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Seasonal predation by flounder (*Platichthys flesus* (L.)) in the deeper parts of Kiel Bay

by

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Abstract

As part of an extensive investigation into the food of demersal fish in the Kiel Bay Abra alba community, the guts of 1170 flounders (Platichthys flesus (L.)) were examined. The percentage of empty guts was very high (75.8%). The food consisted mainly of small crustaceans, with Diastylis rathkei holding a share by weight of 35.8% of the identifiable gut contents, and of polychaetes. An estimate of the amount of flounders feeding in the trawl path shows that in 1971 predation on macrobenthos was strongest during and shortly after spawning despite the fact that the percentage of empty guts is highest at this time as well. The total amount of macrobenthos consumed by flounders in the deeper parts of Kiel Bay is rather insignificant as compared with that taken by other demersal fish like cod and dab.

Introduction

The flounder (Platichthys flesus (L.)) is one of the commercially important demersal fish species in the western Baltic. Its biology and population dynamics have recently been studied by Muus (1967) and Saeger (1974), showing that except for the spawning season when large amounts of sexually mature fish seek for the deeper areas the flounder is basically a shallow water species. For this reason catches in summer and autumn are nearly exclusively based on fishing by trammel nets. The number of flounders caught by trawling in areas >18 m depth is very small during this period.

The present investigation is part of a comprehensive study on the availability and production of macrobenthic food in the Abra alba community of Kiel Bay and the utilization of this food by demersal fish (Arntz & Brunswig, 1975; Arntz, in press). The food of dab (Arntz, 1971) and of cod (Arntz, 1974; 1977) have been published; similar studies on the food of plaice, whiting and gobies are under way.

The aim of this paper is to find out whether the large arounts of flounders present in the deeper Kiel Bay in late winter and spring and the few specimens found during summer and autumn feed on benthos at all, and to assess their predatory importance in relation to the other demersal fish inhabiting the area.

Material and methods

Trawling in 6 areas of Kiel Bay (Boknis Eck, Dorschmulde, Vejsnäs Rinne, Millionenviertel, Süderfahrt, Hohwachter Bucht - cf. Arntz, 1974) with a water depth ranging from 18 to 35 m was carried out monthly during the period January 1971 to March 1972. No fishing could be undertaken in February and September 1971. Of the 215.5 1-hour hauls in 1971/72, 29.5 hours fell within two "24 hour fishings" (13.5 resp. 16 hauls within 24 hours) in March 1971 and January 1972 (Vejsnäs Rinne); an additional 24 hour fishing (12 hauls) was carried out in April 1975. In each case, an 80 ft groundtrawl with a standard trawl codend (12 mm meshes) was used from board the research vessels "Alkor" or "H. Wattenberg".

The total number of flounders caught was 1313 (Table 1). The catch per hour was low (< 10) from May 1971 to January 1972 and high during the spawning season, reaching peaks of 20.9 and 18.5 in March 1971 and 1972 respectively (Fig.1).

In total, 1170 flounder guts (Table 2) were sampled directly after hauling, preserved individually in 11% Formalin and later on sorted in the laboratory. Numbers and wet weight of the different food species were determined separately for stomach and midgut but the contents are lumped together in this paper as "gut contents". In some cases, the exact number - especially of bivalves - could not be determined because the fish had chewed their food beyond identification.

The material is split up into 4 size groups, ≤ 20 cm, 21-25 cm, 26-30 cm and > 30 cm. The respective percentages for these groups were 1.4, 23.6, 37.4 and 37.6%. Thus according to Saeger's (1974) age data, the majority of the flounders treated in this paper belong to age groups II-IV.

Results

1. Percentage of empty guts

Of the 1114 flounders examined in 1971/72, 844 (75.8%) had not fed at all, i.e. the three parts of the gut were completely empty. The percentage of empty flounders varies considerably throughout the year (Fig.1): It was 0% from June to October, between 40-60% in May, November/December and in January 1971, and $> 70\%$, with a maximum around 95% in January/February 1975, shortly before, during and shortly after the spawning season. The rate of empty guts

increased with the size of the fish. It was 58.3% in flounders ≤ 20 cm (in the following referred to as "size group I"), 69.7% in flounders 21-25 cm ("size group II"), and 72.0% resp. 84.4% in size groups III and IV. There are also differences between the 6 trawling areas, with only 61% empty in Millionenviertel und 93% in Boknis. Eck; these figures are, however, somewhat misleading since the material for the different areas is not equally distributed over the seasons.
Of the 326 flounders which had fed only 242 (20.7% of the total catch) had identifiable contents in their stomach or midgut. On these 242 specimens the following analysis of the food is based.

