ACTA ICHTHYOLOGICA ET PISCATORIA
Vol. XX, Fasc. 1 Szczecin 1990

Iwona KOSTRZEWSKA-SZLAKOWSKA[1], *Jacek SZLAKOWSKI*[2]

Fish biology

SUMMER FOOD OF JUVENILE TURBOT, *PSETTA MAXIMA* (L.) AND FLOUNDER, *PLATICHTHYS FLESUS* (L.), AT ŚWIĘTOUŚĆ, POMERANIAN BAY

LETNI POKARM NARYBKU, *PSETTA MAXIMA* (L.) I STORNI. *PLATICHTHYS FLESUS* (L.) Z REJONU ŚWIĘTOUŚCIA, ZATOKA POMORSKA

[1] Institute of Ecology, Polish Academy of Sciences, Dziekanów Leśny
[2] Institute of Zoology, Polish Academy of Sciences, Warszawa

Summer food of 0-and I-age group turbot and flounder utilizing shallow, inshore nursery ground at Świętouść, Pomeranian Bay were examined. Juvenile turbot fed mostly on mysid. *Neomysis integer*, Pisces and *Crangon crangon*. Amphipod *Bathyporeia pilosa* was ot little importance. Juvenile flounder fed on polychaete, *Nereis diversicolor*, and amphipod *Bathyporeia pilosa* and *Gammarus spp.* Tiny bottom-stages of Mollusca were of minor importance. Shifts in diet preferences as a function of fish size were observed in both species. Owing to differences in diet composition practically no diet-overlap was found between larger turbot and flounder, from age group I. Between O-group fish, of these species, diet-overlap high as 36% for two food items shared, *Calanoida* and *Bathyporeic pilosa*, occurred.

INTRODUCTION

Two species of pleuronectiform fishes turbot, *Psetta maxima* and flounder, *Platichthys flesus*, utilise the shallow, inshore nursery ground at Świętouść, Pomeranian Bay, as a site of benthic recruitment, early growth and intensive feeding.

The flounder, *Platichthys flesus* (L.), is the most abundant and the most commercially important flatfish dwelling in southern Baltic. Therefore the biology of this species, as well the food and feeding habits of adult and young fish are fairly good known.

Feeding of flounder in the Baltic Sea was studied by Hertling (1928), Hessle (1930), Blegvad (1932), Mulicki (1947), Bokova (1954), Żeltenkova (1954), Müller (1968), Szypuła and Załachowski (1978).

Little is known, however, of the feedning of the turbot, *Psetta maxima* (L.). Only mentioned above, Hertling (1928) and Müller (1968) provided some data on the food of this fish.

The purpose of this paper was to examine and compare the prey composition in stomach contents, and its changes during the growth of juvenile turbot and flounder, age groups 0 and I, dwelling together in shallow, inshore nursery ground at Świętouść, Pomeranian Bay.

MATERIALS AND METHODS

Juvenile turbot were sampled in July 1982 and 1983 at Świętouść, Pomeranian Bay (Fig. 1). Some additional samples were taken in August/September 1984 and May 1985. Juvenile flounder were collected only in July 1983. Total materials yielded in 313 specimens of turbot and 197 of flounder for food studies.

Juvenile flatfish were sampled with a 67x75 cm hand push-net, which had a mesh size 7 mm, at depths approximately from 0.1 to 1 m.

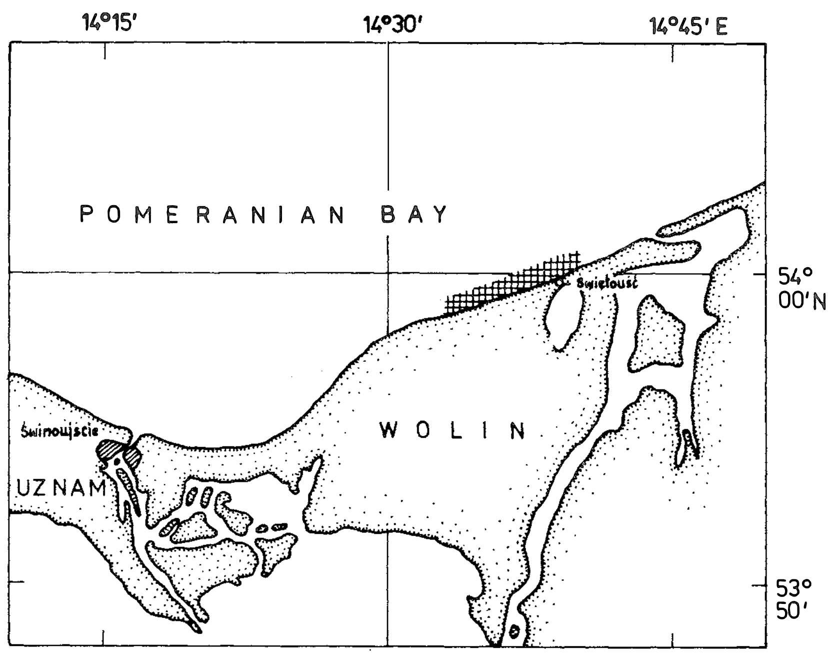

Fig. 1. Sampling area for juvenile turbot and flounder at Świętouść. Pomeranian Bay in 1982–85 yrs.

Fish were preserved in 4% formalin in sea water and all subsequant analyses took places in the laboratory (in 1983 fish were measured and weighted before preservation). In the laboratory fish were measured to the millimetre below and weighted to 1 mg. Stomach contents of turbot and whole digestive tract contents of flounder were examined under binocular microscope. All food items were sorted and identified to the lowest possible taxon, then counted, measured to 0.1 mm and after removal of excess liquid on filter paper weighted to 1 mg. For the analyses of prey composition in the diet and dietary changes with size, fish were grouped into 1 cm length classes.

The importance of each prey group in the diet of flatfish was evaluated according to it percentages by frequency of occurrence (%F) and percentages by weight (%W; weights were reconstructed from weight standards, calculated by the authors or based on nomograms given by Czislenko, 1968). The percentages by number (%N) was only used for computing two feeding indices for each prey item:

IRI=index of relative importance (Pinkas et al., 1971)=(%N+%W)x%F and

MFI = main food item (Zander, 1982) = $\sqrt{((\%N+\%F)/2)x\%W)}$.

