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A SURVEY OF THE DIET AND DISEASES OF *GADUS MORHUA* L. AROUND HELGOLAND IN THE GERMAN BIGHT

by

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Abstract

During May and June 1988 a number of hauls were made around Helgoland with the RV "VICTOR HENSEN". A total of 377 cod (*Gadus morhua* L.) were investigated. They were measured, the stomach fullness estimated and the contents indentified. Crustaceans and fish were the main prey species with some polycheates, gastropods and bivalves being taken as well.

The infestation rates with the gill parasite *Lernaeocera branchialis* and *Clavella adunca* were noted, as well as spinal shortening and pseudobranchial tumours.

Introduction

The cod *Gadus morhua* L. is found in the cool temperate waters of the northern hemisphere, distributed in a variety of habitats from the shoreline to well down the continental shelf, in depths of 600 meter. It has been intensively studied because the cod is of commercial importance.

Gadus morhua is a predator, its food consists of a wide range of crustaceans, worms, brittlestars and fishes, among which are included herring, sandeels, capelin and smaller gadoid fishes. Although the food of gadoids is well known (e.g. EHRENBAUM 1936, HAGMEIER and KÜNNE 1950, KÜHL 1973), it is very important to carry out the investigations in a bordered study area.

During the last years, diseases of North Sea fishes gained in importance (Mc INTYRE and PEARCE 1980) and therefore the question whether the disease might be caused by pollution or not (e.g. SINDERMANN 1983). *Gadus morhua* turned out to be one of the most frequently afflicted species with a variety of externally visible disease phemomena (e.g. WATERMANN et al.1982). Since 1977 systematic fish-disease surveys were conducted in the German Bight (North Sea).

In the present study the diet and diseases of *Gadus morhua* from different stations around Helgoland in the German Bight (North Sea) were investigated.

Material and methods

Adult cod (*Gadus morhua*) were collected from May to the end of June 1988 at different stations around Helgoland in the German Bight (North Sea), seen in Figure 1. Three surveys with a total of 15 hauls were conducted with the RV "VICTOR HENSEN".

A semipelagic trawl and a bottom trawl was used to catch adult cod. Immediately after capture all cod were sorted and a subsample of up to 100 cod was investigated. For estimation of stomach fullness and diet 377 cod were investigated. The total length of cod was measured to the nearest lower centimeter.

Before dissection the cod were examined for any externaly visible diseases and ectoparasites. The stomach fullness was estimated on a relative scale out of 10 before the contents were removed and identified on board.

For the calculation of percentage presence of prey organisms only fish with food in their stomachs were considered

as regurgitation of stomach contents during capture could have taken place. All fish from each station were considered for the calculation of parasite infestation rates.

Results

Cod with body lengths between 17 cm and 71 cm were collected at different stations around Helgoland in the German Bight.

Investigations from May 1988 showed that the most important food items by volume are crustaceans, with fish and polychaetes making up a relatively small, but constant proportion of the diet (Tab.1+2). Fish were taken more by the smaller cod, especially the species *Ammodytes* spp., whereas crustaceans (*Eupagurus bernhardus* and *Macropipus holsatus*) were taken more by the larger ones.

The food of cod, collected during June, consisted in generally of crustaceans, fish and polychaets. The most important food species observed at the beginning of June were *Crangon crangon* and *Ammodytes* spp. (Tab.3). Smaller cod showed a higher prey-diversity. At the end of June *C. crangon* was observed as the most important food species, whereas the crustaceans *Eupagurus bernhardus* and *Macropipus holsatus* were also found in high abundances (Tab.4+5). For percentage composition of diet see Tables 1-5.

Highest infestation rates of the parasite *Lernaeocera branchialis* was found in cod with body lengths between 30 cm and 45 cm. Smaller and larger specimen showed lower rates during all time of investigation (Tab.6-8). A slight infestation of the parasit *Clavella adunca* was observed during June, as well as spinal shortening, pseudobranchial tumours and branchial ulcers (Tab.7+8). For percentage composition of diseases see Tables 6-8.

Moreover, one unusual infestation was noticed: the occurence of *Mytilus edulis* as an epizootic organisim upon *Lernaeocera branchialis* parasites in the gill cavity was observed (Fig.2).

