we suggest that 35% of the stock is in the north-eastern and 60% of the stock in the central North Sea. The remaining 5% is believed to stay in the southern North Sea.

During the feeding migration in the third quarter of the year the mackerel is spread all over the North Sea. The relative abundance of the stock is not well known (Anon., 1979). We make the assumption that most of the mackerel catches is taken in Q3 and that the relative abundance in different areas is reflected in the catches reported in Bulletin Statistique for the years 1973, 74, 75 and 76 when the fisheries still were unregulated. One should, however, note that these figures include catches both from the North Sea and Western mackerel stocks. In the northern North Sea most of the fish is pelagic, while we believe that the fish is distributed closer to the bottom in the central and southern North Sea. In Q4 the situation should be something half-way between the situation in Q3 and Q1. Anon. (1981) assumes that the mackerel is out of the southern North Sea in November.

Number at age group and length

The number in each age group in the North Sea mackerel stock in 1981 and the mean length at each age is given in Table 7, based on Anon. (1982) and Norwegian unpublished results.

Temperatures in the North Sea

To be able to compute the digestion rate of fish the ambient temperature must be known. Table 8 give approximate temperatures by quarter at the bottom and at 10 m depth for the subdivisions of the North Sea defined in Fig. 1. The data is compiled from Tomczak and Goedecke (1964).

The calculation of consumption

Data on digestion rate for mackerel is given by Mehl and Westgård (1983). The consumption in tonnes of prey species i, prey size group j by predator age group n, C_{ijn} is given by:

$$C_{ijn} = \sum_{k,l,m} f(T_{klm}) \cdot \bar{w}_{klmn} \cdot N_{klmn} \cdot r_{ijklmn} \cdot D \cdot Q \cdot S \qquad (1)$$

where

$f(T_{klm})$ = rate of digestion (per hr) in area k and quarter l in depth stratum m. T=temperature in ^{o}C.

$\bar{w}_{klmn}$ = mean stomach content in grams in area k and quarter l in depth stratum m for age group n of the predator.

r_{ijklmn} = proportion of the weight of the stomach content that was size group i of prey species j in area k and quarter l in depth stratum m in predator age group n.

N_{klmn} = number of individuals of predator age group n in area k and quarter l in depth stratum m.

D = 24, number of hours in one day.

Q = 91.25, number of days in one quarter of the year.

S = 10^6, scaling factor to get C_{ijn} in tonnes.

Only two depth strata, bottom and surface were used. The program used to compute the consumption is given in Appendix II. The total biomass consumed by the mackerel stock during 1981 was estimated to about 1001000.0 tonnes which is approximately 2.25 times the biomass of the North Sea mackerel stock in 1981. In Table 9 the mackerel's consumption in tonnes of nine fish species is given for different prey size classes. From data on mean weight and age composition within each prey size group, the figures in Table 9 could be used to calculate consumption in number by age group which is what would be needed in a multispecies virtual population analysis. Although this was not done, it is clear from Table 9 that mackerel eats mainly 0 and 1 group fish.

DISCUSSION AND CONCLUSIONS

Steven, 1949, and Walsh and Rankine, 1979, found a seasonal variation in stomach fullness that agrees well with the present material. The stomach content is low during the winter months and then increases in spring to reach a maximum level in early summer, and then gradually decrease.

The diet of mackerel varies between seasons and areas. In the winter months euphasiids is the most important food item, in the rest of the year fish dominates the diet in the north-western and southern North Sea, crustaceans in the north-eastern and central North Sea. This general pattern was also found by Walsh and Rankine, 1979.

The most important fish prey species were sand eel, Norway pout and sprat. The most important crustaceans were Meganyctiphanes n. and Calanus f. Euphasiids, fish and copepods contributed roughly with 1/3 of the mackerel's diet each. This is in agreement with Jones and Richards, 1976, who estimated that mackerel consumed about 27% primary carnivores.

The prey size preference of different sized mackerel is presented here only for mackerel caught by bottom trawl. In these data it is evident that large sized mackerel consume more and

bigger fish prey than small mackerel. We have no samples where mackerel is taken simultaneously at different depths and therefore no firm conclusions can be drawn about the mackerel's prey size preference in general.

Our calculations of the North Sea mackerel stock's consumption must be regarded as preliminary and unprecise. This is due mainly to the following:

- Samples are too few to make an accurate description of variation in the diet between seasons, areas and different sized mackerel.
- All areas were not sampled by the same methods.
- The relative abundance of mackerel in the different areas of the North Sea during the year is not well known.
- The gut clearance rate of all the different prey types for different sizes of mackerel is not known.
- Diurnal variations in the stomach content is not well described.

The average weight of an individual in the North Sea mackerel stock in 1981 was 0.5 kg and the total biomass was about 444 tonnes (Anon., 1982). Combined with our result that the stock consumed about 1 million tonnes, this results in an average daily ration of 0.6% of an individual's body weight per day. This is in the right order of magnitude. We lack, however, data on the size of the maintenance ration of mackerel. From figures reported on other fish species one should expect that our estimates of the North Sea mackerel stock's consumption are on the lower side.

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Table 1. Number of fish sampled for stomach analysis in the North Sea in 1981 and 1982 by area, quarter and fishing method.

Area	Q1	Q2	Q3	Q4	Sum
Northwestern North Sea	7 Bottom trawl	39 Bottom trawl	271 Bottom and pelagic trawl	204 Pelagic trawl	521
Northeastern North Sea	34 Hand line	275 Drift net	477 Drift net, purse seine, hand line	38 Purse seine	824
Central North Sea	40 Bottom trawl	246 Drift net Bottom trawl	676 Hand line Bottom trawl	255 Pelagic trawl Bottom trawl	1217
Southern North Sea	0	294 Bottom trawl	632 Bottom trawl	186 Bottom trawl	1112
Total North Sea	81	854	2056	683	3674

Table 2a. Average stomach content wet weight (g) in Q1 by area and predator size group, number of stomachs in parenthesis.

Area	Predator size group 20–29 cm	30–39 cm	40–49 cm	20–49 cm
Northwestern North Sea	-	2.68 (5)	0.1 (2)	1.94 (7)
Northeastern North Sea	0.12 (1)	0.15 (13)	0.22 (20)	0.19 (34)
Central North Sea	0.11 (33)	0.13 (4)	-	0.11 (37)
Southern North Sea	-	-	-	-
Total North Sea	0.11 (34)	0.72 (22)	0.21 (22)	0.31 (78)

Table 2b. Average stomach content wet weight (g) in Q2 by area and predator size group, number of stomachs in parenthesis.