IRI stresses the frequency of occurrence, whereas MFI stresses the percentages by weight. In this paper these indices were expressed in percentages (%IRI, %MFI) to make comparison easier.

Diet overlap between turbot and flounder was calculated according to Shorygin (1952) by summing the smaller values, in this case the percentage of weights, for all prey items shared by the two species.

Accordingly:

$$D.O. = \sum_{i=1}^{n} \min(a,b)$$

where: D.O. = diet overlap (in %),

a = percentage weight of a given prey item in the diet of species A,

b = percentage weight of the same prey item in the diet of species B,

n = total number of prey items.

RESULTS

Prey composition.

Psetta maxima. The stomach contents of juvenile turbot consisted of six components (Table 1., Fig. 2):

1. Calanoid copepodite – *Acartia spp., Pseudocalanus spp., Temora spp..*
2. Amphipod – *Bathyporeia pilosa.*
3. Mysid – *Neomysis integer.*
4. Decapod – *Crangon crangon.*
5. Pisces – *Pomatoschistus microps, P. minutus, Ammodytes tobianus, Lucioperca lucioperca* (juv.), *Platichthys flesus* (juv.).

Table 1

Psetta maxima. Prey composition by length classes. %W: % weight %F; % frequency of occurrence; %N: % number; %IRI, %MFI: percentage values of feeding indices of prey categories

Prey	I	Length class (cm)									
		2.0–2.9	3.0–3.9	4.0–4.9	5.0–5.9	6.0–6.9	7.0–7.9	8.0–8.9	9.0–9.9	10.0-10.9	11.0-11.9
Calanoida	%F	22.9	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	%W	18.6	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	%N	89.7	66.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	%IRI	33.3	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	%MFI	32.6	10.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bythyporeia pilosa	%F	70.5	86.9	60.0	33.3	28.6	16.7	16.7	9.1	0.0	0.0
	%W	56.8	29.2	10.8	3.9	3.2	1.1	1.5	6.0	0.0	0.0
	%N	7.0	20.0	70.8	8.8	4.9	3.1	1.6	12.7	0.0	0.0
	%IRI	60.4	76.1	68.0	3.8	1.7	0.4	0.3	1.7	0.0	0.0
	%FMI	48.0	50.6	38.6	9.1	7.2	2.9	3.9	7.4	0.0	0.0
Neomysis integer	%F	21.0	25.0	20.0	66.7	71.4	100.0	83.3	63.6	70.0	83.3
	%W	18.0	7.3	1.9	46.8	96.8	98.9	95.8	40.1	55.9	29.2
	%N	3.2	12.5	19.4	88.8	95.1	96.9	98.1	81.8	95.6	96.4
	%IRI	6.0	8.8	5.9	80.7	98.3	99.6	99.4	75.5	79.8	78.2
	%MFI	15.3	15.2	8.6	60.6	92.8	97.1	91.2	50.0	61.8	50.5
Crangon crangon	%F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.3	20.0	16.9
	%W	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.6	4.6	22.0
	%N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.9	2.0
	%IRI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.8	3.0
	%MFI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.9	6.4	13.9
Pisces	%F	2.9	10.0	20.0	33.3	0.0	0.0	16.7	45.5	60.0	50.0
	%W	5.7	60.7	84.7	49.3	0.0	0.0	2.7	37.9	39.5	48.8
	%N	0.1	0.5	5.6	3.0	0.0	0.0	0.3	3.2	3.5	1.6
	%IRI	0.2	10.9	25.1	15.5	0.0	0.0	0.3	18.2	19.4	18.8
	%MFI	3.1	22.8	47.1	30.3	0.0	0.0	4.9	27.8	31.8	35.6
Other	%F	0.9	3.3	10.0	0.0	0.0	0.0	0.0	9.9	0.0	0.0
	%W	0.9	1.0	2.6	0.0	0.0	0.0	0.0	0.4	0.0	0.0
	%N	0.02	0.2	4.2	0.0	0.0	0.0	0.0	0.9	0.0	0.0
	%IRI	0.01	0.07	0.9	0.0	0.0	0.0	0.0	0.1	0.0	0.1
	%MFI	1.0	1.3	5.7	0.0	0.0	0.0	0.0	0.9	0.0	0.0
No of stomachs examined	x	142	80	12	4	7	9	9	16	16	18
No of stomachs with prey	x	105	60	10	3	7	6	6	11	10	12