Discussion

The investigation of stomach contents of adult cod demonstrated that the present results are corraborated by the

results of previous studies (EHRENBAUM 1936, HAGMEIER and KÜNNE 1950, KÜHL 1973), undertaken in North Sea waters. Although crustaceans dominate, there are differences between the major prey species found in this survey compared to the above authors' results. This is probably due to regional differences in the composition of the benthic and pelagic fauna. KÜHL(1973) found that *Crangon crangon* and mysids were the main prey species in the diet of *G. morhua* from the Elbe estuary. Whereas in the present study of cod collected around Helgoland, crustaceans and fish were the dominant prey with some polychaets, gastropods and bivalves being taken as well.

The diet of *G. morhua* changes as the fish get larger, switching from small crustaceans, such as prawns (*C. crangon*), mysids and amphipods to crabs (*Eupagus bernhardus* and *Macropipus holsatus*). Linkeds with this is a reduction of the species diversity of the diet.

With the smaller cod, body lengths up to 30 cm, *C. crangon* was the predominant prey species, with *Ammodytes* spp. and *Eupagurus bernhardus*, polychaetes and *Ophiura* spp. also featuring prominantly. The smallest cod, body length 17 cm, were found to have eaten some fish larvae, *C. crangon* and *Ammodytes* spp., which are pelagic.

In larger cod, body lengths from 45 cm and over, flatfish remains were found in their stomachs, such as *P. platessa, S. solea* and *L. limanda*. No flatfish were found in smaller cods. When cod reach a body length of 45 cm, crabs, such as *Macropipus holsatus, Eupagurus bernhardus* and *Corystes* spp. become the main prey species, with *Macropipus holsatus* dominanting compared with fish. KÜHL(1973) found that *Carcinus maenas* was a dominant prey species of *G. morhua* in the Elbe estuary. Beyond the estuary the composition of food of the older cod was richer. Polychaets were important components, also *M. holsatus*, sprat, small whiting and flatfishes. In this survey no *C. maenas* were found in the diet of North Sea cod.

Holothurians and *Buccinum undatum* were found in the stomach of some cods, especially larger ones. KÜHL(1973) did not find any holothurian in the *G. morhua* he examined. This could mean that holothurians are only regionally important as prey items or seasonally.

Large cod are more active predators - so it its possible for them to capture more fish. However, the trend towards becoming more piscivorous, exists.

In *G. morhua* with body lengths between 30 and 45 cm highest infestation rates with the parasite *Lernaeocera branchialis* were observed. A slight infestation with the parasite *Clavella adunca* as well as spinal shortening, pseudobranchial tumours and branchial ulcers of cod were found. Diseases of cod, which were systematically recorded in the

German Bight within the last few years (DETHLEFSEN 1984,1988). Moreover, one unusual infestation, first described by SLINN(1957) was observed: *Mytilus edulis* growing on a *Lernaeocera* in the gill cavitiy. Damage to inside of gill cover from abrasion of shells, as well as extensive damage and destruction of gill filaments was also noticed. This phenomen was also described by BANNING(1974), who investigated *G. morhua* from Dutch coastal waters.

Literature

BANNING, P. van (1974): Two remarkable infestations by *Lernaeocera* spp.(Copepoda parasitica). J.Cons.int.Explor Mer, 35 (2), 205-206.

DETHLEFSEN, V.(1984): Diseases in North Sea fishes. Helgoländer Meeresunters. 37, 353-374.

DETHLEFSEN, V.(1988): Ten years fish disease studies of the Federal Research Board Fisheries Hamburg. ICES C.M./ E:23, 26pp.

EHRENBAUM, E.(1936): Naturgeschichte und wirtschaftliche Bedeutung der Seefische Nordeuropas. Handb. Seefisch. Nordeuropas. Bd.2.

HAGMEIER, A., KÜNNE, C.(1950): Die Nahrung der Meerestiere. Handb. Seefisch. Nordeuropas. Bd.1 (5a/b), 1-542.

KÜHL, H.(1973): Nahrungsuntersuchungen an einigen Gadiden im Elbe-Mündungsgebiet. Arch.FischWiss. 24, 141-149.

McINTYRE, A.D., PEARCE, J.B.(eds.), (1980): Biological effects of marine pollution and the problems of monitoring. Rapp.P.-v.Reun.Cons.int.Explor.Mer 179, 1-346.

SINDERMANN, C.J.(1983): An examination of some relationships between pollution and disease. Rapp.P.-v.Reun. Cons.int.Explor.Mer 182, 37-43.

SLINN, D.J.(1957): *Mytilus* epizootic upon *Lernaeocera*. Rep. Mar.Biol.Sta.Port Erin 70, 23-26.

WATERMANN, B., DETHLEFSEN, V., HOPPENHEIT, M.(1982): Epidemiology of pseudobranchial tumours in Atlantic cod (*Gadus morhua*) from the North Sea and the Baltic Sea. Helgoländer Meeresunters. 35, 231-242.