2. Composition of food

Compared with other demersal fish in the deeper Kiel Bay, flounders have a fairly wide food spectrum as can be seen from Tables 3 and 4. On the other hand, the number of really important food species is rather small. By far the most important food item is the cumacean Diastylis rathkei which is also the main food for dab and juvenile cod (Arntz, 1971, 1774). Surprisingly high is the amount of priapulids (mostly Halicryptus spinulosus) and of the polychaete Terebellides stroemi which - despite its abundance - does not play an important role in the food of dab and cod. Other major food species include the bivalve Abra alba, the polychaetes Nephthys spp., Pectinaria koreni and - to a lesser degree - Capitella capitata and Harmothoe sarsi. The latter is most abundant in summer and autumn when it is taken in large numbers by cod and dab; but during this time flounders, as shown in Fig.1, are rare.
Diastylis is also the most important food in terms of incidence frequency, being eaten by 80.6% of all flounders containing food. It is followed by Abra alba, Pectinaria koreni, Terebellides stroemi, priapulids and Nephthys (Table 3).
In terms of weight, crustaceans provided the largest share (36.3%) of the identifiable stomach contents. Polychaetes were the second important group (33.2%). Priapulids provided 19.0%, molluscs - bivalves only - 10.3%. Other groups (fish and nemerteans), with 1.2%, do not play a significant part. (All figures are means for flounders > 20 cm in length; size group I was excluded because the share of these fish was very small).

With increasing size of the flounder, the share by weight of crustaceans decreases, while that of molluscs and priapulids increases (Fig.2). The share of polychaetes as a whole does not show any significant changes although there are differences in the individual species (cf. Table 5). In the case of molluscs and crustaceans only one species (Abra, Diastylis) is responsible for this shifting in the diet (Table 5).
Again for the whole material excl. size group I, Diastylis (35.8%), priapulids(19.0%) and Terebellides (13.9%) provide over two-thirds of the weight of the identifiable gut contents. The six most important species , including Abra (7.9%), Nephthys (5.5%) and Pectinaria (4.0%), provide 86.1% of the flounders' food.

3. Seasonal and diel aspects

Unlike the other demersal fish investigated so far, flounders in the deeper parts of Kiel Bay do not exhibit a very distinct seasonality in the composition of their food. As can be seen from Table 3, most food items seem to be taken throughout the different seasons without a particular pattern. Table 6 gives the average weight of certain species per gut containing these forms in the first quarter as opposed to the rest of the year. For the three most important food items there is no difference; on the other hand there is quite a clear increase for certain bivalves and polychaetes. Because of the material being so scanty it is not possible, however, to follow up the percentage of the more important food species through individual months or seasons as was done for cod and dab.
Another question is the relative seasonal importance of flounders for the predation on macrobenthos available in the Abra alba community. For this purpose, the number of fish containing food (Table 7) was calculated from the data used in Fig.1. It turns out that, according to the season, the number of flounders caught feeding in the trawl's path - i.e. in an area about 10 m x 3 miles wide - varies between 0.1 and 5.0. The real numbers may be twice as high if a 50% efficiency of the trawl is assured. In addition, the flounders might digest their food more rapidly during the warm season as has been shown by de Groot (1971), thus increasing the relative importance of the few specimens in the Abra alba community in summer (see below).

Although three 24 hour fishings were carried out, it was not possible to come to any conclusions about the diel rhythm of feeding in "deep" water and about the diel rate of food intake like in former studies on plaice (Hempel, 1964), dab (Arntz, 1971) and cod (Arntz, 1974). In two cases, the number of fish per haul was insufficient, and in the Vejsnäs Rinne trawling in March 1971 when a large number of fish was caught 81% were empty, and the rest kept a consistantly low gut filling around 0.2 g throughout the fishing. Anglers in shallow water of Kiel Bay report that flounders feed twice a day, at about sunrise and sunset. Since this tallies with Muus' (1967) and de Groot's (1971) findings and with our own data for Kiel Bay dab, we may assume that the basic feeding rhythm of flounders in deeper water may be similar. The amount of food taken per day must be smaller than in dab since guts of flounders from deeper water contain in general much less food than those of dab of the same size.