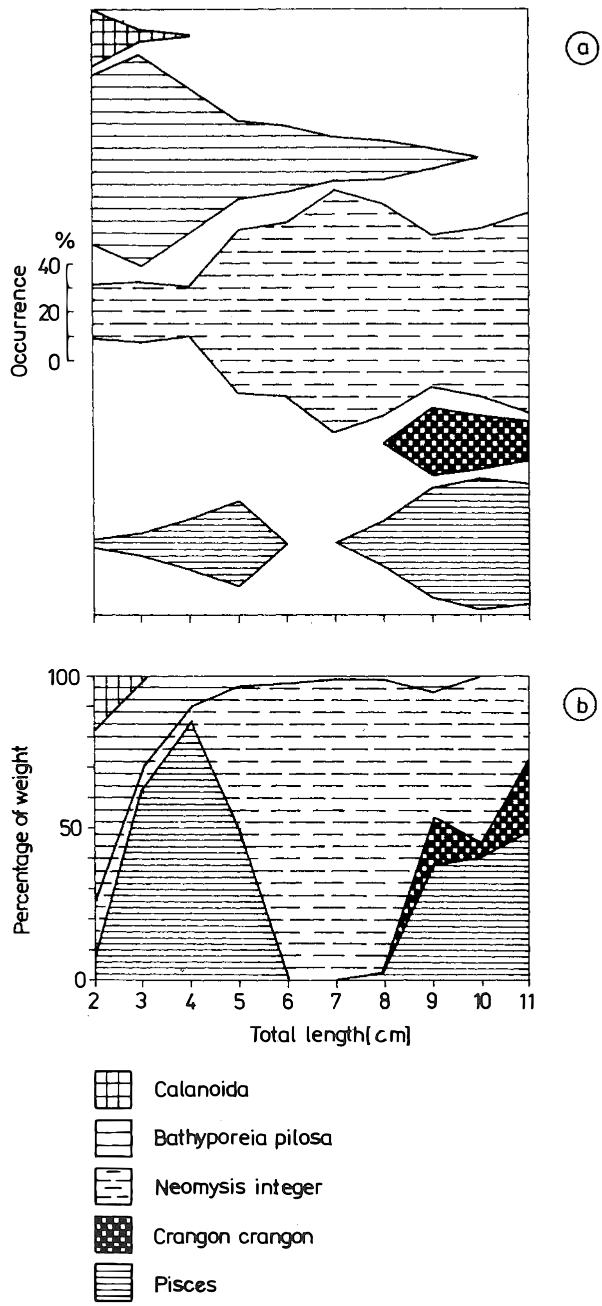

Fig. 2. ***Psetta maxima.*** **Prey composition by length classes.**
a: by frequency of occurrence (%F); b: by percentage of weight (%W).

6. Other – *Gammarus spp., Calliopius rathkei, Corophium volutator, Idotea spp.* (not included in Fig. 2).

Planctonic calanoids were founa only in stomachs of the smallest fish, from length classes 2.0–2.9 and 3.0–3.9 cm in length. Their importance in food were low, decreasing from 22.9 to 3.3% by frequency of occurrence and from 18.6 to 1.7% by weight.

Nectobenthic species *Bathyporeia pilosa* played an important role in food of turbot 2.0–4.9 cm in length, representing 60.0–86.7% by frequency of occurrence and 10.8–56.8% by weight. In larger (and older fish) the importance of this prey item fell down to 33.3–9.1% by frequency of occurrence and 1.1–6.0 by weight. In the food of fish larger than 10.0 cm *B. pilosa* was not found. Percentage frequency of occurrence and percentage by weight of this species decreased gradually with increasing of fish length.

The next nectobenthic species, mysid *Neomysis integer,* gradually replaced *B. pilosa* in the food of turbot. It was found in stomach of fish from all length classes. *N. integer* played an important role as a prey item both by percentage occurrence and by weight. In fish smaller than 4.9 cm in length it formed only 20–25% by frequency of occurrence and 1.9–18.0% by weight but in larger fish 60–100% by frequency of occurrence and 29.9–98.9% by weight.

The brown shrimp, *Crangon crangon,* was for the first time found in the stomachs of turbot longer than 9.0 cm. This species was the constant component of the food of large turbot, 9.0–11.9 cm in length (age group I), representing 16.7–27.3% by frequency of occurrence and 4.6–22.0% by weight.

Pisces were found in food of fish of nearly all length classes. The lack of this prey item in food of fish from length range 6.0–7.9 cm was caused rather by scarcity of data. *Pisces* occurred in the food of very early bottom-stages of turbot, just after metamorphose. The smallest turbot with "*Pisces*" prey item in stomach had 1.95 cm in length. In terms of weight *Pisces* formed the most important (49.3–84.7%) part of the diet of turbot of length 3,0–5.9 cm (age group 0) with frequency of occurrence 10.0–33.3%. In larger turbot, from length range 9.0–11.9 cm, *Pisces* represented 37.9–48.8% of the total stomach contents by weight with frequency of occurrence 45.5–60.0%.

The role of "Other prey" was negligible.

The differences between diet composition of 0-and I-age group turbot were observed (Table 2., Fig. 3). In food of 0-age group turbot the major role in diet played small crustaceans, like *Calanoida* (5.6% by weight and 13.5% by frequency of occurrence) and *B. pilosa* (30.4% by weight and 74.7% by frequency of occurence). *N. integer* formed 12.6% of total stomach contents by weight and 23.0% by frequency of occurrence. Surprisingly high share of *Pisces,* 50.2% by weight, compared with only 6.7% by frequency of occurrence is likely to be overestimated. The value of 10–20% by weight could have been more proper rather in this respect to. *C. crangon* was totally lacking in the diet of smaller fish. In food of I-age group turbot the most important groups of prey both by weight (47.1%), and by frequency of occurrence (76.8%) was *N. integer, Pisces* (38.2% by weight, and 34.6% by frequency of occurrence) and *C. crangon* (13.6% and 13.5% respectively). Calanoids were lacking in the diet of larger fish and importance of

Table 2

Psetta maxima. Comparison of prey composition between age group 0 and I.
Values used to calculate diet-overlap are underlined

Prey item	age group 0; n = 178 %W	%F	%N	%IRI	%MFI	age group I; n = 52 %W	%F	%N	%IRI	%MFI
Calanoids	5.6	13.5	82.5	23.5	20.0	0.0	0.0	0.0	0.0	0.0
B. pilosa	30.4	74.7	11.0	61.2	45.0	1.0	9.6	2.9	0.3	2.0
N. integer	12.6	23.0	6.1	8.5	17.5	47.1	76.9	94.3	87.1	62.4
C. crangon	0.0	0.0	0.0	0.0	0.0	13.6	13.5	1.0	1.6	9.8
Pisces	50.2	6.7	0.3	6.7	16.2	38.2	34.6	1.7	11.1	25.4
Other	1.2	2.2	0.1	0.01	1.2	0.06	1.9	0.1	0.002	0.2

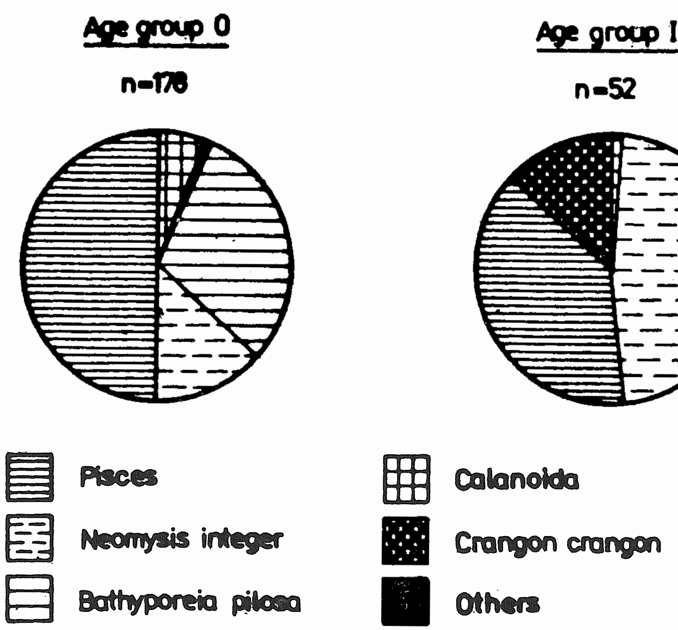

Fig. 3. *Psetta maxima.* Comparison of prey composition by percentage of weight of prey items in total stomach contents in age group 0 and I.

