FOOD COMPOSITION AND PREY SELECTION OF COD, *GADUS MORHUA* (ACTINOPTERYGII: GADIFORMES: GADIDAE), IN THE SOUTHERN BALTIC SEA

Marzenna E. PACHUR and Jan HORBOWY[*]

Department of Fishery Resources, National Marine Fisheries Research Institute, Gdynia, Poland

Background. At the end of 1980s, ecological regime shifts occurred in the Baltic. Since, the Baltic fish assemblage has been dominated by sprats, whereas before cod was the dominant fish species. The majority of previous food studies refer to the period before the shift. This raises the question, how changes in the Baltic ecosystem have affected the diet of cod. The aim of the presently reported study was to identify the differences in the food composition of cod depending on the area, depth, season, and the cod size and compare it with the findings from the 1970s and 1980s.

Materials and methods. Food composition and selection of prey size for Baltic cod was evaluated by examining the stomach contents of 556 adult cod, collected in 2006 and 2007. Fish stomachs were sampled from research catches within the Polish Exclusive Economic Zone.

Results. The main component of the cod diet were the clupeids, constituting more than 67% of the total weight of the food recovered from the specimens studied. Other fishes in the diet represented Gobiidae, Ammodytidae, as well as young cod. The dominant invertebrate in the diet was the isopod *Saduria entomon* which accounted for 13% of the diet by weight. The weight proportion of larger fish, such as herring, *Clupea harengus* (L.), and cod, increased with the cod size, while the proportion of small- and medium-sized fish (sprats, gobies) decreased. The food composition of cod varied seasonally. The weight proportion of European sprat, *Sprattus sprattus* (L.), was much higher in winter (55%) than in fall (27%), while the proportion of cod in the diet was higher in the fall (10%) than in winter (4%). The proportion of sprat in the diet increased with depth, while that of Ammodytidae and Gobiidae showed a decreasing trend. At depths greater than 40 m, the proportion of invertebrates in cod stomachs decreased. This study demonstrated a significant area effect for sprat; year effect for sprat and *Saduria entomon*; a seasonal effect for young cod and *S. entomon*; and a depth effect for sprat, young cod, and *S. entomon*. The occurrences of herring and small cod increased in the stomach as the predator increased, while no significant relation was found for sprat and *S. entomon*. The data collected do not indicate that cod select a specific size of sprat or herring, though cod were found to use size selection for *S. entomon* and juvenile cod.

Conclusion. The food composition of cod has undergone certain changes compared to results of Załachowski (1977, 1985), which covered the 1970s and 1980s. Currently, the proportion of clupeids in the food is approximately 67% (in weight), while during the 1977–1982 it was in the range of 25%–50% depending on cod length. In 2006 and 2007 sprat was the main cod diet component rather than herring.

Keywords: cod, Baltic, feeding, prey size, cannibalism

INTRODUCTION

Studies of fish diet are important for two reasons. Firstly, they allow us to learn about the interactions among particular species in a given environment, thus making substantial contributions to the knowledge of that ecosystem. Secondly, the results of these studies can be used in mathematical models to describe stock dynamics. In the late 1970s and early 1980s, researchers focused their attention on the impact that interactions among species can have on stock dynamics. It was recognised that intensive exploitation of resources can cause disturbances to the ecosystem balance, which can result in changes in species interactions. Omitting information on species interactions can result in gross errors in stock estimation (Horbowy 1996). Consequently, several multi-species models were developed that take trophic interactions into consideration, and attempts were made to employ these models in resource management. One approach that was often applied was the multi-species virtual population model (Helgason and Gislason 1979). Due

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[*] Correspondence: Dr Jan Horbowy, Zakład Zasobów Rybackich, Morski Instytut Rybacki – Państwowy Instytut Badawczy, ul. Kołłątaja 1, 81-332 Gdynia, Poland, phone: +48 587-356-267, fax: +48 587-356-110, e-mail: *horbowy@mir.gdynia.pl* (M. Pachur: *pachur@mir.gdynia.pl*).

to its relatively simple trophic structure, the Baltic Sea is a good study area for the application of multi-species models, and it is standard practice in stock assessment to take the clupeid mortality caused by cod predation into consideration (Anonymous 2012).

Studies of the food composition of cod from the southern Baltic were conducted as early as the 1950s and 1960s (Reimann 1955, Strzyżewska 1959, 1962, Chrzan 1962). Załachowski (1977, 1985, 1986, 1992) presented an evaluation of the quantity, composition, and biomass of the food consumed by the cod population in Polish waters within 1972–1974, 1977–1982, and 1986–1989. Arntz (1977) studied the food of adult cod in the western Baltic. Uzars (1985) and Uzars and Plikshs (2000) investigated the issue of feeding, and analysed cannibalism among Baltic cod from subdivisions 25, 26, and 28 based on material from 1963–1990. Neuenfeldt and Beyer (2003, 2006) draw attention to environmentally driven cod-prey overlap and its effect on food composition in the Baltic.

At the end of 1980s, ecological regime shifts had been observed in the Baltic (Alheit et al. 2005). The Baltic ecosystem is currently dominated by sprats, which is in contrast to the 1980s when the dominant species was cod. The majority of food studies refer to the period when cod was the dominant species, and this raises the question of how changes in the Baltic ecosystem have affected the cod diet. The aim of the presently reported study was to identify the differences in the food composition of cod depending on the area, depth, season and the cod size and to compare the today's cod diet with that of the 1970s and 1980s.

MATERIALS AND METHODS

The samples used in this study (556 cod stomachs) were collected between February 2006 and November 2007 from fishing grounds in ICES subdivisions 25 and 26 within the Polish Exclusive Economic Zone (EEZ) (Fig. 1, Table 1). The samples were collected from scientific catches made from the R/V *Baltica* deploying a tv3 bottom trawl for 0.5 h.