4. Estimate of the amount of macrobenthos consumed by flounders

Assuming a 50% trawl efficiency and a summer (June-October) feeding rate twice as high as in winter, i.e. a diel food consumption of 1% of body weight during the winter and 2% during the summer for those flounders which are feeding in the Abra alba community, the amount of food taken in the trawl path can be estimated for the two seasons. As "body weight", for this rough calculation a mean value of 200 g per flounder is used. This value takes into account the length composition of the flounders containing food in 1971 and the different K values for males and females as given by Saeger (1974).

The "true" mean number of flounders in the trawl path (cf. Table 7) was then 1.3 during the "summer" months June-October and 5.3 in "winter" 1971 (rest of the year). With the 2% resp. 1% of body weight diel feeding rates, the monthly amount of macrobenthos taken by flounders in the trawl path is 5.2 g (wet weight) in summer and 10.6 g in winter, or roughly 100 g during the year 1971.

Conclusions

The present investigation shows that the food of flounders in the deeper parts of Kiel Bay, like that of juvenile cod and dab, is based nearly exclusively on macrobenthos. Food coincidence with the other demersal fish species is high if the taxonomic groups are considered and in the case of Diastylis rathkei as the common primary food item. On the other hand priapulids and Terebellides stroemi are an important food for flounders but only of secondary importance for other demersal fish. Surprisingly low was the share taken by bivalves which according to Blegvad (1916), Hertling (1928) and Mulicki (1947) are normally among the main food items. This is true for Kiel Bay shallow waters where flounders take Mytilus in large amounts (own samples, unpubl.).

Probably the clue to the feeding biology of flounders in the Abra alba community has to be sought in the fact that these fish are only guests in this area which have come there to spawn rather than for feeding. This also explains the lack of a clear seasonality in food intake which has been described for flounders in other areas (Mulicki, 1947; Moore & Moore, 1976), and the apparent lack of a diel rhythm of feeding in deeper water.

The impact of flounders on macrobenthos in the area investigated is almost negligible. As pointed out above, in 1971 it was highest during the spawning period in spite of the high percentage of empty guts, but the 1972 spring samples show that the number of flounders feeding at this time of the year can be much lower. The 100 g macrobenthos consumed in 1971 on the trawl path ($\hat{=}$ 55,000m^2) corresponds to the annual minimum production on 1 m^2 as estimated by Arntz & Brunswig (1975). Thus flounders consume 0.002% of the macrobenthic production in the Abra alba community - indeed not a very severe predation.

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Table 1 Number of hauls carried out in 1971/72 and total number of flounders caught (whole Kiel Bay)

Month	I.71	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I.72	II	III	IV.75	Σ
Number of 1-hour hauls	8	No sampling	25	13.5	39	17	4	20	No sampling	16	7	15	29	11	11	12	227.5
Number of flounders caught	74		522	239	60	18	6	5		2	2	16	56	54	203	56	1313

Table 2 Number of flounder puts investigated according to trawling areas and months (n = 1170)

Month	Boknis Eck	Dorschmulde	Vejsnäs Rinne	Millionenviertel	Süderfahrt	Hohwachter Bucht
I.71	-	15	1	15	-	43
III	43	26	253^{+++}	33	24	34
IV	29	34	39	18	26	59
V	-	-	-	57	1	2
VI	1	1	8	1	6	1
VII	-	-	-	4	2	-
VIII	-$^{++}$	-$^{++}$	-$^{++}$	5	-	-$^{++}$
X	-$^{++}$	-$^{++}$	-$^{++}$	-$^{++}$	2	-$^{++}$
XI	2	-$^{++}$	-$^{++}$	-$^{+}$	-$^{++}$	-
XII	4	5	2	1	1	3
I.72	11	8	15^{+++}	14	5	3
II	11	10	12	3	1	17
III	52	23	54	34	18	22
IV.75	-	-	-	56^{+++}	-	-