Area	Predator size group 20–29 cm	30–39 cm	40–49 cm	20–49 cm
Northwestern North Sea	2.33 (13)	3.64 (24)	4.05 (2)	3.22 (39)
Northeastern North Sea	0.01 (10)	6.08 (103)	8.18 (162)	7.10 (275)
Central North Sea	6.43 (15)	7.82 (120)	10.34 (111)	8.87 (246)
Southern North Sea	2.58 (124)	4.81 (128)	9.82 (39)	4.53 (291)
Total North Sea	2.76 (162)	6.05 (375)	9.12 (314)	6.56 (851)

Table 2c. Average stomach content wet weight (g) in Q3 by area and predator size group, number of stomachs in parenthesis.

Area	Predator size group 20-29 cm	30-39 cm	40-49 cm	20-49 cm
Northwestern North Sea	3.37 (72)	5.64 (166)	4.79 (33)	4.93 (271)
Northeastern North Sea	1.27 (81)	2.04 (267)	3.20 (129)	2.22 (477)
Central North Sea	1.53 (193)	2.98 (357)	3.59 (126)	2.68 (676)
Southern North Sea	1.31 (236)	1.89 (295)	4.60 (101)	2.11 (632)
Total North Sea	1.63 (582)	2.86 (1085)	3.82 (389)	2.70 (2056)

Table 2d. Average stomach content wet weight (g) in Q4 by area and predator size group, number of stomachs in parenthesis.

Area	Predator size group 20-29 cm	30-39 cm	40-49 cm	20-49 cm
Northwestern North Sea	0.85 (13)	3.86 (108)	4.96 (83)	4.12 (204)
Northeastern North Sea	-	2.76 (18)	5.03 (20)	3.95 (38)
Central North Sea	2.10 (69)	2.43 (163)	3.10 (23)	2.40 (255)
Southern North Sea	0.65 (38)	2.16 (127)	1.66 (21)	1.86 (186)
Total North Sea	1.51 (120)	2.73 (416)	4.30 (147)	2.85 (683)

Table 3a. Percent wet weight of different prey categories in the stomach content of mackerel caught by bottom trawl in Q1. Number of stomachs in each length group in parenthesis.

Prey categories	Prey size class	Predator size group 20-29 cm (16)	30-39 cm (9)	40-49 cm (2)
Var. evertebrata	Unknown	2.4	0.1	-
Crustacea	Unknown	0.7	-	3.8
	0-1.9 cm	48.5	0.9	-
	2-4.9 "	46.8	95.5	-
Pisces	Unknown	1.6	2.7	-
Indeterminatus	Unknown	1.6	0.7	96.2

Table 3b. Percent wet weight of different prey categories in the stomach content of mackerel caught by bottom trawl in Q2. Number of stomachs in each length group in parenthesis.

Prey categories	Prey size class	Predator size group 20-29 cm (139)	30-39 cm (179)	40-49 cm (82)
Var. evertebrata	Unknown	0.5	-	-
	0-4.9 cm	0.9	0.9	0.2
Crustacea	Unknown	-	2.4	6.1
	0-1.9 cm	4.9	3.6	11.2
	2-4.9 "	-	10.7	22.4
Urochordata	0-1.9 cm	2.6	5.7	0.6
Pisces	Unknown	53.4	31.5	17.3
	0-4.9 cm	0.1	1.7	2.5
	5-9.9 "	0.7	12.6	16.1
	10-14.9"	23.7	22.5	14.5
	15-19.9"	2.9	1.6	5.7
Indeterminatus	Unknown	10.2	6.5	3.4

Table 3c. Percent wet weight of different prey categories in the stomach content of mackerel caught by bottom trawl in Q3. Number of stomachs in each length group in parenthesis.

Prey categories	Prey size class	Predator size group 20-29 cm (394)	30-39 cm (571)	40-49 cm (176)
Var. evertebrata	Unknown	0.1	0.1	0.6
	0-4.9 cm	1.0	0.5	1.7
	5-9.9 cm	-	0.4	0.4
Crustacea	Unknown	0.5	0.9	0.3
	0-1.9 cm	33.0	29.3	7.1
	2-4.9 "	2.3	9.1	16.1
	5-9.9 "	-	0.2	0.1
Urochordata	0-1.9 cm	27.9	5.5	1.3
Pisces	Unknown	3.6	4.0	3.5
	0-4.9 cm	4.1	0.9	0.3
	5-9.9 "	10.8	24.3	30.7
	10-14.9"	0.5	10.4	19.7
	15-19.9"	-	0.5	2.3
Indeterminatus	Unknown	15.9	13.8	15.8

Table 3d. Percent wet weight of different prey categories in the stomach content of mackerel caught by bottom trawl in Q4. Number of stomachs in each length group in parenthesis.

Prey categories	Prey size class	Predator size group 20-29 cm (92)	30-39 cm (282)	40-49 cm (48)
Var. evertebrata	Unknown	1.2	-	-
	0-4.9 cm	17.4	5.2	1.6
	5-9.9 "	9.1	1.2	-
Crustacea	Unknown	-	0.1	-
	0-1.9 cm	17.2	37.6	6.5
	2-4.9 "	-	12.0	67.7
Urochordata	0-1.9 cm	33.9	8.4	-
Pisces	Unknown	2.2	1.3	1.0
	0-4.9 cm	5.1	0.6	-
	5-9.9 "	-	6.8	12.6
	10-14.9"	-	15.9	3.4
	15-19.9"	-	-	-
Indeterminatus	Unknown	14.0	10.4	7.1

Table 4. Stomach content composition in percent wet weight by area and quarter for the main food items in the diet of the mackerel.

Main food item	Northwestern North Sea					Northeastern North Sea					Central North Sea					Southern North Sea				
	Q1	Q2	Q3	Q4	81-82	Q1	Q2	Q3	Q4	81-82	Q1	Q2	Q3	Q4	81-82	Q1	Q2	Q3	Q4	81-82
Copepods	-	7.9	4.6	19.1	10.0	-	33.8	41.0	32.5	36.0	-	48.6	12.1	21.1	30.5	-	4.9	8.4	11.6	7.2
Euphausiids	97.8	2.2	9.8	55.3	26.4	1.8	59.9	27.5	62.2	49.0	69.4	19.9	46.6	26.5	31.3	-	+	+	+	+
Other evertebrates	-	-	5.5	4.8	5.0	2.8	1.1	17.6	0.8	6.6	20.2	0.4	8.0	29.6	7.1	-	7.7	33.7	0.2	18.8
Fish	-	89.9	72.3	16.8	52.6	-	5.1	11.2	3.7	7.3	9.7	31.5	28.9	13.2	27.8	-	78.7	37.0	66.8	58.4
Unidentified	2.2	1.0	7.8	4.0	6.0	95.4	0.1	2.7	0.7	1.1	0.7	0.6	4.4	9.6	3.3	-	8.7	20.9	21.4	15.6

Table 5a. Food composition in weight percent in Q1 by area, gear and predator size group. Number of stomachs in parenthesis.