The fish sampled for their stomach contents were measured to the nearest cm (total length defined as the length from the tip of the upper jaw to the tip of the caudal fin, TL) and weighed to the nearest g. The stomachs were labelled, placed in buckets, and preserved in 70% alcohol. Only the anterior part of the alimentary tract (the oesophagus and stomach) was analysed. The contents of the alimentary tracts were weighed to the nearest 0.1 g. The food items found in the stomachs were sorted, counted, weighed, and identified to the lowest taxonomic unit. Proportion of the total weight and frequency of occurrence of each of the food components were determined. For a presentation of the overall food composition, the frequency and weight indices were calculated and shown in 'Costello plot' (Costello 1990). The weight of digested unrecognisable prey, which made up just a small percentage of the total food consumed, has not been analysed.

All of the fish occurring in the stomach contents were measured to the nearest 0.5 cm determining either total length (TL) or standard length (SL, defined as the length from the tip the upper jaw to caudal fin base). In case of a broken tails, total length was determined from the TL–SL relation. The weight of consumed fish was meas-
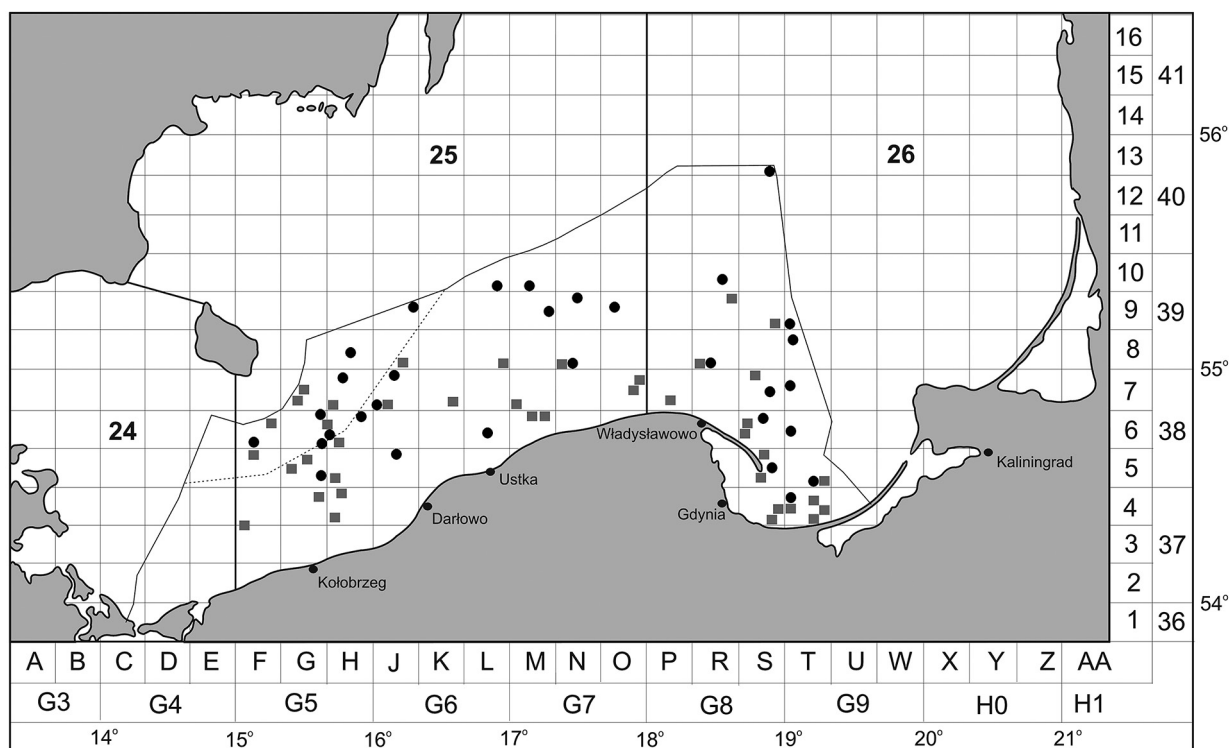

Fig. 1. Distribution of sampling sites in 2006 and 2007 (● 2006, ■ 2007) in the Baltic (borders of the Polish Exclusive Economic Zone marked by a thin solid line)

ured from the weight–length relation, or from the relation between the otolith size and fish size (Härkönen 1986). The lengths of *Saduria entomon* (Isopoda) were determined to the nearest 0.1 cm, and the weight of individual, undigested *S. entomon* was determined to the nearest 0.01 g. The weight of all *S. entomon* in cod stomachs was determined multiplying the mean individual weight of the undigested individuals by the number of all individuals of *S. entomon* found in the stomachs. Prey size selection was analysed by relating the mean length of prey (TL) of a given species to the mean length of cod.

A precise taxonomic identification of fish prey to the species level was sometimes difficult because of digestion, thus it was necessary to group specimens as Clupeidae gen. spp. or Actinopterygii gen. spp. Prey items representing the fish families Ammodytidae and Gobiidae (either identified to the species level or not identified) were pooled because they constituted a small share of the samples.

The total stomach contents in the samples were extrapolated to the whole population by weighing the stomach contents of the different length classes of cod by the mean proportion of a given length class in the population. The length distribution of the population was determined based on length samples collected during research cruises aboard the R/V *Baltica* (Fig. 2).

The generalized linear models (GLM; Nelder and Wedderburn 1972) were used to test for statistical effects of selected factors (year, season, depth, area) and a covariate (predator length) on stomach contents, expressed as occurrences of a given food item (fraction of fish with that item), *p*. The following model was used:

G(*p*) = year + season + area + depth + length,

where: the year is 2006 or 2007, the season is winter (February) or fall (November), the area is Subdivision 25 or Subdivision 26, depth is depth < 60 m or depth >= 60 m, and cod length was expressed in 10 cm intervals. G is the link function and in the analysis the logit link was used and the distribution of the response was assumed to be binomial. GLMs were applied to separate analyses of the occurrences of sprat, herring, young cod, and *S. entomon* in cod stomachs. Depth was constrained to two levels only to provide a better coverage of the strata.

