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Diet of polar cod, Boreogadus saida, in the Barents Sea related to fish size and geographical distribution

by

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ABSTRACT

Polar cod stomachs collected during autumn of 1986-1988 in the Barents Sea were analysed. The results indicated that polar cod is an opportunistic feeder, and that the observed changes in feeding pattern from one region to another, is in accordance with prey availability in a particular region. The consumption increased with increasing polar cod length through an increase in prey size, rather than in the number of prey. The mean index of stomach fullness in the Northeastern part, reveal a high feeding activity in the Arctic water.

INTRODUCTION

Polar cod, Boreogadus saida, is the only Arctic endemic species among all members of the family Gadidae occurring in the Barents Sea (Bergstad et al., 1987). It has been identified as a biological pivot of many of the marine vertebrates in the Arctic region (Sameoto, 1984). To date, only few investigations provide data on the feeding habits of polar cod in the Barents Sea (Ponomarenko, 1968; Hognestad, 1968; Panasenko and Soboleva, 1980; Lønne and Gulliksen, 1989), with very little attention being paid to geographical or fish size differences in feeding habits. In addition, they are in general based on a small number of fish. It has been shown that predation by planktivorous fish (capelin and polar cod) have a large impact on the zooplankton composition and production in the Barents Sea (Skjoldal and Rey, 1989; Hassel et al., in prep.) during their feeding migration to the Northern parts of the Barents Sea in summer and autumn. This led Shleinik (1973) to conclude that during that period polar cod made vertical migrations for food, Calanus and Euphausiidae, moving to the pelagic layer in the daytime and sinking to the near bottom layers at night. The objective of the present study, was to determine the feeding habit of polar cod in different geographical regions and ontogenetical variation in diet.

MATERIAL AND METHODS

Stomach samples of polar cod were collected onboard Norwegian research vessels during routine surveys in autumn of 1986-1988. Predator length, age, weight, sex, and maturity stage were recorded, and the stomachs of individual fish was frozen for later analysis. The methods of sampling and stomach contents analysis are described in detail in Mehl (1986). For the present investigation the Barents Sea is divided into three regions; Northeastern, Southeastern and Central part (Fig.1). A total of 15 trawl stations were taken in the Northeastern, 9 in the Southeastern and 6 in the Central part. Three size classes of polar cod, (8-10.9cm, 11-13.9cm and 14-16.9cm) were considered in the present study.

RESULTS

Table 1, 2 and 3 presents the diet compositions for all length groups of polar cod in the three regions. The number of determinable prey items which are consumed by polar cod varies from one region to another; 11 different prey items in the Northeast, 7 in the Southeast and 8 in the Central part of the Barents Sea. Based on weight percentage and frequency of occurence, the diet of the polar cod of all length groups collected in the Northeastern part of the Barents Sea shows that Amphipoda (most likely Parathemisto spp.) was the most important food item and represented about 88.7% of the average stomach contents weight. In contrast the diet of polar cod in the Southeastern part, consisted primarily of Copepods (Calanus spp.), Amphipoda and Euphausiidae (most likely Thysanoessa spp.); whereas, Amphipoda and Euphausiidae were the major contributors in the Central part. A number of invertebrates such as the Caridea, Pandalus borealis (size group:5-6.9cm), Pontophilus norvegicus (size:2.5-2.9cm) and fish species, Sebastes (size 1-1.4cm) were of lesser importance in the Northeastern

region. In addition, fish species such as; Lumpenus lampretaeformis (-size:5-6.9) and Hippoglossoides platessoides (size:2- 3.9cm) were recorded in stomachs collected in Southeastern and Central parts, respectively.

Table 4, 5 and 6 demonstrates diet composition of different size groups of polar cod in the three regions. Stomachs sampled in Northeast were characterized in terms of weight and frequency; Amphipoda and Euphausiidae were the two most important items in length group 8-10.9cm. As polar cod length increase, Amphipoda became the major prey consumed, (90.88%) in length group 11-13.9cm and 85.53% of total average stomach contents weight in length group 14-16.9cm.