Table 3

Platichthys flesus. Prey composition by length classes. %W: % weight; %F: % frequency of occurrence; %N: % number; %IRI, %MFI: percentage values of feeding indices of prey categories

Prey		Length class (cm)						
		2.0–2.9	3.0–3.9	4.0–4.9	5.0–5.9	6.0–6.9	7.0–6.9	8.0–8.9
Calanoida	%F	0.0	79.2	44.8	23.8	2.3	11.1	0.0
	%W	0.0	47.6	1.9	0.1	0.08	0.14	0.0
	%N	0.0	95.6	22.6	9.7	1.7	5.9	0.0
	%IRI	0.0	77.5	10.9	3.9	0.04	0.7	0.0
	%MFI	0.0	59.8	10.1	1.7	0.1	0.4	0.0
Bythyporeia pilosa	%F	100.0	62.5	58.6	60.0	77.3	77.8	81.8
	%W	2.9	50.6	54.7	30.0	38.9	26.5	19.8
	%N	66.7	1.3	3.6	13.9	67.2	82.3	78.0
	%IRI	51.6	22.2	33.9	43.7	89.4	93.9	89.6
	%MFI	20.0	37.4	51.9	55.0	62.4	62.2	54.0
Gammarus spp.	%F	0.0	0.0	3.4	4.0	2.3	7.4	9.1
	%W	0.0	0.0	7.1	8.8	3.9	34.2	12.6
	%N	0.0	0.0	0.05	1.0	0.8	8.4	20.3
	%IRI	0.0	0.0	0.2	0.6	0.1	3.5	3.4
	%MFI	0.0	0.0	5.1	8.3	3.5	21.6	18.9
Nereis diversicolor	%F	50.0	0.0	3.4	4.0	4.5	3.7	9,1
	%W	97.1	0.0	31.1	58.4	46.5	37.8	67.5
	%N	33.3	0.0	0.05	0.1	0.3	0.4	1.2
	%IRI	48.4	0.0	1.0	3.9	2.3	1.6	7.0
	%FMI	80.0	0.0	8.9	18.3	12.9	12.2	25.7
Molusca	%F	0.0	8.3	69.0	38.1	22.7	7.4	0.0
	%W	0.0	1.8	5.2	1.1	7.8	1.0	0.0
	%N	0.0	3.1	73.7	74.5	22.7	2.7	0.0
	%IRI	0.0	0.3	54.0	47.8	7.6	0.3	0.0
	%MFI	0.0	2.8	24.0	13.3	15.3	2.7	0.0
Chironomidae	%F	0.0	0.0	0.0	4.0	4.5	0.0	9.1
	%W	0.0	0.0	0.0	0.9	1.8	0.0	0.1
	%N	0.0	0.0	0.0	0.6	7.0	0.0	0.5
	%IRI	0.0	0.0	0.0	0.1	0.4	0.0	0.07
	%MFI	0.0	0.0	0.0	1.7	3.5	0.0	1.4
Other	%F	0.0	0.0	0.0	4.8	6.8	3.7	0.0
	%W	0.0	0.0	0.0	0.7	1.0	0.4	0.0
	%N	0.0	0.0	0.0	0.1	0.4	0.2	0.0
	%IRI	0.0	0.0	0.0	0.07	0.1	0.02	0.0
	%MFI	0.0	0.0	0.0	1.7	2.4	1.4	0.0
No of stomachs examined	x	7	33	36	27	53	30	11
No of stomachs with prey	x	2	24	29	21	44	27	11

B. pilosa was minor (1% by weight and 9.6% by frequency of occurrence).

Owing to these differences diet-overlap between these two age groups (without taking *Pisces* into consideration) was low, not exceeding 14%. With *Pisces* this value could have grown even to 52%, but 25–30% is more likely.

Platichthys flesus. In the diet composition of the flounder seven components were found (Table 3., Fig. 4):

1. Calanoids – *Centropages hematus, Temora longicornis, Pseudocalanus elongatus, Acartia spp., Eurytemora spp.*,
2. Amphipod – *Bathyporeia pilosa.*
3. Gammarids – *Gammarus oceanicus, G. zaddachi.*
4. Polychaete – *Nereis diversicolor.*
5. Molluscs – *Cardium edule, Macoma baltica, Mytilus edulis, Hydrobia ulvae.*
6. Chironomids larvae.
7. Other – *Neomysis spp., Calliopius rathkei, Corophium volutator, Asellus aquaticus, Idotea granulosa* (not included in Fig. 4).

Planctonic calanoids were found in nearly all length classes but the smallest, 2.0–2.9 and the largest, 8.0–8.9 cm in length. The lack of calanoids in the diet of the smallest fish was caused most likely by the very small size of this sample (only 2 fish with prey in stomach); as in the next length class, 3.0–3.9 calanoids share was 47.6% by weight and 79.2 by frequency of occurrence. In next length classes a drastic drop in the importance of calanoids in food composition were observed.

Bathyporeia pilosa found in food of fish from all length classes was an important prey item of juvenile flounder. In smaller fish it formed more than 50% of the total stomach contents be weight and by frequency of occurrence. It decreased gradually with increasing length of flounder but in the largest fish still formed nearly 20% by weight and 82% by frequency of occurrence.

B. pilosa was followed by gammarids species, *Gammarus spp.*, which occurred of fish from length range 4.0–8.9 cm and formed 3.9–34.2% of the stomach contents by weight and 2.3–9.1% by frequency of occurrence.