$^{+}$No trawling $^{++}$No flounders in the haul(s) $^{+++}$24 hour fishing

Table 3 Platichthys flesus (L.): More important benthic food species+ during the investigation period I. 1971-III.1972 (all trawling areas)

Food species	Months I-III			IV-VI			VII-XII			Whole period			
	N° of guts with identifiable contents 147			80			15			242			
	N° of fish +	n	g	N° of fish +	n	g	N° of fish +	n	g	N° of fish +	% inc. frequency	∑ n	∑ g
Abra alba	35	118+	9.85	23	98+	13.07	11	68	5.75	69	28.5	284+	28.67
Macoma baltica	-	-	-	1	20+	0.90	1	+	0.75	2	0.8	20+	1.65
Harmothoe sarsi	7	19	0.63	6	50	2.44	-	-	-	13	5.4	69	3.07
Nephthys spp.	10	20	0.95	19	68+	16.39	4	12	3.24	33	13.6	100+	20.58
Capitella capitata	13	589+	4.26	-	-	-	2	7+	2.11	15	6.2	596+	6.37
Pectinaria koreni	33	189	3.47	13	195	7.05	1	1	0.04	47	19.4	385	10.56
Terebellides stroemi	13	249+	10.27	17	347+	10.96	9	451	12.74	39	16.1	1047	33.97
Microdeutopus gryllotalpa	-	-	-	5	55	0.13	-	-	-	5	2.1	55	0.13
Corophium spp.	1	40	0.37	1	14	0.03	-	-	-	2	0.8	54	0.40
Diastylis rathkei	105	6321+	84.70	77	3716	56.75	13	1153	11.74	195	80.6	11,190+	153.19
Gastrosaccus spinifer	10	18	0.23	5	8	0.09	-	-	-	15	6.2	26	0.32
Priapulids	29	215	34.86	5	16	5.65	2	9	2.38	36	14.9	240	42.89

+Only species which occured in > 20 specimens

Table 4 Less important food species of flounder in Kiel Bay (whole investigation period)

Mollusca	n	Polychaeta	n	Crustacea	n	Others	n
Nucula tenuis	1	Harmothoe imbricata	1	Idotea spp.	1	Nemertini	1
Musculus niger	3	Pholoe minuta	1	Amphipoda undet.	1	Ophiura albida	1
Mytilus edulis	2	Scoloplos armiger	1			Ascidians	4
Montacuta bidentata	5	Pherusa plumosa	1			Pomatoschistus minutus	1
Cardium fasciatum	8	Amphicteis gunneri	6			Clupeid	1
Cyprina islandica (juv.)	15	Euchone papillosa	5			Undet.fish (rem.)	3
Macoma calcarea	3						
Phaxas pellucidus	9						
Saxicava arctica	1						
Aloidis gibba	5						
Siphon	1						

Table 5 Size-dependent share of some important food species in the food of Kiel Bay flounder (all trawling areas; values = % of ident. gut contents)

Size group	Abra	Diastylis	Priapulids	Nephthys	Pectinaria	Terebellides	
≤20 cm+	1.2	59.1	0	0	0.2	0	+ only in 3 trawling areas
21-25 cm	4.4	55.4	6.1	1.4	5.2	10.4	
26-30 cm	8.9	33.1	17.5	8.2	3.3	19.0	
>30 cm	10.5	18.9	33.4	7.0	3.4	12.2	

Table 6 Average weight of more important food species per flounder + in the first quarter and the rest of the year

Species	1st quarter Ø g	2nd-4th quarter Ø g
Abra alba	0.3	0.6
Macoma baltica	0.0	0.8
Harmothoe sarsi	0.1	0.4
Nephthys spp.	0.1	0.9
Capitella capitata	0.3	1.1
Pectinaria koreni	0.1	0.5
Terebellides stroemi	0.8	0.9
Diastylis rathkei	0.8	0.8
Priapulids	1.2	1.2

Table 7 Flounders per 1 hour trawling with guts containing food (calculated from Fig.1)