In addition, an analysis of variance was used to compare cod food composition at length between years. A Shapiro–Wilk test was used to test the normality of the distribution for ANOVA tests.

RESULTS

Food composition. Clupeids dominated in the diet of cod and together with unidentified components they comprised over 67% of the total food weight (Fig. 3, Table 2). The weight proportion of sprat in the diet was nearly fourfold higher than that of herring, *Clupea harengus* L. Other fish found in the diet—Gobiidae, Ammodytidae, and cod—made up between 2% and 5% of the total prey weight. Invertebrates constituted approximately 20% of the food mass of which the isopod *Saduria entomon* made up 13%. The food components with the highest frequency

Table 1

Number of cod, *Gadus morhua*, stomachs collected by depth and subdivision

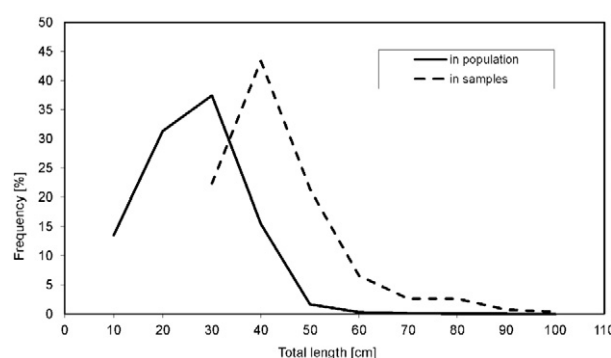| Season	ICES subdivision	Depth [m]	No. of stomachs	Total
February 2006	25	53–75	83	150
	26	60–102	67	
November 2006	25	27–91	88	126
	26	30–99	38	
February 2007	25	20–77	81	147
	26	25–99	66	
November 2007	26	28–75	66	133
	25	17–75	67	

Fig. 2. Length distribution (10 cm length classes) of cod, *Gadus morhua*, in the population (from four bottom surveys in winter and fall 2006 and 2007, *n* = 30 661) and of cod studied in the diet analysis (*n* = 556)

of occurrence were sprat (51%) and *S. entomon* (44%). Cod fed regularly on fish belonging to the family Gobiidae, Mysidacea, as well as on shrimp *Crangon crangon* (29%–35%). The occasional food items of cod were: polychaetes *Bylgides sarsi*, amphipods *Pontoporeia* sp., and herring. Cod occurred in only 2.5% of the fish stomachs examined.

The confirmed Gobiidae were mostly fish of the genus *Pomatoshistus* and in a few cases round gobies, *Neogobius melanostomus* (Pallas, 1814), were also found. Among the Ammodytidae identified were small sandeel, *Ammodytes tobianus* L. and great sandeel, *Hyperoplus lanceolatus* (Le Sauvage, 1824) (known also as sand lance), but in many cases these fish were excessively digested, which made species identification impossible. In addition to the more commonly occurring species described above, the rare findings were: European flounder, *Platichthys flesus* (L.); fourbeard rockling, *Enchelyopus cimbrius* (Linnaeus, 1766); three-spined stickleback, *Gasterosteus aculeatus* L.; garfish, *Belone belone* (Linnaeus, 1761); eelpout, *Zoarces viviparous* (L.); and European anchovy, *Engraulis encrasicholus* (L.).

We observed also less common invertebrates such as: *Gammarus* sp., polychaetes *Nereis diversicolor*, *Diastylis rathkei*, *Corophium volutator*, *Hyperia galba*, and

Palaemon adspersus, along with individual Baltic clams, *Macoma balthica*, or long-neck clams, *Mya arenaria*. Two Mysidacea species found were identified as *Neomysis integer* and *Mysis mixta*. The former of was more abundant in the stomachs of cod caught in shallower waters.

The stomachs of fish longer than 80 cm contained large cod, flounder, fourbeard rockling. Together, these three fish species constituted a total of 72% of the food weight. Among them the most important was cod (40%). The remainder of the food consisted of clupeids.
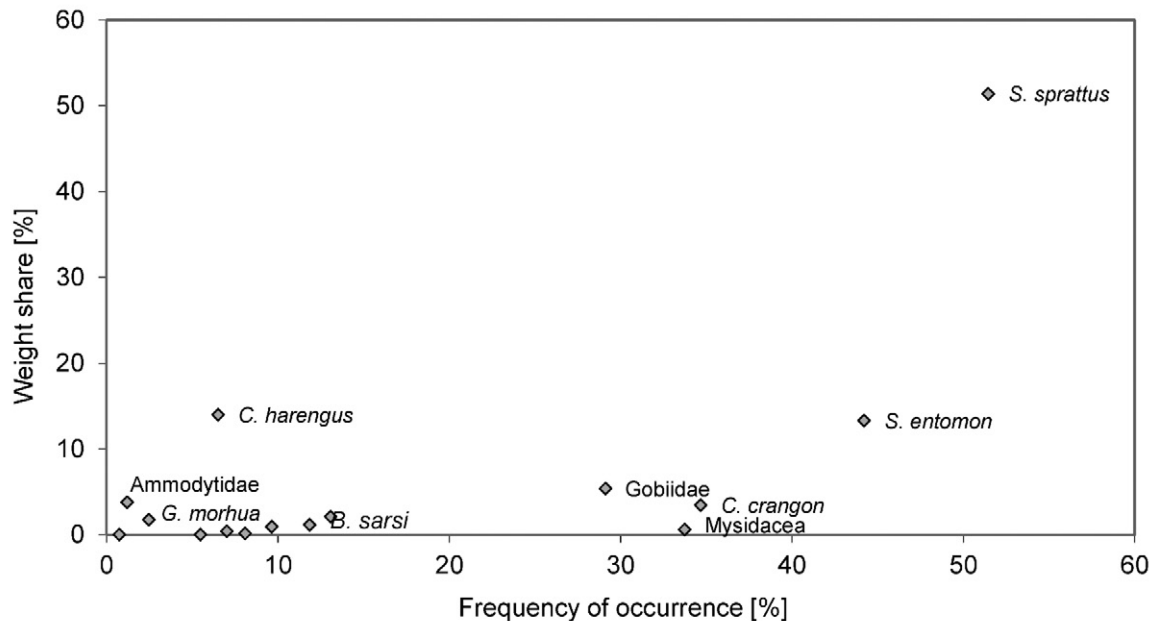