The polychaete, *Nereis diversicolor,* represented 31.1–67.5% of the total stomach contents by weight but only 3.4–9.1% by frequency of occurrence, in the diet of fish longer than 4.0 cm. In the smallest fish the weight share of this prey item was extremely high due to the scarcity of data. Though according to weight method *N. diversicolor* was the most important as a food item in flounder the comparison of values of %IRI and %MFI for *B. pilosa* and *N. diversicolor* revealed greater importance of the former.

The tiny bottom-stages *of Mollusca* occurred in the food of fish from length range 3.0–7.9 cm, and especially frequently in two length classes, 4.0–4.9 and 5.0–5.9 cm, with frequency 69% and 38% respectively, but played insignificant role according to weight method.

The role of *Chironomidae* and "Other prey" in food of flounder were negligible.

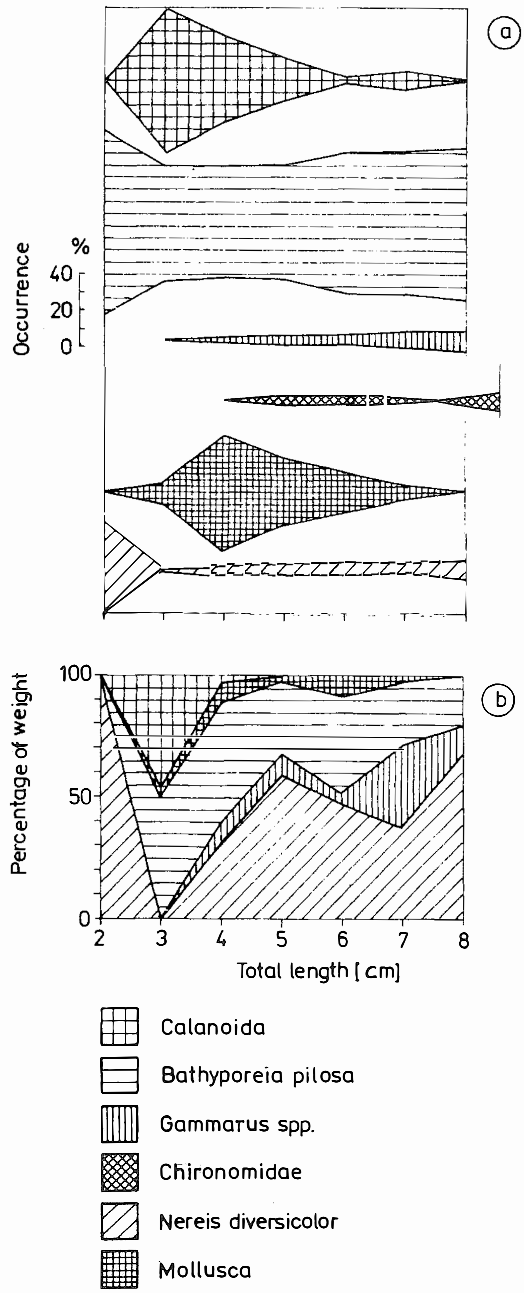

Fig. 4. *Platichthys flesus.* Prey composition by length classes.
a: by frequency of occurrence (%F); b: by percentage of weight (%W).

The main bulk of food of flounder in both age groups was formed by crustaceans (Tab. 4 Fig. 5). During the growth of fish smaller forms like *Calanoida* were soon replaced

Table 4

Platichthys flesus. Comparison of prey composition between age group 0 and I. Values used to calculate diet-overlap are underlined

Prey item	Age group 0; n = 55					Age group I; n = 103				
	%W	%F	%N	%IRI	%IMFI	%W	%F	%N	%IRI	%MFI
Calanoida	9.8	58.2	69.1	51.8	30.1	0.04	8.7	5.4	0.6	0.7
B. pilosa	43.7	61.8	2.2	40.0	44.6	28.4	76.7	51.5	84.2	58.1
Gammarus spp.	4.4	1.8	0.02	0.09	2.4	17.1	4.8	4.4	1.4	12.2
N. diversicolor	38.5	3.6	0.04	1.6	9.6	50.8	4.8	0.3	3.4	14.9
Mollusca	3.6	40.0	28.7	14.6	13.3	2.6	19.4	35.6	10.2	10.8
Chironomidae	0.0	0.0	0.0	0.0	0.0	0.6	3.9	2.5	0.2	1.9
Other	0.0	0.0	0.0	0.0	0.0	0.5	4.8	0.2	0.04	1.5

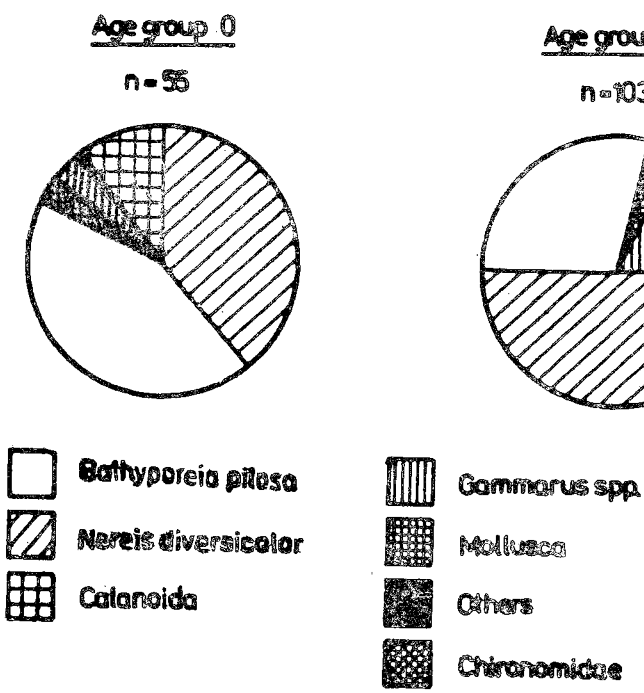

Fig. 5. *Platichthys flesus.* Comparison of prey composition by percentage of weight of prey items in total stomach contents in age group 0 and I.