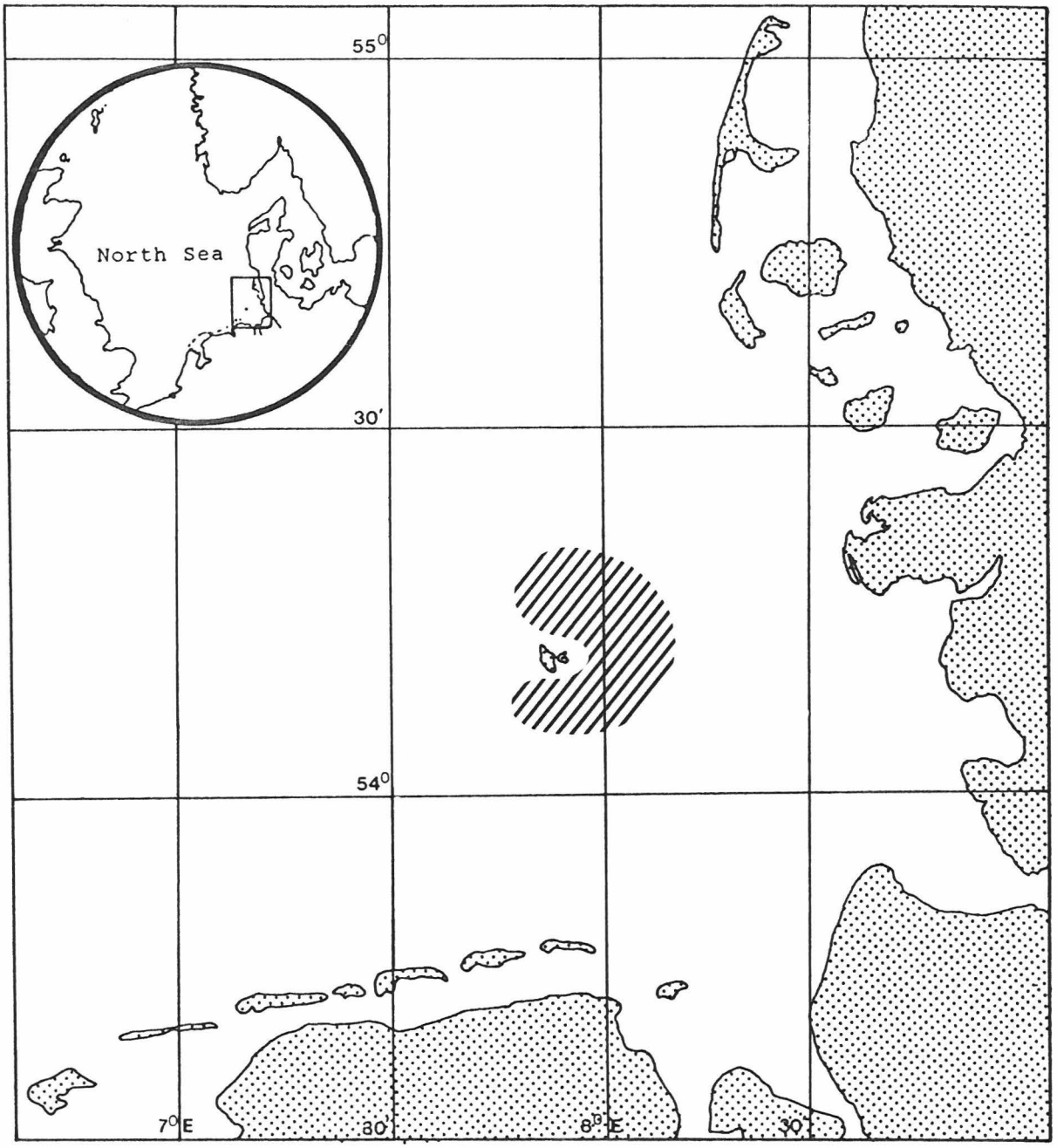

Fig.1: Study area in the German Bight (North Sea). The capture area is marked by lines.