Fig. 3. Costello-plot (frequency of occurrence and weight of prey items) in the studied population of cod, *Gadus morhua* (data recalculated on cod population)

Table 2

Food composition of cod, *Gadus morhua* (data recalculated on cod population)

Prey category	Taxonomic group	Frequency [%]	Weight [%]	Subdivision 25	Subdivision 26
Bylgides sarsi	Polychaeta	11.9	1.2	0.3	2.3
Nereis diversicolor		5.5	~ 0	0.0	0.0
Mysidacea gen spp.	Crustacea	33.8	0.6	0.6	0.6
Pontoporeia sp.		9.7	0.9	1.6	0.0
Gammarus sp		8.1	0.2	0.3	0.0
Saduria entomon		44.2	13.3	16.5	8.9
Crangon crangon		34.7	3.4	4.8	1.5
Mytilus sp.	Bivalvia	0.7	~ 0	0.0	0.0
Sprattus sprattus	Actinopterygii	51.5	51.4	38.8	68.8
Clupea harengus		6.5	14	16.8	10.2
Clupeidae gen. spp.		13.1	2.1	1.6	2.9
Ammodytidae gen. spp.		1.2	3.8	6.5	0.0
Gobiidae gen. spp.		29.1	5.4	6.7	3.6
Gadus morhua		2.5	1.7	2.8	0.3
Actinopterygii gen. spp.		7	0.4	0.4	0.5
Platichthys flesus		1.2	0.2	0.2	0.3
Belone belone		0.3	1.2	2.2	0.0
Enchelyopus cimbrius		0.1	0.1	0.1	0.0
Other fishes		2.2	0.0	0.0	0.1

"Actinopterygii gen. spp." were fish undetermined; "Other fishes" include rarely occurring, determined fish (*Gasterosteus aculeatus*, *Zoarces viviparous*, and *Engraulis encrasicholus*); Data for ICES subdivisions are given by weight %.

Cod cannibalism expressed as a frequency of occurrence was 5%. Cannibalism was observed in 29 stomachs, and it was observed more often in the winter (5%) than in the fall (4%). The smallest cod cannibal was 39 cm in length. In about 30% of the cases noted, the cod consumed were larger than 20 cm. The largest cod consumed was about 40 cm and its weight was 16% of the predator's weight. The young of the year cod were eaten mostly in the winter.

Statistical analysis of occurrences of prey species. A significant year effect was observed for the frequency of occurrences of sprat ($P < 0.001$) and *Saduria entomon* ($P < 0.001$); sprat occurred more frequently in 2007 while *S. entomon* occurred more frequently in 2006. A seasonal effect was significant for young cod ($P < 0.03$) and *S. entomon* ($P < 0.001$). Young cod occurred more frequently in the winter, while *S. entomon* was observed more frequently in the fall.

The effect of subdivision was significant ($P < 0.02$) only in the case of sprat, and sprat occurred more often in stomachs collected in Subdivision 26 than in Subdivision 25. Depth stratum was a significant factor for sprat ($P < 0.002$), young cod ($P < 0.004$), and *Saduria entomon* ($P < 0.001$), while it was not significant for herring ($P < 0.2$). Sprat occurred more frequently in cod stomachs collected from deeper waters (≥ 60 m), while *S. entomon* and young cod occurred more frequently in cod sampled from shallower waters (< 60 m).

The length of predator significantly influenced the frequency of occurrence of herring ($P < 0.001$) and young cod ($P < 0.001$) in predators' stomachs.

The proportion of deviance (the GLM measure of data variability, similar to variance for models with normal errors) explained by significant factors and the co-variate was small for the prey items considered and ranged from 19% for sprat and herring to 30% for young cod and *S. entomon*.

Food composition as dependent on cod length. The food composition of cod varied depending on the size of cod analysed (Fig. 4). The two-year mean of sprat in the food weight was high in the 30–50 cm length class (30%–50%), but declined sharply to 20% in cod from the 80 cm length class.

The proportion of herring increased from just a few percent in the food of the 30–40 cm length class cod to over 20% for 80 cm cod. Similarly, the proportion of cod in the food of the 40 cm cod was marginal, while in the 60–80 cm length classes it increased, on average, from 10% to 30%. Consistent with these findings, cod length was found to be significant in the GLM examining the frequency of occurrence of herring and young cod in cod food. The mean proportion by weight of *Saduria entomon* in the cod diet did not exhibit a clear trend with cod length: it declined in the 20–50 cm length classes from approximately 50% to 15%, but increased again in the 60–80 cm classes to approximately 20%–30%. The proportion of herring and juvenile cod at a given cod length did not differ much in 2006 and 2007 and the difference was not significant ($P = 0.42$ and $P = 0.17$, respectively). However, the proportions of sprat and *S. entomon* differed signifi-

cantly in the two years ($P < 0.007$ and $P < 0.001$, respectively), being consistent with differences in the frequency of occurrence as analysed by a GLM. In 2006, the proportion of sprat was lower than that of *S. entomon*. One year later, there were more sprat than *S. entomon*, with a clear downward trend in the proportions of these two food components with increasing cod length for bigger cods.

The proportion by weight of Gobiidae in the diet of cod decreased with increasing cod length (Fig. 5), while the proportion of Ammodytidae varied. In the 60 cm length class, there was a higher proportion by weight of fish from the "other" group comprised of rarely consumed fish such as fourbeard rockling, eelpout, flounder, and anchovy. The weight of small invertebrates such as Mysidacea, *Gammarus* sp., *Pontoporeia* sp., *Crangon crangon*, and *Bylgides sarsi* declined in the diet of larger cod. The frequency of occurrence of food organisms decreased with increasing cod size for Gobiidae and all invertebrates, except for *Bylgides sarsi*, which increased in frequency (Fig. 5). Generally, the diversity of invertebrates in the diet decreased with cod size.