Analysis of stomach content from the southeastern region (Table 5) revealed that in the length group 8-10.9cm, Copepoda (Calanus spp.) and Euphausiidae (Thysanoessa spp.) were the major dietary components, constituting 36.71% and 47.84% respectively, whereas in the length group 11-13.9cm, four different prey became important; Copepoda (17.86%), Amphipoda (35.87%), Euphausiidae (29.05%) and Teleostei (15.28%). Crustacea, Amphipoda, Euphausiidae and Teleostei contributed significantly to the diet of the length group 14-16.9cm, both in terms of weight and frequency.

The fish in size group 8-10.9cm collected in the Central part had mainly fed on Copepoda (17.40%), Amphipoda (31.03%) and Euphausiidae (48.28%) while the weight percentage of Copepoda was reduced to 4.02% in length group 11- 13.9cm, Amphipoda occupied 39% of the stomach weight and Euphausiidae 52.66%. These last two taxa represented about 74.6% and 19.26% in length group 14-16.9cm.

DISCUSSION

Several authors (Lowry and Frost, 1981; Bradstreet and Cross, 1982; Sameoto, 1984; Bradstreet et al., 1986; Lønne and Gulliksen, 1989) characterized polar cod as an opportunistic feeder; the data presented in this paper support that hypothesis. Polar cod preyed upon Copepoda, Amphipoda and Euphausiidae (Tab. 2) in the Southeastern area where Calanus sp. dominated in number and biomass (Hassel, personal comm.). The Euphausiid (Thysanoessa rashii) contributed significantly to the zooplankton abundance in the Southeastern part of the sea where their abundance was established due to local recruitment (Drobysheva, 1982; Boytsov and Drobysheva, 1987). Amphipoda dominated the diet in the stomachs collected in Northeastern region and Amphipoda and Euphausiidae were the main food items in Central part (Table 3). It has been reported that during 1986-1988, Amphipoda (Parathemisto spp.) had a high contribution to the total zooplankton biomass in the Northeastern part of the Barents Sea (Skjoldal and Hassel, personal comm.). From the evidence presented above, the changes in feeding patterns from one region to another, is likely to be due to changes in particular prey availability in a particular region than to a change in feeding strategy of polar cod in the Barents Sea.

The total average stomach contents weight increased with increasing polar cod length in all regions. This occurred through an increase in prey size consumed, rather than increase in the number of prey. Number of prey did not increase with increasing polar cod length (Tab.4, 5 and 6). The mean index of stomach fullness was highest in the Northeastern part (2.99%) compared with the Southeastern (2.07%) and the

Central part (2.21%). If the average stomach fullness in a fish population is an index of the feeding rate of that population (Lilly, 1989), this reflects a high feeding activity of polar cod in Arctic water (Northeastern region).

There are no evidences for a higher growth rate of this species in Arctic water than in the rest of the Barents Sea. On the contrary, the results presented in Gjøsæter and Ajiad, (1990) show a significantly slower length growth in the eastern and north-eastern parts of the Barents Sea in 1987-89.

Cannibalism in polar cod was reported by Ponomarenko (1968). No single incidence of cannibalism was found during 1986-1988 in the three regions. Cannibalism may have occured more extensively, if one-year- olds had been associated with the schools of fry (Lilly, 1980). During the present investigation, non of typical benthic preys have been recorded in polar cod stomachs. However, diet of polar cod reported from other areas of the Arctic region shows that this species very seldom feed directly off the bottom (Lilly, 1980; Lowry and Frost, 1981; Sameoto, 1984). Gastropoda has been reported in the stomachs from the North of Svalbard area (Lønne and Gulliksen, 1989), but it was not stated whether these were benthic or pelagic forms.

The relationship between plankton biomass and stomach content weight is difficult to establish in species such as polar cod. This is because most plankton gears fail to catch krill, which contributes significantly to the diet of polar cod, quantitatively (Skjoldal and Rey, 1989), and krill is only to a little degree included in the plankton biomass values.

In summary, polar cod is an opportunistic feeder. The observed changes in feeding patterns from one region to another, is in accordance with prey availability in a particular region. The consumption increased with increasing polar cod length. This occured through an increase in preys size rather than in the number of preys. A high mean index of stomach fullness in the Northeastern part, revealed a high feeding activity in Arctic water. The relationship between stomach contents weight and zooplankton biomass is not possible to establish.