Table 5

Comparison of prey composition of turbot, *Psetta maxima*, and flounder, *Platichthys flesus*, by percentage of weight (%W) of prey items in total stomach contents (all data). Values used to calculate diet-overlap between these two species are underlined

Prey item	*Psetta maxima*	*Platichthys flesus*
Calanoida	0.7	0.6
B. pilosa	4.8	29.2
Gammarus spp.	0.0	16.4
N. integer	42.7	0.0
N. diversicolor	0.0	50.2
Mollusca	0.0	2.6
Chironomidae	0.0	0.6
C. crangon	11.8	0.0
Pisces	39.7	0.0
Other	0.2	0.5

by *B. pilosa,* and this gradually by *Gammarus spp.* The main food item by weight method in both age groups was *N. diversicolor,* but its share in food composition due to hight weight standards is overestimated.

Similar prey composition of stomach contents of flounder from age group 0 and I resulted in high diet-overlap, 73.9% by percentage of weight. Smaller share, of rather overestimated *N. diversicolor,* in food of 0-group flounder could have given a diet-overlap not exceeding 50%.

Diet – overlap between juvenile turbot and flounder.

Differences in prey composition resulted in moderate diet-overlap between fish from age group 0, and practically no overlap between age groups I, as in all data for both age groups taken together. The only food shared in bigger amount was *B. pilosa.* Diet-overlap between 0-group fish (with only two food items shared, *Calanoida* and *B. pilosa*) attained as much as 36% (in %W, Table 2 and 4). Between fish from age groups I diet-overlap attained only 1% (Table 2 and 4), and in both age groups (all data) 5.6%.

DISCUSSION

Juvenile flatfish abundance and distribution is connected with water depth, avoiding larger predators, obtaining suitable food and cover (Riley et al, 1981). Shallow, inshore nursery ground at Świętouść, Pomeranian Bay, utilized by juvenile turbot and flounder meets all these requirements. Most of the sampled area formed sandy bars, not exceeding 1 m at depth, usually much shallower, parallel to the shoreline, covered with the so called" moving sands", with big stones scattered sparsely. In some places narrow strips of gravel bordered on the very shore (Szlakowski, 1985). Mulicki (1959) stated the Pomeranian Bay is a feeding ground for young flatfish.

The food composition of juvenile flatfish preying in this habitat reflected to some extent abundance and distribution of prey organisms. The "moving sands" habitat is inhabited mostly by crustaceans, like *Bythyporeia pilosa, Neomysis integer, Crangon crangon* and polychaete *Nereis diversicolor* (Żmudziński, 1982), which also formed the main bulk of food, both of turbot and flounder. The prey organisms which formed the prey item "Other" and were found in the food of flatfish in very few quantities, like *Gammarus spp.*, *Calliopius rathkei, Corophium volutator*, small isopods and molluscs abide at big stones (personal observation).

De Groot (1971) in detailed studies on the feeding of flatfish showed that turbot belong to the predatory flatfish, fish-feeders, and flounder to the benthophagic group of flatfish, crustaceans feeders, but also feeding on molluscs and polychaetes. According to Hertling (1928) turbot lived mainly on fish, the large ones especially on *Ammodytes*, the smaller on *Gobius*, also on crustanceans, such as mysids and *Crangon*. Müller (1968) found that juvenile turbot, 1.9–7.0 cm in length (caught in the Baltic near the island of Bornholm, during its first summer) fed mainly on fish (*Ammodytes tobianus, Pomatoschistus spp.*) and amphipods (*Gammarus zaddachi, G. locusta, C. volutator*). Mysids (mainly *N. integer*) and isopods (*Eurydice pulchra, Idotea viridis*) were secondary food animals. *Malacostraca* formed 90%, and *Pisces* 10% of food contents by number method. According to Müller, the presence of crustaceans and fish, but the lack of polychaetes and oligochaetes, in the food of 0-group turbot indicate predatory way of life from the very begining. De Groot (1971) stated the juvenile turbot from North Sea, up to 10 cm in lenght, fed primarily on polychaetes and molluscs; and that fish from length range 11–20 cm fed on crustaceans, mostly *Crangon*. Turbot over 20 cm in length was fish-feeder. Similarly, Braber and De Groot (1973) recorded mysids and young brown shrimp, *C. crangon* as a food of juvenile turbot from the coastal waters of Netherlands. Older juveniles fed on adult shrimp. Fish as food for the first time were found in turbot with length 11 cm. Turbot from length range 11–30 cm relied mainly on fish, whereas from length range 31–65 cm were exclusively fish-feeders. The first fish species found was the goby, *Gobius spp.*, then *Osmerus eperlanus, Ammodytes*, pleuronectids and gadoids. The fish mainly preyed on was sandeel, *Ammodytes tobianus*, and as turbot grew larger, gadoids. Jones (1973) found many components in the food of juvenile turbot from coastal waters of Wales: *Amphipoda, Cumacea, Isopoda, Mysidacea, Crangon, Brachyura, Mollusca, Polychaeta, Pisces* and dipteran larvae. Mysids and polychaetes were the most important food items both by percentage occurrence and by weight, while amphipods and isopods taken frequently were of minor importance by weight. *Pisces* were taken only by larger (10–15 cm) turbot, at the start of the second year of life.

From the above review, two differences in feeding of juvenile turbot from the Baltic and North Sea result. Firstly, the lack of benthic organisms, like polychaetes and molluscs in the diet of Baltic turbot, and their presence in the food of North Sea turbot. Secondly, the presence of fish in the diet of very young bottom-stages of Baltic turbot, and their lack in the diet of North Sea turbot, up to 10 cm in length. As polychaetes and molluscs occurred in the food of juvenile flounder dwelling together with turbot, their lack in the diet of Baltic turbot (that is were available in the environment but were nor eaten) was most likely connected with some food selectively, abundance of prey fitting more properly to turbot's feeding habits (in wide meaning, ad described by De Groot, 1971), and practically no competition with other fish species.

Data presented in this paper revealed that turbot from early bottom-stages is a predatory fish, feeding actively on moving prey. Also distinct shifts in prey preference as a function of fish size were observed. As fish grew larger small food items, like *Calanoida* and *B. pilosa* were neglected in favour of *N. integer, C. crangon* and *Pisces*, which yielded far more energy per individual item. Polychaetes and molluscs were totaly lacking, in the diet of juvenile turbot. Such size-dependent predation may minimize diet-overlap between small and larger fish.