		Northwestern North Sea			Northeastern North Sea			Central North Sea			Southern North Sea
		Demersal			Pelagic			Demersal			
Prey categories	Prey size class	20 29 (0)	30 39 (5)	40 49 (2)	20 29 (1)	30 39 (13)	40 49 (20)	20 29 (33)	30 39 (4)	40 49 (0)	
Phaeophyta		-	-	-	-	-	-	-	0.8	-	
Cnidaria		-	-	-	-	4.8	1.8	17.5	3.4	-	NO
Amphipoda		-	-	-	-	-	-	1.4	24.4	-	
Euphausiacea		-	99.3	3.8	100	-	-	79.9	-	-	
Decapoda		-	-	-	-	0.4	-	-	-	-	
Teleostei	unknown	-	-	-	-	-	-	0.3	71.4	-	SAMPLES
Indeterminatus		-	0.7	92.6	-	94.8	98.2	0.8	-	-	
Grams pr stomach		-	2.68	0.10	0.12	0.15	0.22	0.11	0.13	-	

Table 5b. Food composition in weight percent in Q2 by area, gear and predator size group. Number of stomachs in parenthesis.

		Northwestern North Sea			Northeastern North Sea			Central North Sea						Southern North Sea		
		Demersal			Pelagic			Demersal			Pelagic			Demersal		
Prey categories	Prey size class	20 29 (13)	30 39 (24)	40 49 (2)	20 29 (10)	30 39 (103)	40 49 (162)	20 29 (15)	30 39 (51)	40 49 (43)	20 29 (0)	30 39 (69)	40 49 (68)	20 29 (124)	30 39 (128)	40 49 (39)
Phaeophyta		-	-	-	-	-	-	-	+	-	-	-	-	0.7	+	+
Cnidaria		-	+	-	100	+	+	-	+	+	-	-	+	+	+	+
Polychaeta		-	-	-	-	-	-	-	-	-	-	-	0.7	1.2	1.0	0.3
Mollusca		-	-	-	-	-	-	-	-	-	-	+	-	-	-	+
Cephalopoda		-	-	-	-	-	-	-	-	-	-	-	-	+	0.3	4.3
Copepoda		-	9.5	19.8	-	25.7	37.7	-	5.7	10.3	-	69.0	68.5	6.4	2.4	7.7
Amphipoda		-	+	-	-	0.6	1.4	-	+	+	-	-	+	-	+	+
Euphausiacea		4.1	1.6	1.6	-	68.2	56.0	-	41.3	61.9	-	3.7	10.5	+	+	-
Decapoda		-	-	-	-	-	+	+	0.6	+	-	-	-	+	-	-
Urochordata		-	-	-	-	-	-	-	-	-	-	-	-	3.4	8.3	1.1
Teleostei	unknown	11.6	54.0	-	-	3.5	2.2	0.2	0.6	0.5	-	8.3	3.8	67.0	36.6	0.8
	0- 4 cm	-	-	-	-	0.7	1.2	-	-	-	-	-	-	-	+	-
	5- 9 cm	-	-	-	-	0.2	1.2	1.2	-	-	-	-	-	-	7.5	4.2
	10-14 cm	-	-	-	-	-	-	-	-	-	-	-	-	-	3.5	0.9
Clupeidae	5- 9 cm	-	-	-	-	-	-	-	0.6	-	-	-	-	-	1.3	-
Clupea sprattus eggs		-	-	-	-	-	-	-	-	-	-	-	-	0.1	+	+
Maurolicus	0- 4 cm	-	-	-	-	0.6	-	-	-	-	-	-	-	-	-	-
muelleri	5- 9 cm	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-	-
Gadidae	unknown	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-
	0- 4 cm	-	-	-	-	0.2	+	-	-	-	-	-	-	-	0.1	-
Trisopterus	0- 4 cm	3.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
esmarkii	5- 9 cm	1.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ammodytidae	unknown	-	4.7	-	-	-	-	-	3.0	1.5	-	0.3	-	2.5	8.1	29.8
	0- 4 cm	41.9	9.6	47.7	-	-	-	-	5.1	3.8	-	13.2	7.4	+	-	1.4
	5 -9 cm	37.3	19.2	30.9	-	-	-	-	10.8	20.5	-	5.3	8.7	0.5	4.5	8.1
	10-14 cm	-	-	-	-	-	-	85.0	30.6	-	-	-	0.4	5.2	15.2	25.9
	15-19 cm	-	-	-	-	-	-	12.3	-	-	-	-	-	-	2.3	10.5
Scomber scombrus eggs		-	-	-	-	-	-	-	+	+	-	-	-	0.1	+	+
Indeterminatus		-	1.4	-	-	-	-	1.2	1.8	1.5	-	0.1	-	13.0	8.8	5.0
Grams pr stomach		2.33	3.64	4.05	0.01	6.08	8.18	6.43	5.70	7.63	-	9.38	12.06	2.58	4.81	9.82

Table 5c. Food composition in weight percent in Q3 by area, gear and predator size group. Number of stomachs in parenthesis.