Food composition by subdivision, season and depth. In Subdivision 26, sprat made up 69% of the weight of the food consumed, while in Subdivision 25 sprat made up 39% of the diet by weight (Table 2), which was consistent with the significantly higher frequency of occurrences of
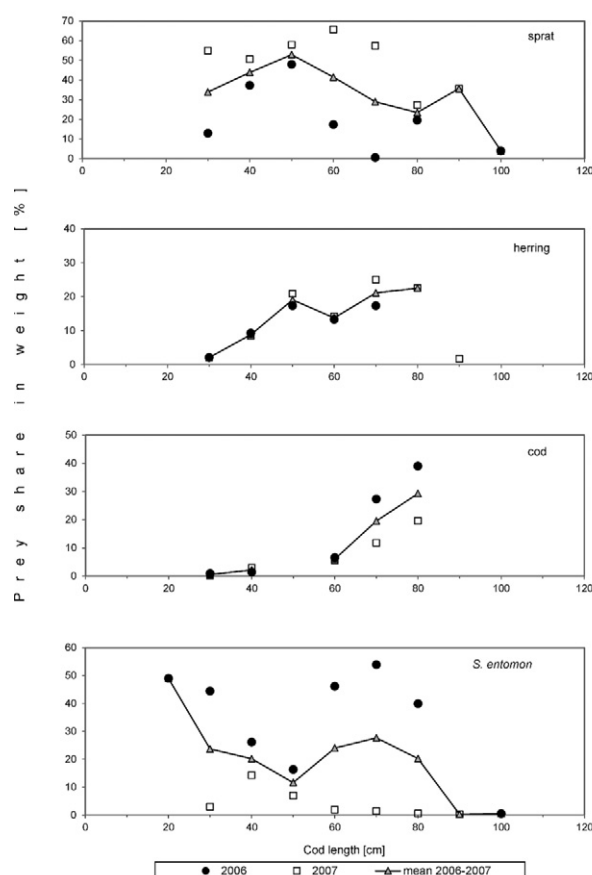

Fig. 4. Weight proportion of the main components of cod, *Gadus morhua*, diet (sprat, herring, cod, *S. entomon*) as dependent on predator length groups

sprat in cod stomachs collected in Subdivision 26. The proportion of other food components was generally lower in Subdivision 26 than in Subdivision 25.

The proportion by weight of sprat in cod food was much higher in winter (55%) than in fall (27%). The proportion of cod in the diet was 10% in the fall and 4% in the winter. Moreover, the proportion of Ammodytidae was markedly higher in the fall than in the winter of 2007. Proportions of herring and *Saduria entomon* were generally similar in both seasons, except for large proportions of *S. entomon* in the fall of 2006 (Fig. 6).

The proportion of sprat by weight in the diet largely increased at depths exceeding 60 m (Fig. 7). The proportion of herring was the highest at depths between 40 to 60 m. As depth increased, the proportions of Gobiidae declined. Fish of the family Ammodytidae occur only in the coastal zone, primarily at depths between 15 to 20 m. The proportion of *Saduria entomon* increased down to the depth of 60 m, and then decreased considerably in deeper waters (a decrease from 23% to 7% of the total weight). The greatest species diversity of other invertebrates occurred in stomachs sampled at depths of 40 m. Below this depth, the proportion of Mysidacea, *Gammarus* sp., *Pontoporeia* sp., and *Crangon crangon* decreased. Among the Mysidacea, at depths down to 40 m, there was a several-fold numerical advantage of *Neomysis integer* over *Mysis mixta*, while to depths of 20 m, only the former genus was observed. Below the depth of 40 m, the quantity of *Neomysis integer* decreased in favour of *Mysis mixta*. **Cod food selectivity.** The data collected do not indicate size selection of sprat or herring by cod (Fig. 8) and the

correlation coefficients for the dependence of herring or sprat length on cod length are close to zero. There is a clear size selection for *Saduria entomon* and juvenile cod ($P < 0.001$ in both cases; Fig. 8). The correlation coefficients (R) of these dependencies were 0.51 and 0.84, respectively. With *S. entomon*, the correlation between the isopod length and the cod length increased with sampling depth, and for samples from depths of 40 m, 60 m, 80 m, and 100 m the values for the correlations were 0.47, 0.49, 0.78, and 0.84, respectively.

DISCUSSION

The food habits of cod were found to change with season, area, and depth. However, these factors affected stomach contents of cod in different ways for specific prey items. For example, the area effect was significant only for sprat, the depth effect was significant for sprat, young cod, and *Saduria entomon*, the season effect was significant for young cod, and *S. entomon*. The food composition of cod changed markedly with cod size; larger cod had higher weight share of fish than the smaller individuals. The size selection was observed for such prey items as young cod and *S. entomon* but has not been significant for sprat and herring.