Month	I.71	III	IV	V	VI	VII	VIII	X	XI	XII	I.72	II	III
Flounders containing food (n/hr)	4.3	5.0	3.2	0.9	1.1	1.5	0.3	0.1	0.1	0.5	0.5	0.3	0.7
n/hr when assuming 50% efficiency of the trawl	8.6	10.0	6.4	1.8	2.2	3.0	0.6	0.2	0.2	1.0	1.0	0.6	1.4

II (9.3)

IX (0.4)

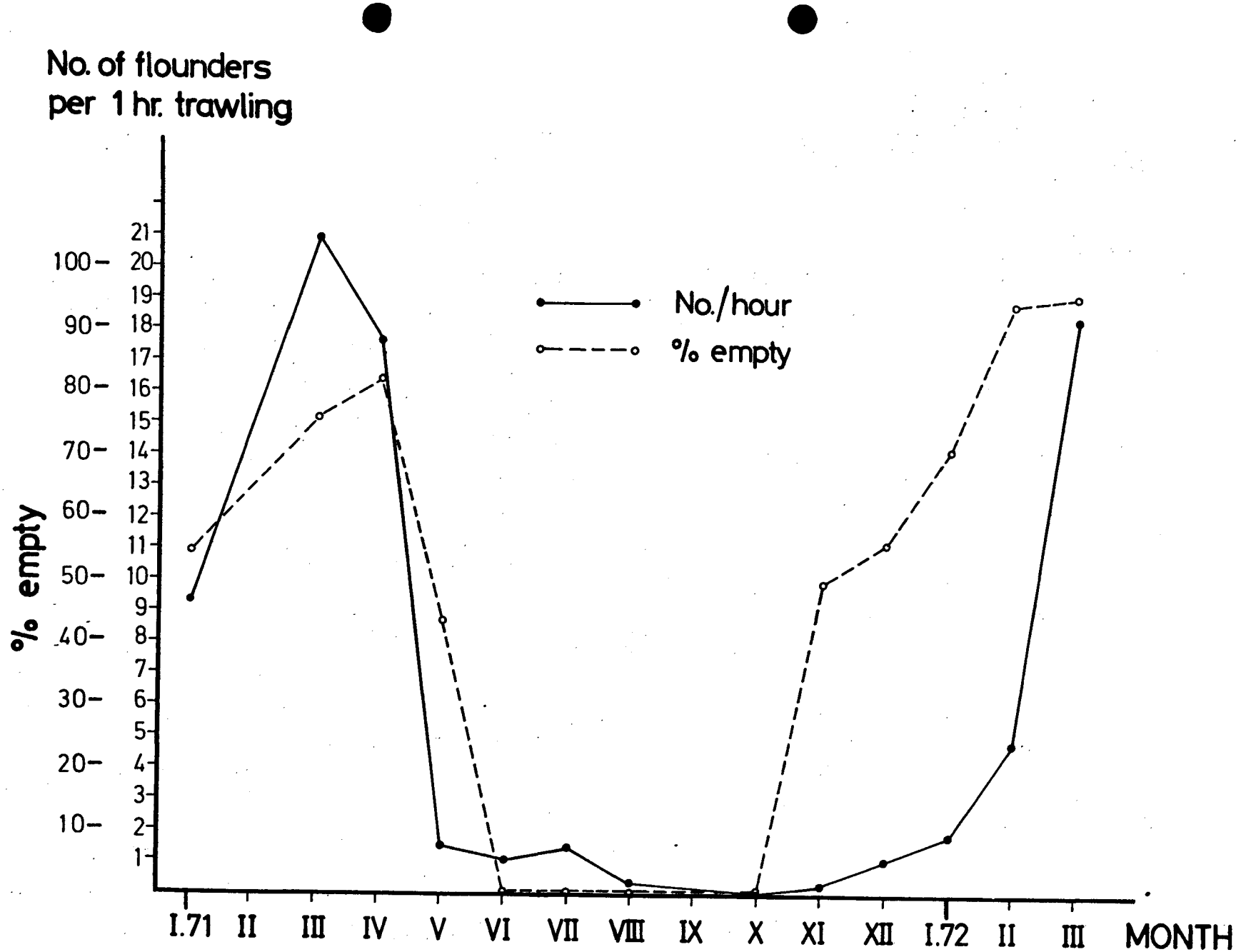

Fig. 1: Catch of flounders per 1 hour trawling and percentage of empty guts during the 1971/72 investigation period. All areas; total number of hauls: 215.5; total number of flounders caught: 1257; number of flounders examined: 1114.