		Northwestern North Sea						Northeastern North Sea			Central North Sea						Southern North Sea		
		Demersal			Pelagic			Pelagic			Pelagic			Demersal			Demersal		
Prey categories	Prey size class	20 29 (27)	30 39 (72)	40 49 (31)	20 29 (45)	30 39 (94)	40 49 (2)	20 29 (81)	30 39 (267)	40 49 (129)	20 29 (62)	30 39 (159)	40 49 (92)	20 29 (131)	30 39 (198)	40 49 (34)	20 29 (236)	30 39 (295)	40 49 (10)
Phaephyta		-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	0.2	0.1	0.8
Cridaria		+	+	+	0.5	0.5	-	+	+	0.1	+	0.1	+	+	+	0.2	+	+	0.1
Polychaeta		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	0.4	-
Mollusca		+	+	-	-	-	-	-	-	-	-	+	-	+	+	-	0.8	0.1	-
Cephalopoda		-	-	+	-	-	-	-	-	-	-	-	-	-	0.1	1.8	0.2	2.3	2.8
Copepoda		41.1	6.5	6.2	1.0	0.8	-	11.0	44.7	43.5	56.3	16.7	16.9	8.6	3.4	1.3	10.2	10.8	4.5
Amphipoda		0.2	5.2	6.0	-	+	-	+	1.0	+	0.1	+	+	0.9	+	+	0.2	0.4	+
Euphausiacea		8.0	31.3	+	1.0	2.4	-	5.7	19.1	44.2	23.1	72.5	77.3	31.3	33.7	5.4	+	+	+
Decapoda		+	4.4	6.0	-	-	-	1.5	2.5	-	-	+	-	11.4	1.7	2.4	12.7	23.7	20.4
Urochordata		10.9	3.8	2.3	0.8	0.1	-	75.9	13.9	3.1	8.0	1.2	0.6	23.4	6.0	1.5	33.9	5.8	1.1
Teleostei	unknown	0.1	7.8	10.8	21.8	36.1	-	0.4	1.1	0.3	6.5	2.9	2.0	3.8	1.0	1.0	1.4	4.4	3.1
	0- 4 cm	-	0.2	-	-	-	-	-	0.1	-	+	-	-	0.1	+	-	0.8	0.2	-
	5- 9 cm	-	0.6	2.5	-	-	-	-	0.8	2.0	-	-	-	-	5.8	-	2.6	7.3	2.6
	10-14 cm	-	-	-	-	-	-	-	-	-	-	2.2	-	-	-	-	-	-	-
Clupeidae	unknown	-	-	-	-	-	-	-	0.6	0.2	-	-	-	-	-	-	-	-	-
	5- 9 cm	-	-	-	-	-	-	-	-	2.4	-	-	-	6.4	2.3	18.8	-	-	2.1
	10-14 cm	-	-	-	-	-	-	-	-	-	-	-	-	-	2.8	28.5	-	-	3.1
Clupea	5- 9 cm	-	-	-	-	-	-	-	-	-	-	-	-	3.5	7.0	-	5.0	1.8	6.9
harengus	10-14 cm	-	-	-	-	-	-	-	-	-	-	-	-	-	11.0	11.5	-	6.1	7.3
	15-19 cm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.8
Clupea	unknown	-	-	-	-	-	-	-	4.6	2.6	-	-	-	-	-	-	-	-	-
sprattus	5- 9 cm	-	-	-	-	-	-	-	-	-	-	-	-	-	1.2	-	-	1.4	12.8
	10-14 cm	-	-	-	-	-	-	-	7.4	-	-	-	-	-	-	-	-	-	7.8
Maurolicus mulleri	5- 9 cm	-	-	-	-	2.3	-	-	-	-	-	-	-	-	-	-	-	-	-
Gadidae	unknown	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
	0- 4 cm	0.3	-	+	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
	5- 9 cm	-	3.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gadus	5- 9 cm	-	-	-	-	-	-	-	-	-	-	-	-	-	0.6	-	-	-	-
morhua	10-14 cm	-	-	-	-	-	-	-	-	-	-	-	-	-	1.9	-	-	-	-
Melano- grammus aeglefinus	10-14 cm	-	2.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trisopterus	unknown	-	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
esmarkii	0- 4 cm	-	-	-	-	1.5	-	-	0.2	-	-	-	-	-	-	-	-	-	-
	5- 9 cm	-	13.7	7.9	13.7	20.7	100	-	1.1	-	0.6	-	-	-	1.0	22.1	-	-	2.3
Sygnathus	0- 4 cm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.3	+	-
rostelladus	5- 9 cm	-	-	-	-	-	-	-	-	-	-	-	-	0.1	1.4	-	-	-	-
Trachurus	0- 4 cm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.2	0.2	+
trachurus	5- 9 cm	-	-	-	-	-	-	-	-	-	-	-	-	0.8	-	-	-	6.3	5.3
Ammodytidae	unknown	13.7	-	-	3.5	6.4	-	-	-	-	-	-	-	-	-	-	+	-	-
	0- 4 cm	-	0.4	1.1	4.7	0.9	-	-	-	-	-	-	-	-	-	-	1.5	1.4	-
	5- 9 cm	23.8	8.1	-	51.6	27.0	-	-	-	-	-	-	-	-	10.8	4.9	0.4	-	-
	10-14 cm	-	1.6	-	-	-	-	-	-	-	-	-	-	1.6	-	-	-	-	-
	15-19 cm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.3	-
Calionymus	0- 4 cm	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-	-	+	0.3
lyra	5- 9 cm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10-14 cm	-	-	-	-	-	-	-	-	-	-	-	-	-	2.5	-	-	-	-
Limanda	0- 4 cm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
limanda	5- 9 cm	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	0.4	-
Indeterminatus		1.9	9.8	57.1	1.4	1.2	-	5.4	2.9	1.8	5.4	4.3	3.1	6.6	5.3	0.7	24.5	25.4	13.2
Grams pr stomach		2.27	4.86	3.36	4.02	6.23	27.0	1.27	2.04	3.20	1.64	2.80	3.07	1.48	3.12	5.00	1.31	1.89	4.60

Table 5d. Food composition in weight percent in Q4 by area, gear and predator size group. Number of stomachs in parenthesis.