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Table 1. Diet compositions of polar cod from 1986-1988 in the Northeastern part of the Barents Sea.

Taxa	Size	W%	N%	F% *
Crustacea(indet)	indet	.79	-	3.0
Copepoda	indet	4.19	-	7.5
Flabellifera	indet	2.25	-	.3
Amphipoda	indet	65.43	2.56	50.2
Hyperiidae	2.0-2.4cm	.18	2.56	.3
	indet	11.97	-	6.9
Parathemisto	1.0-1.4cm	.88	35.90	.3
	1.5-1.9cm	.45	10.26	1.0
	2.0-2.4cm	.82	7.69	1.0
	3.0-3.9cm	1.08	5.13	.7
	indet	5.38	10.26	2.3
Euphausiidae	indet	2.51	-	8.5
Caridea	indet	1.14	-	.3
Pandalus borealis	5.0-6.9cm	2.07	5.13	.7
Pontophilus norvegicus	2.5-2.9cm	.15	2.56	.3
Sebastes	1.0-1.4cm	.34	17.95	.3
indeterminatus	indet	.36	-	2.3

Total number of stomachs	305
Percentage of empty stomach	18.0
Mean index of stomach fullness	2.99%
Mean fish length(cm)	12.58
Average stomach content weight (g)	.38

*
W = weight
N = number
F = frequency

Table 2. Diet compositions of polar cod from 1986-1988 in Southeastern part of the Barents Sea

Taxa	Size	W%	N%	F%
Crustacea(indet)	indet	5.42	-	8.5
Copepoda	indet	17.37	-	19.5
Amphipoda	indet	35.40	-	14.6
Parathemisto	2.0-2.4cm	.43	7.69	.6
	2.5-2.9cm	1.05	7.69	.6
	indet	1.87	23.08	1.2
Euphausiidae	1.5-1.9cm	.33	7.69	1.2
	2.5-2.9cm	.36	7.69	.6
	indet	28.18	15.38	29.9
Teleostei	indet	7.65	23.08	6.1
Lumpenus lampretaeformis	5.0-6.9cm	1.94	7.69	.6

Total number of stomachs	164
Percentage of empty stomach	24.4
Mean index of stomach fullness	2.08
Mean fish length(cm)	12.28
Average stomach contents weight(g)	0.19

Table 3. Diet compositions of polar cod from 1986-1988 in Central part of the Barents Sea

Taxa	Size	W%	N%	F%
Crustacea(indet)	indet	1.42	-	1.3
Copepoda	indet	5.13	-	4.4
Amphipoda	1.0-1.4	.06	10.00	.6
	indet	23.02	-	21.4
Hyperiidae	2.5-2.9cm	2.76	50.00	1.3
	indet	21.68	-	13.8
Parathemisto	2.5-2.9cm	.68	10.00	.6
Euphausiacea	indet	.30	-	.6
Euphausiidae	2.0-2.4cm	.36	10.00	.6
	indet	39.39	-	33.3
Hippoglossoides platessoides	2.0-2.4cm	.56	10.00	.6
	3.0-3.9cm	1.39	10.00	.6
Indeterminatus	indet	3.23	-	8.8

Total number of stomachs	159
Percentage of empty stomach	17.6
Mean index of stomach fullness	2.21
Mean fish length(cm)	12.32cm
Average stomach contents weight(g)	0.21

Table 4. Diet compositions of different size classes of polar cod from 1986-1988 in the Northeastern part of the Barents Sea