Species	Size class 33-45 cm n=30		Size class 46-70 cm n=24	
Ammodytes spp.	1	3,33%	1	4,17%
Limanda limanda	1	3,33%	4	16,67%
Solea solea	1	3,33%	--	----
Agonus cataphrac.	--	----	4	16,67%
Merlangius merl.	--	----	1	4,17%
P. platessa	--	----	1	4,17%
Flat fish remains	--	----	3	12,50%
Fish remains	4	13,33%	8	33,33%
Eupagurus bernh.	15	50,00%	8	33,33%
Macropipus holsat.	14	46,67%	14	58,33%
Corystes cassiv.	--	----	1	4,17%
Crangon spp.	10	33,33%	6	25,00%
Mysis spp.	1	3,33%	1	4,17%
Galatea spp.	1	3,33%	--	----
Crustacean remains	5	16,67%	3	12,50%
Nereis spp.	5	16,67%	2	8,33%
Aphrodite aculeata	8	26,67%	3	12,50%
Polychaeta remains	8	26,67%	1	4,17%
Buccinum undatum	6	20,00%	5	20,83%
Nemertini remains	2	6,67%	--	----
Ophiura spp.	2	6,67%	2	8,33%
Holothurian	--	----	1	4,17%

Species	Size class 33-45 cm n=30		Size class 46-70 cm n=24	
Fish	7	23,33%	15	62.50%
Crustaceans	24	80,00%	21	87,50%
Polychaeta	18	60,00%	6	25,00%
Gastropoda	6	20,00%	7	29,17%
Nermertins	2	6,67%	--	----
Ophiura	2	6,67%	2	8,33%
Holothurian	--	----	1	4,17%

Tab.1: Presence of organisms in the diet of Gadus morhua, collected at "Tiefe Rinne" 11.05.1988. Summary on the bottom.

Species	Size class 19-25 cm n=21		Size class >31 cm n=13	
Ammodytes spp.	9	43,37%	5	38,46%
Clupea harengus	--	----	2	15,38%
Fish larvae	6	31,58%	--	----
Fish remains	3	15,79%	1	7,69%
Flatfish remains	--	----	1	7,69%
Eupagurus bernhardus	6	31,58%	1	7,69%
Macropipus holsatus	3	15,79%	5	38,46%
Crangon spp.	5	26,32%	2	15,38%
Mysis spp.	3	15,79%	1	7,69%
Crustacean remains	1	5,26%	3	23,08%
Nereis spp.	4	21,05%	--	----
Polychaeta remains	2	10,53%	2	15,38%
Nemertine remains	--	----	1	7,69%
Buccinum undatum	1	5,26%	1	7,69%
Ophiura spp.	1	5,26%	--	----

Species	Size class 19-25 cm n=21		Size class 26 cm n=13	
Fish	18	94,74%	7	58,85%
Crustaceans	13	68,42%	9	69,23%
Polychaeta	6	31,58%	2	15,38%
Gastropoda	1	5,26%	1	7,69%
Ophiura	1	5,26%	--	----
Nemertins	--	----	1	7,69%

Tab.2: Presence of organisms in the diet of Gadus morhua, collected at "East Helgoland" 10.05.1988. Summary on the bottom.

Species	Size class 17-30 cm n=47		Size class 31-42 cm n=21	
Ammodytes spp.	14	29,79%	6	28,57%
Fish remains	10	21,28%	10	47,62%
Fish larvae	1	2,13%	--	-----
Fish eggs	2	4,26%	3	14,29%
Eupagurus bernhardus	4	8,51%	3	14,62%
Macropipus holsatus	4	8,51%	5	23,81%
Corystes cassivel.	2	4,26%	3	14,62%
Crangon spp.	16	34,04%	8	38,10%
Mysis spp.	9	19,15%	2	9,52%
Amphipoda	4	8,51%	--	----
Galatea spp.	2	4,26%	--	----
Cumacean	--	----	1	4,76%
Crustacean remains	4	8,51%	2	9,52%
Aphrodite aculeata	1	2,13%	--	----
Nereis spp.	1	2,13%	1	4,76%
Polychaeta remains	11	23,40%	4	19,05%
Buccinum undatum	3	6,38%	1	4,76%
Nucula spp.	2	4,26%	--	----
Holothurian	1	2,13%	1	4,76%
Ophiura spp.	1	2.13%	--	----
Unidentifiable rems.	2	4,26%	--	----

Species		Size class 17-30 cm n=47		Size class 31-42 cm n=21	
Fish		23	48,94%	16	76,19%
Crustaceans		32	68,09%	15	71,43%
Polychaeta		14	29,79%	5	23,81%
Gastropoda		3	6,38%	1	4,76%
Holothurians		2	4,26%	1	4,76%
Bivalvia		2	4,26%	--	----

Tab.3: Presence of organisms in the diet of Gadus morhua, collected at "North Helgoland" 04.06.1988. Summary on the bottom.