		Northwestern North Sea			Northeastern North Sea			Central North Sea						Southern North Sea		
		Demersal			Pelagic			Demersal			Pelagic			Demersal		
Prey categories	Prey size class	20 29 (13)	30 39 (108)	40 49 (83)	20 29 (0)	30 39 (18)	40 49 (20)	20 29 (18)	30 39 (31)	40 49 (21)	20 29 (51)	30 39 (132)	40 49 (2)	20 29 (38)	30 39 (127)	40 49 (21)
Phaeophyta		+	-	-	-	-	-	-	-	-	-	+	-	-	0.1	+
Cnidaria		0.1	0.2	0.9	-	-	+	+	+	-	+	+	-	+	+	0.1
Polychaeta		-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Mollusca		14.5	2.4	4.4	-	-	1.2	+	+	+	3.2	4.0	-	-	-	-
Cephalopoda		-	0.4	-	-	-	-	-	-	-	26.4	9.0	-	26.5	2.4	-
Copepoda		0.1	8.9	29.9	-	59.3	19.2	58.0	62.4	48.0	-	0.3	-	20.9	12.7	+
Amphipoda		1.5	1.0	0.1	-	-	-	1.0	0.1	0.1	0.1	1.6	0.2	+	-	-
Euphansiacea		35.5	76.3	34.5	-	39.2	73.6	5.0	11.8	0.1	9.5	45.8	-	-	-	-
Decapoda		+	0.1	+	-	-	-	7.9	0.2	0.1	1.8	0.4	-	+	0.1	-
Urochordata		0.1	+	-	-	-	-	-	-	-	46.6	22.4	-	-	-	0.1
Teleostei	unknown	-	1.6	0.2	-	0.5	-	2.6	0.7	0.4	+	2.1	-	9.2	1.0	5.8
	0- 4 cm	-	+	+	-	-	-	-	-	-	0.9	-	-	-	+	-
	5- 9 cm	-	-	1.1	-	-	-	-	-	-	-	-	-	-	6.3	-
Clupea harengus	5- 9 cm	-	-	-	-	-	-	-	-	-	-	-	-	-	2.5	6.3
	10-14 cm	-	-	-	-	-	-	-	-	-	-	3.3	-	-	23.6	20.1
Clupea sprattus	10-14 cm	-	-	-	-	-	-	-	-	-	-	-	-	-	7.0	-
Trisopterus esmarkii	5- 9 cm	37.3	3.7	10.6	-	-	5.3	7.9	12.0	7.2	-	-	-	-	-	-
	10-14 cm	-	3.2	3.3	-	-	-	10.7	-	38.8	-	-	-	-	-	-
	15-19 cm	-	-	9.2	-	-	-	-	-	-	-	-	-	-	-	-
Trachurus trachurus																
	5- 9 cm	-	-	-	-	-	-	-	-	-	-	-	-	-	11.0	52.8
	10-14 cm	-	-	-	-	-	-	-	-	-	-	-	-	-	9.7	-
Trachinus vipera	5- 9 cm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.5
Ammodytidae	0- 4 cm	-	-	+	-	-	-	-	-	-	1.3	0.9	-	14.7	-	-
	5- 9 cm	-	-	-	-	-	-	-	-	-	-	0.3	-	-	-	-
	10-14 cm	-	-	-	-	-	-	-	-	-	-	-	-	-	2.9	-
Callionymus lyra	0- 4 cm	-	-	-	-	-	-	-	-	-	-	-	-	-	0.8	7.2
Indeterminatus		10.9	2.2	5.6	-	0.9	0.7	6.8	12.7	5.3	10.0	9.7	99.8	28.7	19.8	0.1
Grams pr stomach		0.85	3.86	4.96	-	2.76	5.03	3.85	2.85	3.31	1.49	2.33	0.87	0.65	2.16	1.66

Table 6. Tentative distribution of mackerel in millions of individuals in four areas of the North Sea in 1981.

Area	Depth	Quarter of the year Q1	Q2	Q3	Q4
Northwestern North Sea	Pelagic	0	0	360	125
	Demersal	88	0	40	125
Northeastern North Sea	Pelagic	0	350	360	200
	Demersal	444	50	40	200
Central North Sea	Pelagic	0	440	30	15
	Demersal	0	40	20	10
Southern North Sea	Pelagic	0	6	20	0
	Demersal	0	2	15	0

Table 7. Millions of individuals and length of each age group for the North Sea mackerel stock 1 January 1981.

Age	1	2	3	4	5	6	7	8+	Total
Number	93	49	53	10	62	94	105	422	888
Length (cm)	20.	27.	30.	33.	34.	35.	36.	41.	35.6
Number in % of total	10.5	5.5	6.0	1.1	7.0	10.6	11.8	47.5	100.0

Table 8. Approximate mean temperatures in different areas of the North Sea at the bottom and 10 m depth during the year in °C. (Compiled from Tomczak and Goedecke, 1964).

Area	Depth	Quarter of the year Q1	Q2	Q3	Q4
Northwestern North Sea	10 m	6	8	14	9
	Bottom	7	7	7	8
Northeastern North Sea	10 m	7	8	12	9
	Bottom	7	7	10	9
Central North Sea	10 m	5	8	15	10
	Bottom	5	6	8	9
Southern North Sea	10 m	5	8	16	11
	Bottom	5	8	16	11

Table 9. The North Sea mackerel stock's consumption in tonnes of different prey categories in 1981. The species "other" refers to taxonomic groups for which the consumption are not explicitly given.