Fish size		8-10.9cm		11-13.9cm		14-16.9cm	
Taxa	Size	W%	F%	W%	F%	W%	F%
Crustacea(indet)	indet	.87	2.8	.71	3.1	.77	3.1
Copepoda	indet	2.93	5.5	5.59	10.2	3.71	7.1
Flabellifera	indet	-	-	-	-	3.81	1.0
Amphipoda	indet	61.71	39.4	70.73	51.0	63.42	61.2
Hyperiidae	indet	9.89	5.5	11.14	7.1	12.78	8.2
	2.0-2.4cm	-	-	.60	1.0	-	-
Parathemisto	1.0-1.4cm			2.94	1.0	-	-
	1.5-1.9cm	1.50	1.8	.97	1.0	-	-
	2.0-2.4cm	1.19	.9	1.91	1.0	.20	1.0
	3.0-3.9cm	-	-	-	-	1.83	2.0
	indet	2.69	.9	2.59	2.0	7.30	4.1
Euphausiidae	indet	15.90	16.5	1.68	5.1	.48	3.1
Caridea	indet	-	-	-	-	1.93	1.0
Pandalus borealis	5.0-6.9cm	-	-	-	-	3.51	2.0
Pontophilus norvegicus	2.5-2.9cm	-	-	-	-	.26	1.0
Sebastes	1.0-1.4cm	-	-	1.14	1.0	-	-
indeterminatus	indet	3.32	6.4	-	-	-	-

Total number of stomachs	109	98	98
Percentage of empty stomach	25.9	19.4	11.2
Mean index of stomach fullness	2.51	3.23	3.23
Mean fish length(cm)	9.96	12.67	15.42
Average stomach contents(g)	0.12	0.36	0.70

Table 5. Diet compositions of different size classes of polar cod from 1986-1988 in the Southeastern part of the Barents Sea

Fish size		8-10.9cm		11-13.9cm		14-16.9cm	
Taxa	Size	W%	F%	W%	F%	W%	F%
Crustacea(indet)	indet	3.32	3.3	1.94	7.0	11.99	21.9
Copepoda	indet	36.71	23.0	17.86	22.5	2.71	6.3
Amphipoda	indet	7.66	9.8	30.63	18.3	62.36	15.6
Parathemisto	2.0-2.4cm	-	-	-	-	1.36	3.1
	2.5-2.9cm	-	-	2.30	1.4	-	-
	indet	-	-	28.26	33.8	1.67	3.1
Euphausiidae	1.5-1.9cm	1.45	3.3				
	indet	46.39	31.1	-	-	14.91	18.8
Teleostei	indet	4.48	3.3	11.05	9.9	5.01	3.1
Lumpenus lampretaeformis	5.0-6.9cm	-	-	4.23	1.4	-	-
Total number of stomachs			61		71		32
percentage of empty stomach			26.2		19.7		31.3
Mean index of stomach fullness			2.46		1.83		1.95
Mean length(cm)			10.20		12.65		15.44
Average stomach contents(g)			0.11		0.20		0.30

Table 6. Diet compositions of length groups;8-10.9cm, 11-13.9cm and 14-16.9cm from 1986-1988 in the Central part of the Barents Sea

		8-10.9cm		11-13.9cm		14-16.9cm	
Taxa	Size	W%	F%	W%	F%	W%	F%
Crustacea	indet	-	-	3.11	2.8	-	-
Copepoda	indet	17.40	8.9	4.02	2.8	-	-
Amphipoda	1.0-1.4cm	.31	1.8	-	-	-	-
	indet	23.67	26.8	17.23	25.4	30.19	3.1
Hyperiidae	2.5-2.9cm	-	-	-	-	7.82	6.3
	indet	7.05	5.4	16.26	11.3	36.59	34.4
Parathemisto	2.5-2.9cm	-	-	1.49	1.4	-	-
Euphausiacea	indet	1.57	1.4	-	-	-	-
Euphausiidae	2.0-2.4cm	-	-	-	-	1.01	3.1
	indet	46.71	30.4	52.66	40.8	18.25	21.9
Hippoglossoides platessoides	2.0-2.4cm	-	-	-	-	1.60	3.1
	3.0-3.9cm	-	-	3.04	1.4	-	-
Indeterminatus	indet	3.29	5.4	2.20	8.5	4.54	15.6
Total number of stomachs			56		71		32
Percentage of empty stomach			21.4		11.3		25.0
Mean index of stomach fullness			2.19		2.22		2.23
Mean length(cm)			10.39		12.53		15.25
Average stomach contents(g)			0.11		0.22		0.37

Figure 1. Map showing the Barents Sea, the three sampling areas, and the sample positions inside these areas.