The food composition of cod has undergone certain changes compared to results of Załachowski (1977, 1985), which covered the 1970s and 1980s. Currently, the proportion of clupeids in the food is approximately 67% (in weight), while during the 1977–1982 it was within the range of 25%–50%, depending on cod length. Sprat now dominates the cod diet rather than herring. The proportion
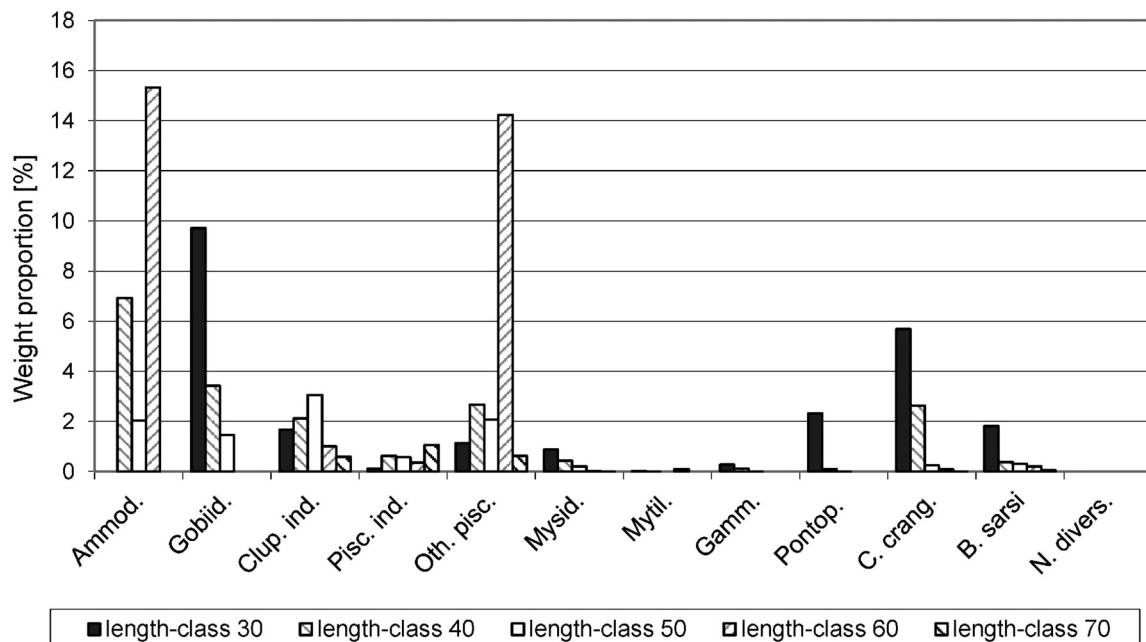

Fig. 5. The weight proportion and frequency of occurrence of the less important components of cod, *Gadus morhua*, diet by predator length groups; Ammod. = Ammodytidae, Gobiid. = Gobiidae, Clup. ind. = Clupeidae gen. spp., Pisc. ind. = Actinopterygii gen. spp., Oth. pisc. = Other fishes (identified), Mysid. = Mysidacea gen. spp., Mytil. = *Mytilus* sp., Gamm. = *Gammarus* sp., Pontop. = *Pontoporeia* sp., C. crang. = *Crangon crangon*, B. sarsi = *Bylgides sarsi*, N. divers. = *Nereis diversicolor*

of herring in the diet studied by Załachowski (1985) was similar to that in the presently reported study, while the proportion of sprat was very low, within the range of 7%–12% in various length classes. In this study, sprat comprised between 20% and 50% of the diets in terms of weight. The reason sprat consumption by cod was so low in the 1977–1982 period was because of the very low sprat biomass in the Baltic at the time. The spawning stock of sprat in the Baltic then was approximately 250 000 t, while the estimate for the 2006–2007 was approximately 900 000 t (Anonymous 2012). In turn, the herring biomass in the central Baltic was in 2006–2007 approximately half of its size in the late 1970s and early 1980s. In the 1950s, the primary food of cod were also clupeids, which comprised between 54% and 78% of the stomach contents, and the dominant among clupeids, as in the 1970s, was herring (Strzyżewska 1962).
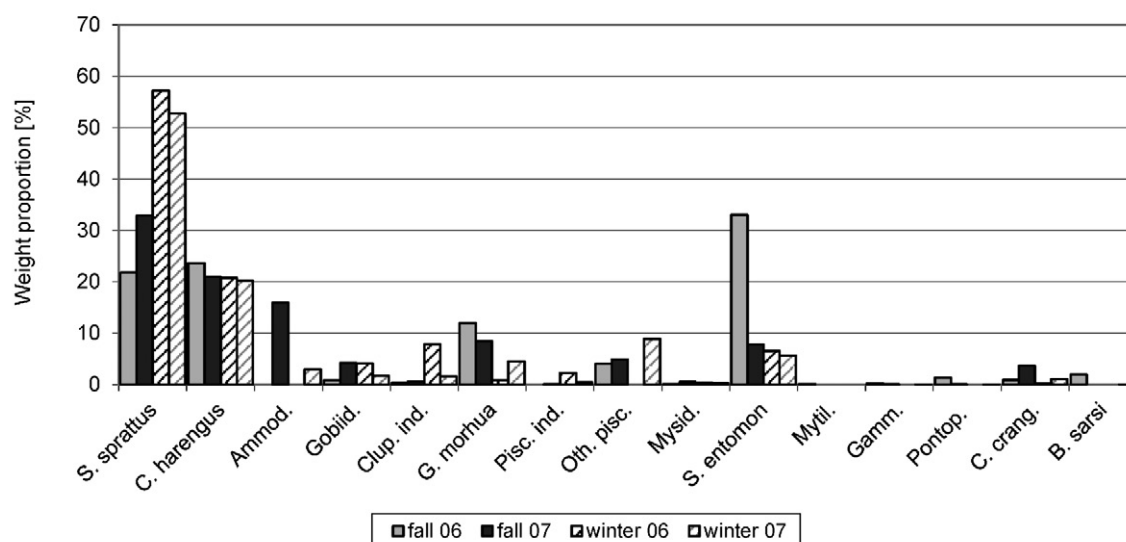