Predator age group	Prey size group (cm) Indet.	0-4	5-9	10-14	15-19		Indet.	0-4	5-9	10-14	15-19	
	"Other"						Teleostei					
1	28820.6	-	-	-	-		4065.8	3.2	225.9	0.0	0.0	
2	15112.9	-	-	-	-		2128.2	1.6	118.3	0.0	0.0	
3	35201.0	-	-	-	-		6939.9	82.7	170.6	16.9	0.0	
4	6488.7	-	-	-	-		1280.5	15.4	30.9	3.0	0.0	
5	41182.1	-	-	-	-		8090.9	96.5	197.5	19.0	0.0	
6	62342.7	-	-	-	-		12261.9	146.1	300.1	29.2	0.0	
7	69384.0	-	-	-	-		13646.7	162.6	333.4	32.4	0.0	
8+	418687.9	-	-	-	-		16767.7	990.5	5364.5	18.7	0.0	
						Sum: 677219.9						Sum: 73540.4
	Clupeidae						Clupea harengus					
1	0.0	0.0	52.5	0.0	0.0		0.0	0.0	32.7	0.0	0.0	
2	0.0	0.0	27.9	0.0	0.0		0.0	0.0	17.3	0.0	0.0	
3	34.3	0.0	43.3	22.0	0.0		0.0	0.0	58.2	99.4	0.0	
4	6.3	0.0	7.6	3.7	0.0		0.0	0.0	9.8	17.3	0.0	
5	40.0	0.0	50.3	25.6	0.0		0.0	0.0	68.0	118.9	0.0	
6	60.6	0.0	76.4	39.0	0.0		0.0	0.0	103.3	180.2	0.0	
7	67.4	0.0	84.7	42.9	0.0		0.0	0.0	113.8	198.9	0.0	
8+	141.9	0.0	2678.8	1469.8	0.0		0.0	0.0	141.9	715.2	78.2	
						Sum: 4974.9						Sum: 1953.0
	Clupea sprattus						Gadidae					
1	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	
2	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	
3	262.8	0.0	11.1	422.7	0.0		0.0	38.9	292.9	0.0	0.0	
4	48.3	0.0	1.9	77.7	0.0		0.0	7.3	54.1	0.0	0.0	
5	306.6	0.0	13.0	493.2	0.0		0.0	45.3	341.7	0.0	0.0	
6	464.4	0.0	19.7	747.1	0.0		0.0	68.6	517.9	0.0	0.0	
7	516.9	0.0	21.8	831.5	0.0		0.0	76.4	576.3	0.0	0.0	
8+	1844.5	0.0	263.3	160.4	0.0		82.5	0.0	0.0	0.0	0.0	
						Sum: 6507.0						Sum: 2101.9
	Gadus Morhua						Melanogrammus aeglefinus					
1	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	
2	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	
3	0.0	0.0	4.1	15.1	0.0		0.0	0.0	0.0	180.3	0.0	
4	0.0	0.0	0.7	2.5	0.0		0.0	0.0	0.0	33.3	0.0	
5	0.0	0.0	4.8	17.6	0.0		0.0	0.0	0.0	210.3	0.0	
6	0.0	0.0	7.3	26.8	0.0		0.0	0.0	0.0	318.7	0.0	
7	0.0	0.0	8.0	29.5	0.0		0.0	0.0	0.0	354.6	0.0	
8+	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	
						Sum: 116.5						Sum: 1097.2
	Trisopterus esmarkii						Ammodytidae					
1	0.0	754.0	2922.1	0.0	0.0		1440.0	829.6	10485.7	14755.2	2139.5	
2	0.0	394.9	1532.0	0.0	0.0		754.2	434.5	5492.5	7728.9	1120.7	
3	13.9	43.6	4261.1	111.6	0.0		1042.7	1433.3	5409.4	1285.1	4.4	
4	2.6	8.1	787.6	20.8	0.0		192.3	260.1	994.5	233.4	0.9	
5	16.4	51.1	4975.0	130.9	0.0		1214.7	1673.0	6310.2	1495.9	4.7	
6	24.7	77.3	7538.5	197.9	0.0		1841.3	2530.4	9560.6	2264.5	7.3	
7	27.5	86.0	8388.2	220.2	0.0		2049.4	2818.7	10638.6	2522.7	8.2	
8	0.0	0.0	68132.8	2218.2	3264.8		1116.0	9027.6	15302.0	910.8	218.4	
						Sum: 106202.1						Sum: 127551.8

Total: 1001264.8

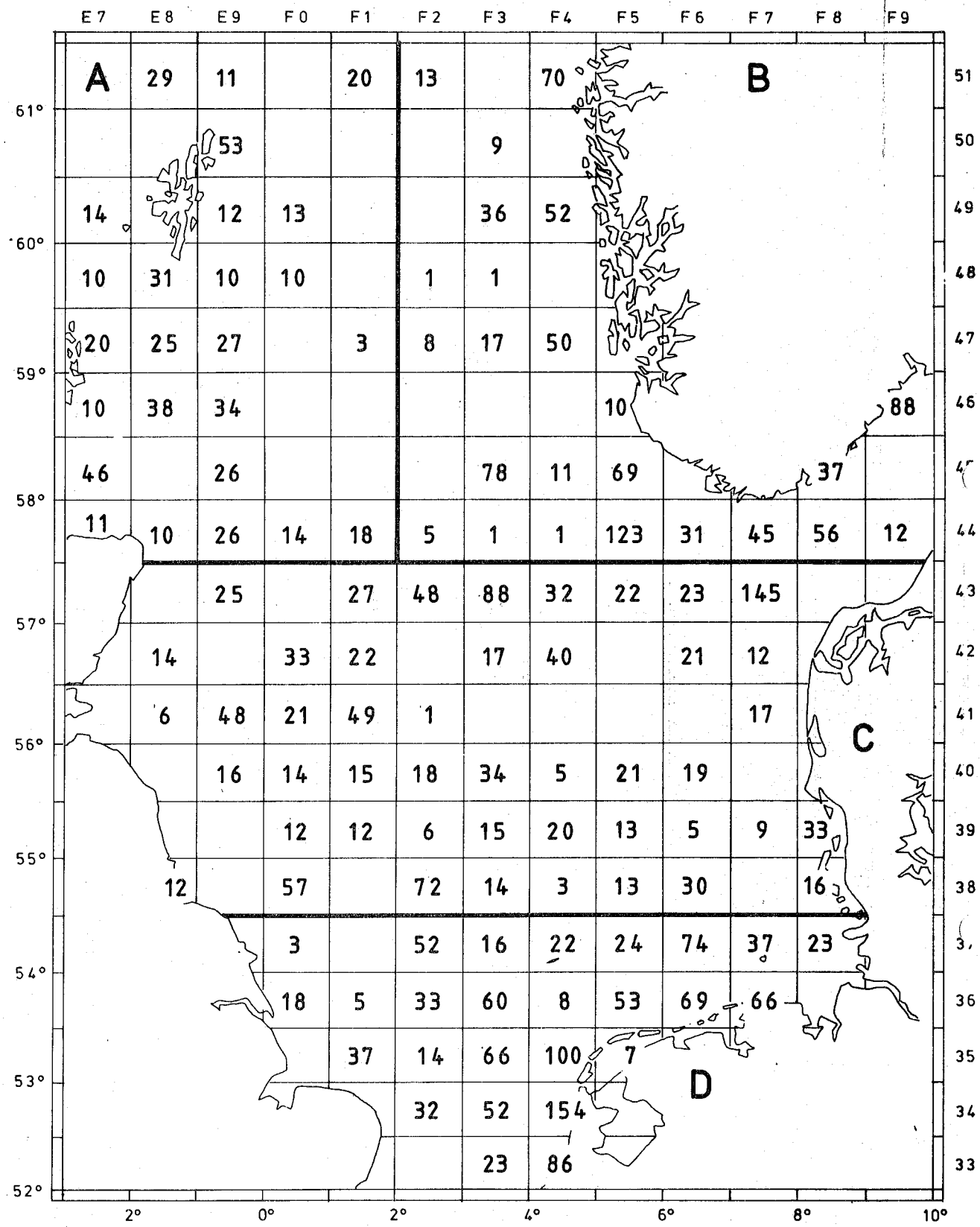

Fig. 1. Total number of mackerel stomachs sampled in different areas of the North Sea in 1981-82. A = northwestern North Sea, B = north-eastern North Sea, C = central North Sea and D = southern North Sea.