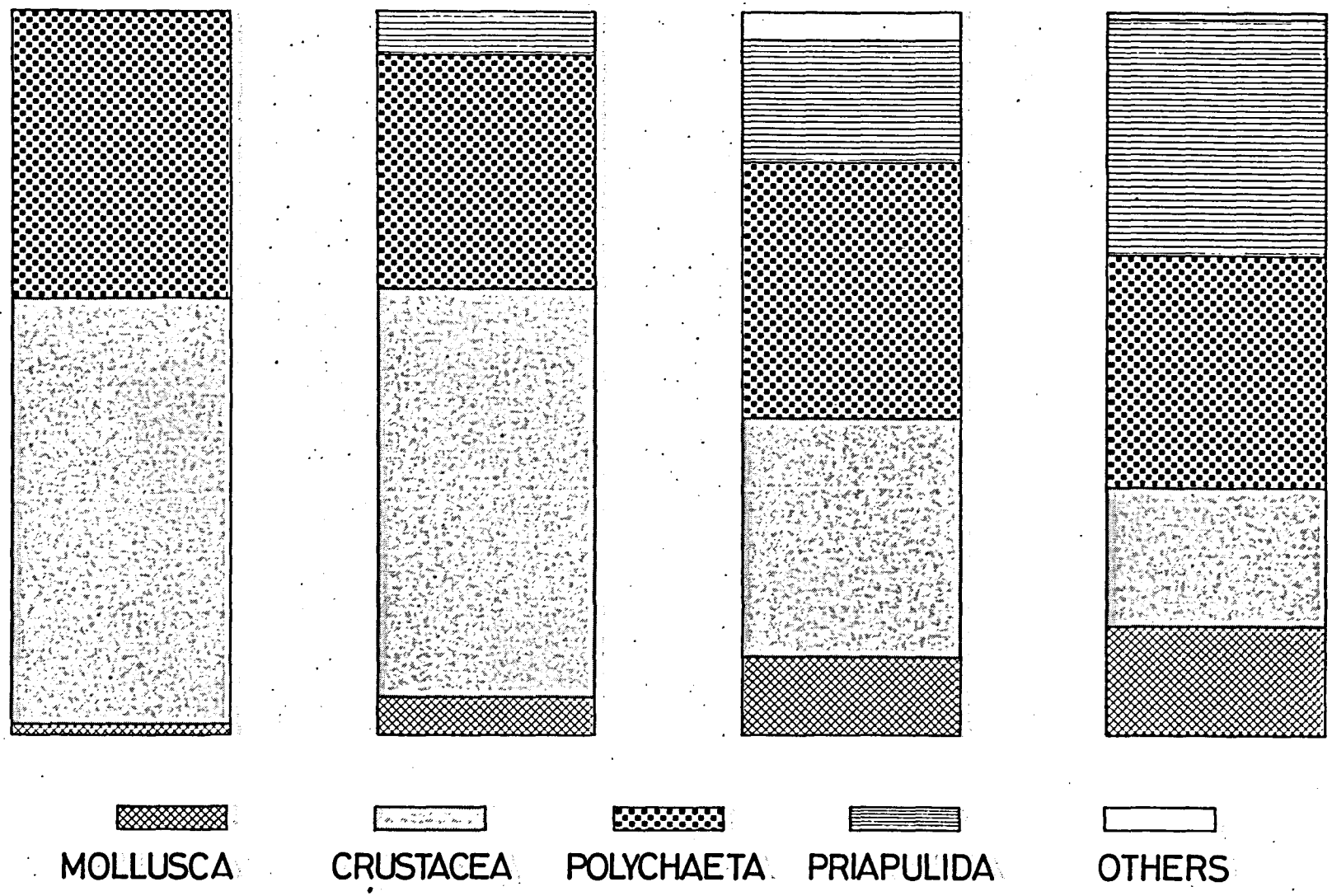

Fig.2: Size-dependent share by weight of the more important taxonomic groups in the food of Kiel Bay flounder. Whole investigation period; all trawling areas.