Fig. 6. Food composition of cod, *Gadus morhua*, by season for cod < 80 cm in length; Ammod. = Ammodytidae, Gobiid. = Gobiidae, Clup. ind. = Clupeidae gen. spp., Pisc. ind. = Actinopterygii gen. spp., Oth. pisc. = Other fishes (identified), Mysid. = Mysidacea gen. spp., Mytil. = *Mytilus* sp., Gamm. = *Gammarus* sp., Pontop. = *Pontoporeia* sp., C. crang. = *Crangon crangon*, B. sarsi = *Bylgides sarsi*, N. divers. = *Nereis diversicolor*
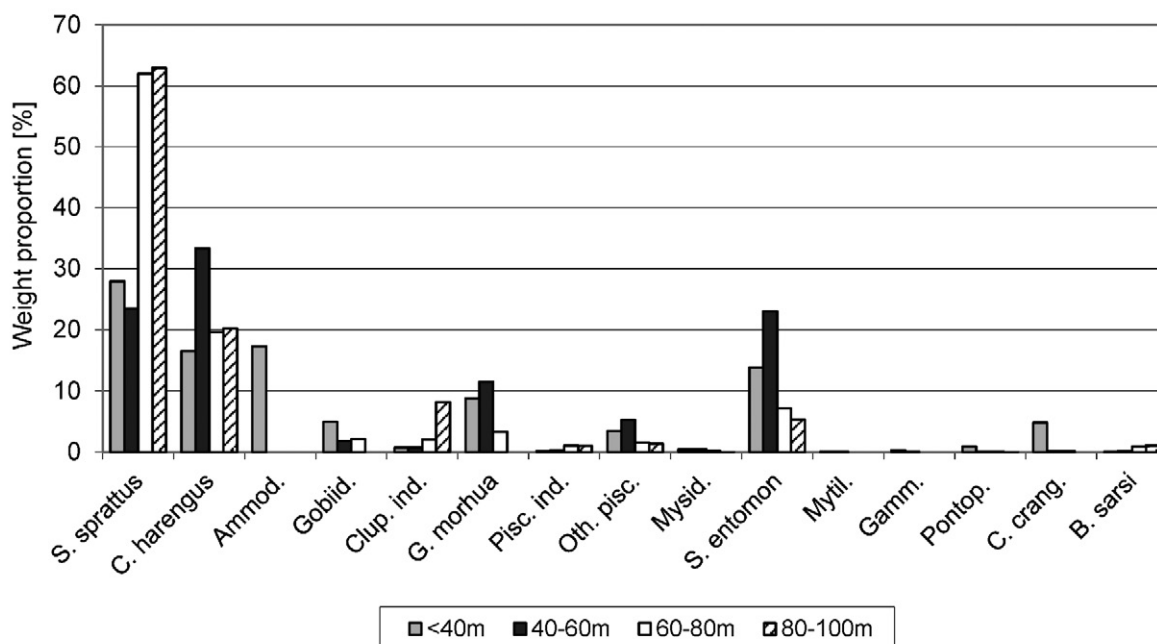

Fig. 7. Food composition of cod, *Gadus morhua*, in relation to depth in 2006 and 2007 for cod < 80 cm; Ammod. = Ammodytidae, Gobiid. = Gobiidae, Clup. ind. = Clupeidae gen. spp., Pisc. ind. = Actinopterygii gen. spp., Oth. pisc. = Other fishes (identified), Mysid. = Mysidacea gen. spp., Mytil. = *Mytilus* sp., Gamm. = *Gammarus* sp., Pontop. = *Pontoporeia* sp., C. crang. = *Crangon crangon*, B. sarsi = *Bylgides sarsi*, N. divers. = *Nereis diversicolor*

The proportion by weight of cod in the stomachs of adult cod calculated by Załachowski (1985) was similar to that observed in the presently reported study. The biomass of cod in the environment during that time period was several times higher than it is now, but this was not reflected in the greater consumption of juvenile cod by adult cod. The low proportion of sprat in the study by Załachowski (1985) was compensated by the higher proportion of invertebrates consumed, especially of *Saduria entomon*, *Bylgides sarsi*, and Mysidacea. The proportion of *S. entomon* was two times higher, while that of *Bylgides sarsi* was more than fifteen-fold higher. The presently reported study noted a high proportion of Gobiidae in the diet of cod (5%), while that observed by Załachowski (1985) was approximately 1%.