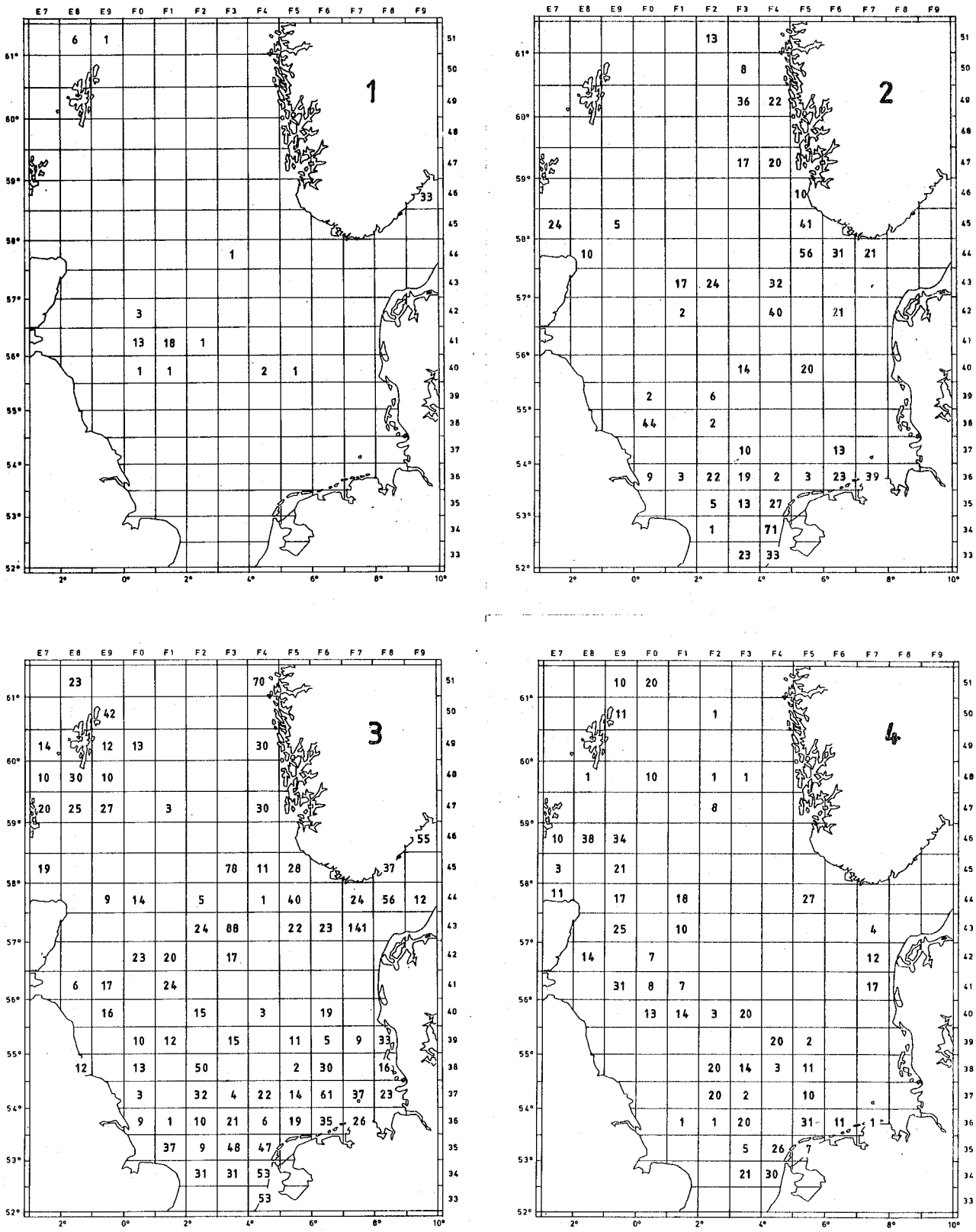

Fig. 2. Number of mackerel stomachs sampled in the North Sea in 1981-1982 by quarter and ICES statistical rectangle.

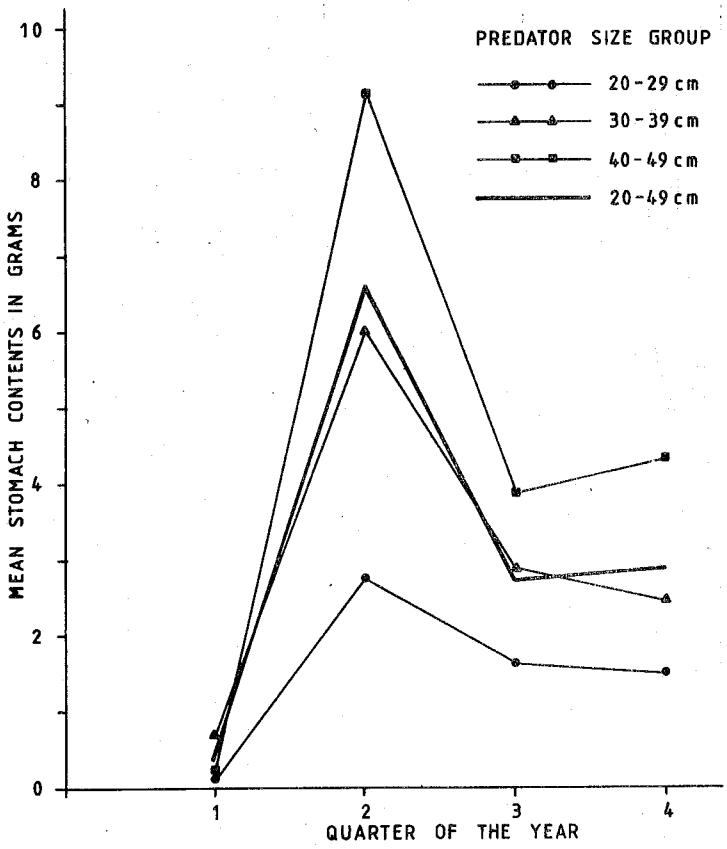

Fig. 3. Average stomach content weight for different size groups of mackerel by quarter.