Extensive studies on feeding of flounder revealed that food composition of this species vary much, and depend on size/age of fish, season of the year, locality, abundance, availability and behaviour of the prey (Hertling, 1928; Mulicki, 1947; Bokova, 1954; Żeltenkova, 1954; Moore and Moore, 1976; Szypuła and Załachowski, 1978). But in spite of differences certain features of feeding of juvenile flounder are common. Small crustanceans, *Calanoida, Cyclopoida, Harpacticoida, Cladocera* and *Ostracoda* are the principal food of the youngest bottom-stages of 0-group flounder, up to 3.0 cm in length (Blegvad, 1932; Mulicki, 1947; Szypuła and Załachowski, 1978). Larger flounder feed on amphipods (mostly *Bathyporeia spp.* and *Gammarus spp.*), isopods and mysids (mostly *N. integer*). Polychaete, *N. diversicolor* is often an important food item too. Such food items as *Mollusca, Pisces* and *Chironomidae* generally play rather minor role in the food of juvenile flounder (Blegvad, 1932). But adult flounder predominantly consume molluscs, in addition crustaceans, few worms and very few fish (Hertling, 1928; Mulicki, 1947; Żeltenkova, 1954). Szlakowski (own data) found that juvenile flounder, length range 6.0–9.0 cm, caught at Kołobrzeg in July 1980, fed heavily on gobiids, *Pomatoschistus spp.* According to Heesle (1930) chironomids played important role in the food of 0 and I-group flounder. Similarly, Szypuła and Załachowski (1978) found that chironomids formed 40.6% of food contents by weight of juvenile flounder caught in channel connecting lake Jamno with Baltic Sea.

So, food composition (and its changes during the growth of fish) of juvenile flounder at Świętouść, reflected feeding ecology and feeding possibilites of this fish at this ground. *Calanoida*, forming the basic food of the smallest flounder, were replaced by amphipods, *B. pilosa* and *Gammarus spp.*, and polychaete, *N. diversicolor*, as fish grew in size. *Mollusca, Chironomidae* and the "Other food" item played minor role in food of juvenile flounder.

As regards *N. integer*, heavily preyed on by turbot (this paper), only one specimen was found in the food of flounder, so it was put into the prey item "Other". This stay in contrast with findings of other authors (Bokova, 1954; Moore and Moore, 1976; Szypuła and Załachowski, 1978), who reported *N. integer* as an important food item. Thus, as this species was not practically eaten at Świętouść, other organisms, amphipods in this respect, were preyed more heavily instead.

In both species examined changes in food composition during the growth in lenght were observed. Smaller food items were neglacted in favour of larger prey. Few, 6–7, prey items were ingested, but only 2–3 formed the main bulk of food in both species. Owing to differences in feeding ecology the prey composition of juvenile turbot and flounder were diverse; and thus diet-overlap, especially in larger, I-group, juveniles, was minimized. Dier-overlap between 0-group fish, for two prey items, *Calanoida* and *B. pilosa,* shared, attained 36%.

The food competition could have been significant between the smallest fish, which fed mostly on *Calanoida*, and *B. pilosa*, but the very young bottom-stages of turbot fed on *Pisces* too, and flounder on *N. diversicolor* respectively. Besides, newly-metamorphosed turbot, 2.0–2.9 cm in lenght, feeding on calanoids and *B. pilosa,* appeared at Świętouść in the mid of July (Szlakowski, 1985), while flounder even to one month earlier (authors observations). During the period studied differences in abundance of the smallest fish from both species occurred. Flounder was presented by larger fish, very few from length class 2.0–2.9. cm.

REFERENCES

Blegvad H., 1932: On the flounder *(Pleuronetes flesus)* and the Danish Flounder Fishery in the Baltic. Rapp. P.-v. Reun. Cons. int. Explor. Mer 78: 1–28.

Bokova E.N., 1954: Pitanije molodi promyslowych ryb Baltijskogo Moria. Trudy VNIRO 26: 163–187. (in Russian).

Braber L., S.J. De. Groot, 1973: The food of five flatfish species (Pleuronectiformes) in the southern North Sea. Neth. J. Sea Res. 6: 163–172.

Czislenko L.L., 1968: Nomogramy dla opredelenia vesa vodnych organizmov po razmeram i formie tela. Itd. "Nauka", Leningrad. (in Russian).

Groot S.J.De., 1971: On the interrelationships between morphology of the alimentary tract, food and feeding behaviour in flatfishes (Pisces: Pleuronectiformes). Neth. J. Sea Res. 5: 121–196.

Hertling H., 1928: Untersuchungen über die Ernährung von Meeresfischen. I. Quantitative Nahrungsuntersuchungen an Pleuronectiden und einigen anderen Fische der Ostsee. Ber. Dt. Wiss. Komm. Meeresforch. N.F. 4(2): 1–124.

Hessle Chr., 1930: The young bottomstages of the flounder (*Pleuronectes flesus* L.) at Färön and the northern part of Gotland. Svenska Hydrogr.-Biol. Kommis. Skrifter Ny Serie: Biologi. Band 1. Nr 4.

Jones A., 1973: The ecology of young turbot, *Scophthalmus maximus* (L.), at Borth, Cardiganshire, Wales. J. Fish Biol. 5: 367–383.

Kostrzewska I., 1985: Biologia narybku i młodzieży storni, *Platichthys flesus* (Linne, 1758) z Zatoki Pomorskiej i z Zatoki Gdańskiej. Praca magisterska, maszynopis. Zakład Biologii Ryb Akademii Rolniczej w Szczecinie. [The biology of juvenile and young flounder, *Platichthys flesus* (Linne, 1758), from Pomeranian Bay and Gdańsk Bay. M. Sc. Thesis, Department of Fish Biology, Academy of Agriculture, Szczecin].

Moore J.W., I.A. Moore, 1976: The basis for food selection in flounders, *Platichthys flesus* (L.), in the Severn Estuary. J. Fish Biol. 9: 139–156.