The incidence of cannibalism, which was observed in all seasons, was 5% (frequency of occurrence). According to Uzars (2000), the average frequency of cod occurrence in stomachs in subdivisions 26 and 28 within 1963–1990 was much lower (about 1%). Cannibalism was noted more often in the winter than in the fall, but in the winter, the prey were mostly the youngest cod. Uzars (2000) reported that the cod consumed in the winter (Nov–Jan) and early spring (Mar–Apr) were mostly from the 0 and 1 age groups (5–15 cm). According to the above-mentioned author, the higher rate of cannibalism was associated with the greater abundance of juvenile cod. The stomachs of large fish, over 60 cm in length, often contained larger cod in excess of 20 cm. In the late 1980s, Załachowski (1986)
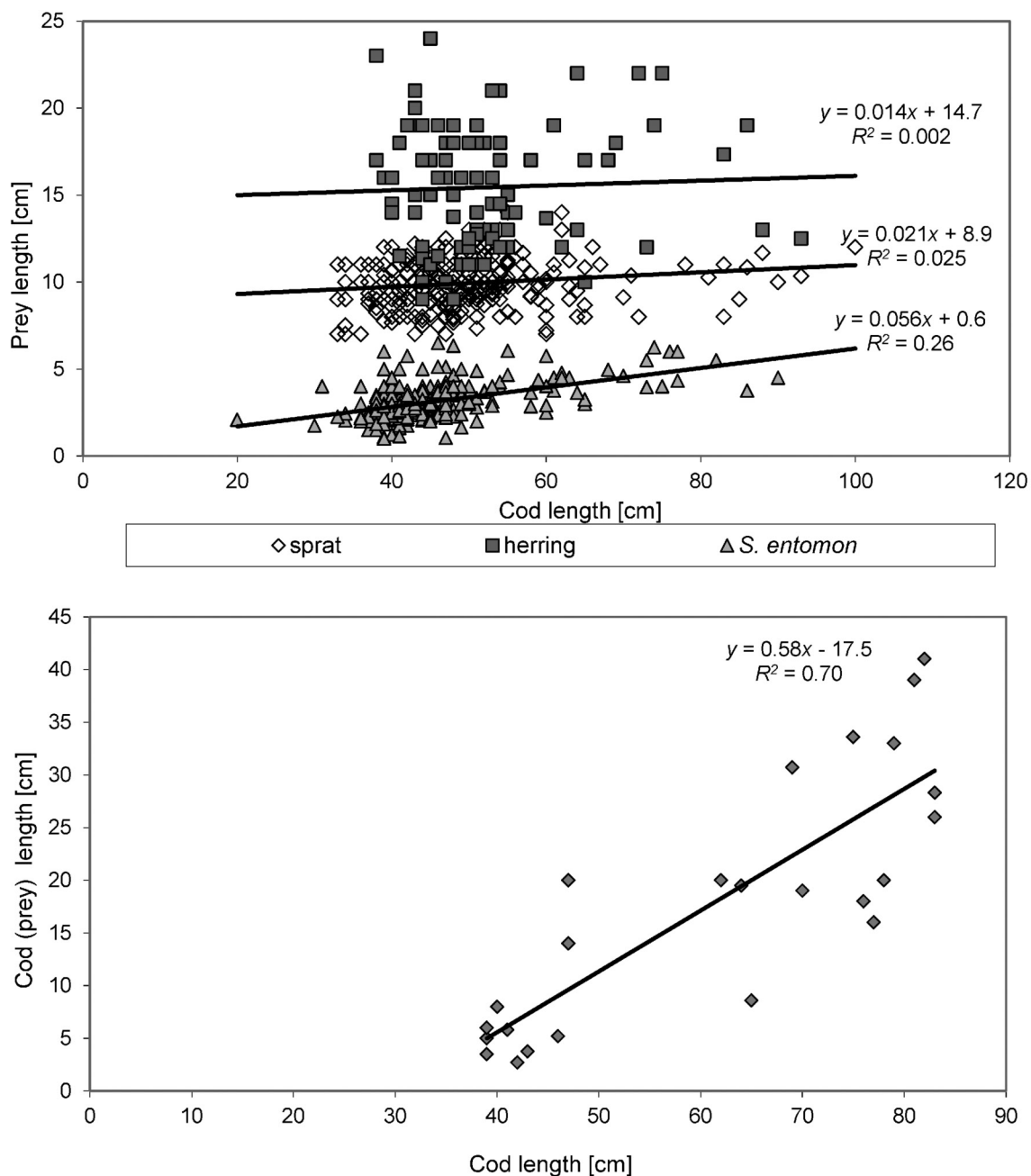

Fig. 8. Relation between mean prey length and cod, *Gadus morhua*, length for its food items: sprat, herring, *Saduria entomon*, and cod

observed that in the years when clupeid consumption was lower, the sampled cod exhibited higher rates of cannibalism.

The type of food consumed by cod depends on their size. The presently reported study confirmed that as cod length increased, the proportion of the diet by weight that was made up of small and medium-sized fish (sprats, gobies) decreased, while the proportion of larger fish, such as herring and cod, increased systematically. These results concur with those reported by Załachowski (1977), who found that small fish species exhibited a consistent decreasing proportion by weight in the diet as cod length increased, and that the highest proportion of fish species of medium size (Ammodytidae, sprat) were noted in medium-sized cod. With the largest species, such as herring and cod, there was an increase in their proportion by weight in cod diets as predator length increased. Chrzan (1962) also stated an increasing proportion of herring in the food that corresponded to increases in cod size. Załachowski (1985) observed a large proportion of fourbeard rockling and cod in the diets of cod beginning at age 6 (i.e., at lengths of 50–60 cm). These components can comprise as much as 50% of all the fish consumed.

In the case of invertebrates, the number of species in the food of cod decreased with increasing length, which was also observed by Cięgielewicz et al. (1972). According to Załachowski (1977), the consumption of *Saduria entomon* increases with length for cod up to 45 cm, and decreases for larger cod. In the presently reported study, a similar tendency was observed in 2007. In 2006, this trend was not observed, but the weight proportion of *S. entomon* was relatively high (Fig. 4). Small invertebrates were consumed less frequently as the length of the predator increased, which is in agreement with the results of Załachowski (1977). Neuenfeldt and Beyer (2003) showed a relation between cod length and the proportion of sprat, herring, and *S. entomon* in cod's diets. This finding was similar to our findings for samples collected from demersal hauls. Also our finding of size selection of *S. entomon* is similar to observation of Chrzan (1962), who stated that bigger cod consumed bigger *S. entomon*.

The higher proportion of sprat in cod food in Subdivision 26 compared to Subdivision 25 (Table 2) was consistent with sprat distribution, measured by the proportion of sprat catches in both subdivisions (Anonymous 2012).

In the fall, a high frequency of *Saduria entomon* (over 60%) was observed in the stomachs of cod, similar to that of Cięgielewicz et al. (1972) and Uzars et al. (2000). *S. entomon* is a significant component of the adult cod diet and even reached 30% of the diet by weight. Fishes of the family Ammodytidae represented the highest individual share of the cod diet in the fall of 2007 (approximately 15%). These results concur with the results obtained by Cięgielewicz et al. (1972) and Załachowski (1977), who noted more Ammodytidae in the food during the fall season.

The cod diet changed with the depth of the feeding grounds. Generally, as depth increased, so did the proportion of sprat in the diet, while the proportion of herring in the diet decreased. These trends were also observed by Załachowski et al. (1975). Gobiidae and Ammodytidae were consumed less frequently as depth increased, as was also noted by Załachowski (1977). The invertebrate composition varied as the depth of the feeding grounds increased. At depths greater than 40 m, the proportions (weight percent) of *Saduria entomon*, Mysidacea, *Gammarus* sp., and *Crangon crangon* in cod stomachs all decreased. The same variations were also observed by Załachowski (1977). The observations of Chrzan (1962) indicated that the frequency of *Crangon crangon* consumption was four times higher in the coastal zone waters than at greater depths.

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