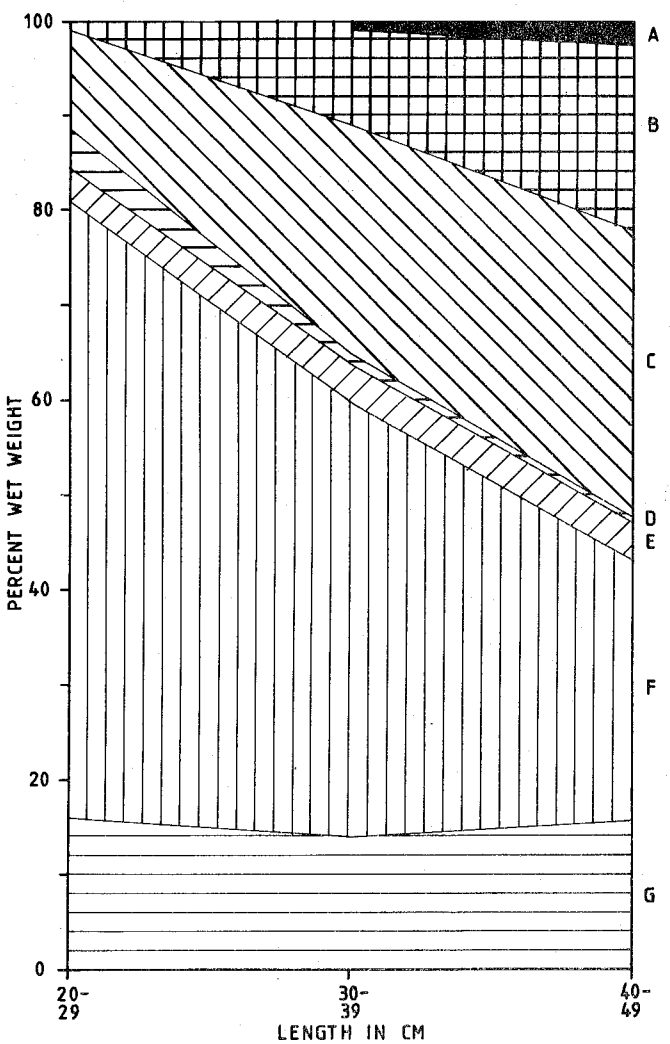

Fig. 4. Percent wet weight of different prey categories in the stomach content of mackerel caught by bottom trawl in Q3. A = fish 15-19 cm, B = fish 10-14 cm, C = fish 5-9 cm, D = fish 0-4 cm, E = fish unknown size, F = other prey species, G = unidentified.

Appendix I

Phaeophycea
Phaeophyceae fucales
Fucaceae
Rhodophyceae
Anthophyta i
Cnidaria
Hydrozoa
Physophora hydrostatica
Cerianthiaria
Polychaeta
Aphrodite aculeata
Nereidae
Nereis pelagica
Nereis virens
Gastropoda
Clione limacina
Bivalvia
Cardiidae
Cephalopoda
Theuthidida
Alloteuthis subulata
Crustacea
Cladocera
Copepoda
Calanoida
Calanus finmarchicus
Temoridae
Cyclopoida
Mysida
Mysidae
Amphipoda
Hyperiidae
Parathemisto
Euphausiidae
Meganyctiphanes norvegica
Thysanoessa
Thysanoessa inermis
Thysanoessa raschii
Caridea
Pandalidae
Crangonidae
Paguridae
Brachyura
Portunidae
Diptera
Cheilostomata
Ophiuroidea
Echinozoa
Urochordata
Salpidae
Oikopleuridae
Teleostei
Clupeidae
Clupea harengus
Clupea sprattus
Maurolicus muelleri
Gadidae
Gadus morhua
Melanogrammus aeglefinus
Trisopterus esmarkii
Syngnathus rostellatus
Trachurus trachurus
Trachinus vipera
Ammodytidae
Callionymus lyra
Scomber scombrus, eggs
Pleuronectiformes
Limanda limanda

Fiskeridirektoratet
Biblioteket

Appendix II

```
C ** CONSUMPTION **
C
      DIMENSION F(2,4,4),R(8,4,4,5,10),WMEAN(8,4,4),XN(8,2,4,4)
      DIMENSION C(8,5,10)
      COMMON F,R,WMEAN,XN
C
C     F(M,L,K)          = RATE OF DIGESTION (1/HR)
C     R(N,L,K,I,J)      = PROPORTION OF DIET
C     WMEAN(N,L,K)      = MEAN WEIGHT OF STOMACH CONTENT (GRAMS)
C     XN(N,M,L,K)       = NUMBER OF INDIVIDUALS
C     C(N,J,I)          = CONSUMPTION IN TONNES
C     I                 = PREY "SPECIES" NUMBER (I = 1 - 10)
C     J                 = PREY SIZE GROUP NUMBER (J = 1 - 5)
C     K                 = AREA NUMBER (K = 1 - 4)
C     L                 = QUARTER OF THE YEAR (L = 1 - 4)
C     M                 = POSITION IN WATER COLUMN(1=PELAGIC,2=BOTTOM)
C     N                 = AGE GROUP OF PREDATOR(N = 1 - 8(+))
C
      OPEN (6,FILE='L-P-2',ACCESS='W')
      XCONST = 0.01*24.*(365./4.)*0.000001*1000000.0
      DO FOR N = 1,8
         DO FOR J = 1,5
            DO FOR I = 1,10
               C(N,J,I) = 0.
               DO FOR M = 1,2
                  DO FOR L = 1,4
                     DO FOR K = 1,4
                        C(N,J,I) = C(N,J,I) + F(M,L,K)*WMEAN(N,L,K)
     &                                 *XN(N,M,L,K)*R(N,L,K,J,I)*XCONST
                     ENDDO
                  ENDDO
               ENDDO
            ENDDO
         ENDDO
      ENDDO
      DO FOR I = 1,10
         WRITE(6,990)
  990    FORMAT(1H1)
         DO FOR N = 1,8
            WRITE(6,1000) N,(C(N,J,I),J=1,5)
 1000       FORMAT(/,1X,I2,5F12.1)
         ENDDO
         SUM = 0.
         DO FOR N = 1,8
            DO FOR J = 1,5
               SUM = SUM + C(N,J,I)
            ENDDO
         ENDDO
         WRITE(6,1001) I,SUM
 1001    FORMAT(//,' TOTAL CONSUMPTION OF SPECIES',I3,' :',F12.1)
      ENDDO
      SUM = 0.
      DO FOR N = 1,8
         DO FOR J = 1,5
            DO FOR I = 1,10
            SUM = SUM + C(N,J,I)
            ENDDO
         ENDDO
      ENDDO
      WRITE(6,1010) SUM
 1010 FORMAT(//,' TOTAL CONSUMPTION',1X,F15.2)
      END
```