Mulicki Z., 1947: Odżywianie się storni (*Pleuronectes flesus* L.) w Zatoce Gdańskiej. [The food and feeding habit of the flounder (*Pleuronectes flesus* L.) in the Gulf of Gdańsk]. Arch. Hydrobiol. i Ryb. 13: 221–259. (in Polish with English summary).

Mulicki Z., 1959: The status of the south Baltic flatfish stock. Rapp. P.-v. Reun. Cons. int. Explor. Mer 147: 39–47.

Muller A., 1968: Die Nahrung junger Plattfische in Nord-und Ostsee. Kieler Meeresforsch. 24: 124–143.

Pinkas L., M.S. Oliphant, I.L.K. Iverson, 1971: Food habits of albacore, bluefin tuna and bonito in California Waters. Fish. Bull. Calif. 152: 1–105.

Riley J.D., D.J. Symonds, L. Woolner, 1981: On the factors influencing the distribution of 0-group demersal fish in coastal waters. Rapp. P.-v. Reun. Cons. perm. int. Explor. Mer 178: 223–228.

Shorygin A.A., 1952: Pitanije i piscevyje vzaimootnosenija ryb Kaspijskogo Moria. Izd. "Piszczep-romizdat", Moskva (in Russian).

Szlakowski J., 1985: Badania nad biologią skarpia, Psetta maxima (L.), z Zatoki Pomorskiej. Praca magisterska, Zakład Biologicznych Zasobów Morza Akademii Rolniczej w Szczecinie. [Studies on the biology of turbot, *Psetta maxima* (L.), from Pomeranian Bay. M. Sc. Thesis, Department of Biological Resources of the Sea, Academy of Agriculture, Szczecin].

Szypuła J., W. Załachowski, 1978: Badania nad biologią storni bałtyckiej w przybrzeżnej strefie rejonu Kołobrzesko-Darłowskiego. [Studies on biology of juvenile Baltic flounder in the inshore zone off the Kołobrzeg-Darłowo region]. Zesz. nauk. AR Szczecin. Ser. Ryb. morskie 70: 27–40. (in Polish with English summary).

Zander C.D., 1982: Feeding ecology of littoral gobiid and blennioid fish of the Banyuls area (Mediterranean Sea). I. Main food and trophic dimension of niche and ecotope. Vie Milieu 32: 1–10.

Żeltenkova M.V., 1954: Recnaja kambala (*Pleuronectes flesus trachurus* Duncker) kak osnovoj potrebitel molluskov Baltijskogo Moria. Trudy VNIRO 26: 137–162. (in Russian).

Żmudziński L., 1982: Zoobentos litoralu Bałtyku. W: Żmudziński L., Ostrowski J., Zoobentos Bałtyku lat sześćdziesiątych. [Baltic Sea littoral zoobenthos. In: Żmudziński L., Ostrowski J., Baltic Sea zoobenthos of the sixties]. WSP Słupsk 82: 5–38 (in Polish with English summary).

Iwona Kostrzewska-Szlakowska, Jacek Szlakowski

LETNI POKARM NARYBKU SKARPIA, *PSETTA MAXIMA* (L.) I STORNI, *PLATICHTHYS FLESUS* (L.), Z REJONU ŚWIĘTOUŚCIA, ZATOKA POMORSKA

STRESZCZENIE

Zbadano zawartość 313 żołądków narybku skarpia, *Psetta maxima* (L.), i 197 przewodów pokarmowych storni, *Platichthys flesus* (L.), występujących razem, licznie, na płytkowodnym, przybrzeżnym żerowisku narybkowym w rejonie Świętouścia, Zatoka Pomorska (Rys. 1).

W pokarmie skarpia wyodrębniono sześć składników: planktonowe *Calanoida, Bathyporeia pilosa, Neomysis integer, Crangon crangon, Pisces* i inne. Wraz ze wzrostem narybku zmieniało się znaczenie poszczególnych składników w jego pokarmie (Rys. 2 i 3, Tabela 1 i 2). *Calanoida* występowały tylko w pokarmie najmniejszego narybku, do 2.9 cm długości. Znaczenie *B. pilosa*, początkowo najważniejszego składnika pokarmu, w miarę wzrostu narybku sukcesywnie spadało, a podstawą pokarmu stały się *N. integer* i *Pisces*. *Pisces* występowały już w pokarmie najmniejszego skarpia, zaraz po jego przejściu do dennego trybu życia. *C. crangon*, duży i ruchliwy skorupiak, pojawił się dopiero w pokarmie większego narybku, powyżej 9.0 cm długości.

W pokarmie storni wyodrębniono siedem składników: *Calanoida, B. pilosa, Gammarus spp., Nereis diversicolor, Mollusca, Chironomidae* i inne (Rys. 4 i 5, Tabela 3 i 4). *Calanoida* były obecne w

pokarmie ryb należących do prawie wszystkich klas długości, ale większe znaczenie odgrywały tylko w pokarmie ryb małych, do 3,9 cm długości. Pokarmem o największym znaczeniu była *B. pilosa* (według częstości występowania i indeksów pokarmowych IRI i MFI), wyprzedzając *N. diversicolor*, której udział w pokarmie, oparty na zrekonstruowanych masach standardowych, i przy małej częstości występowania, wydaje się zawyżony (podobnie jak udział *Pisces* w pokarmie narybku skarpia z grupy wieku 0). Spośród pozostałych składników pokarmu największe znaczenie miały *Gammarus spp.*

Wśród narybku skarpia i storni z grupy wieku o zbieżność pokarmowa dla wspólnych składników pokarmu, *Calanoida* i *B. pilosa*, wyniosła 36%. Dzięki różnicom w składzie pokarmu wśród ryb z grupy wieku I, zbieżność pokarmowa nie przekroczyła 1%, a dla całego badanego materiału 6% (Tabela 5).

Author's address:
Mgr Jacek Szlakowski,
mgr Iwona Kostrzewska-Szlakowska
Instytut Oceanografii Rybackiej
i Ochrony Morza
ul. Kazimierza Królewicza 4
71-550 Szczecin
Polska (Poland)

Received: 1990.01.08