Species	Size class 18-30 cm n=17		Size class 31-40 cm n=17		Size class 41-50 cm n=46		Size class 51-71 cm n=7	
Macropius holsatus	2	11,76%	6	17,64%	26	56,52%	4	57,14%
Eupagurus bernhardus	11	64,71%	11	66,71%	23	50,00%	4	57,14%
Corystes cassivel.	--	----	--	----	1	2,17%	--	----
Cancer pagurus	--	----	--	----	3	6,52%	--	----
Galatea spp.	--	----	2	11,76%	--	----	--	----
Crustacean remains	--	----	--	----	4	8,70%	--	----
Aphrodite aculeata	2	11,76%	4	23,53%	9	19,57%	3	42,86%
Polychaeta remains	--	----	--	----	1	2,17%	1	14,29%
Crangon spp.	8	47,06%	2	11,76%	4	8,70%	1	14,29%
Flatfish remains	--	----	--	----	1	2,17%	--	----
P. platessa	--	----	--	----	2	4,35%	--	----
M. merlangius	--	----	--	----	1	2,17%	--	----
Callionymus lyra	--	----	--	----	1	2,17%	--	----
Fish remains	1	5,88%	1	5,88%	5	10,87%	5	71,43%
Bivalvia	2	11,76%	1	5,88%	2	4m35%	2	28,57%
Buccinum undatum	1	5,88%	3	17,65%	5	10,87%	--	----
Gastropoda	1	5,88%	--	----	--	----	--	----
Ophiura spp.	2	11,76%	--	----	3	6,52%	--	----
Amphipoda	1	5,88%	--	----	--	----	--	----
Unidentifiable rems.	1	5,88%	--	----	--	----	--	----

Species	Size class 18-30 cm n=17		Size class 31-40 cm n=17		Size class 41-50 cm n=46		Size class 51-71 cm n=7	
Fish	1	5,88%	1	5,88%	11	23,91%	5	71,43%
Crustaceans	15	88,24%	16	94,12%	42	91,30%	7	100,00%
Polychaeta	2	11,76%	4	23,53%	10	21,74%	3	42,86%
Gastropoda	2	11,76%	3	17,65%	5	10,87%	--	----
Bivalvia	2	4,76%	1	5,88%	2	4,35%	2	28,57%
Ophiura	2	11,76%	--	----	3	6,52%	--	----
Unidentif. rems.	1	5,88%	--	----	--	----	--	----

Tab.4: Presence of organisms in the diet of Gadus morhua, collected at "Tiefe Rinne" 22.06.1988. For all prey species presence, only fish with food in stomachs were considered. Summary on the bottom.

Species	Size class 20-41 cm n=41	
Sprattus sprattus	4	9,76%
Callionymus lyra	1	2,44%
Fish remains	1	2,44%
Macropius holsatus	10	24,39%
Eupagurus bernhardus	11	26,83%
Corystes cassivel.	3	7,32%
Crangon spp.	28	68,29%
Mysis spp.	8	19,51%
Amphipoda	2	4,88%
Cumacean	1	2,44%
Crustacean remains	6	14,63%
Polychaeta remains	15	36,59%
Ophiura spp.	2	4,88%
Bivalvia	3	7,32%
Unidentifiable rems.	1	2,44%

SUMMARY

Species	Size class 20-41 cm n=41	
Fish	6	14,63%
Crustaceans	38	92,68%
Polychaeta	13	31,71%
Ophiura	2	4,88%
Bivalvia	3	7,32%

Tab.5: Presence of organisms in the diet of Gadus morhua, collected at "North Helgoland" 21.06.1988. All fish grouped into one size class because there are only 8 fish between 31-41 cm.

Parasite	Size class 33-45 cm n=34	Size class 46-70 cm n=25
Lernaeocera	23 67,65% 1 with Mytilus	12 48,00% 1 with Mytilus

Parasite	Size class 19-25 cm n=24	Size class 31 cm n=14
Lernaeocera	8 33,30%	9 64,29%

Tab.6: Infestation rates with Lernaeocera branchialis, on the top: "Tiefe Rinne", on the bottom: "East Helgoland" 10./11.05.1988.

Parasite	Size class 17-30 cm n=59	Size class 31-42 cm n=28
Lernaeocera	16 27,12%	17 60,71% 1 with Mytilus
Clavella	7 11,86%	5 17,86%
Pseudobranchial tumours	1 5,00%	

Tab.7: Diseases and infestation rates with parasites, "North Helgoland" 04.06.1988.

Parasite	Size class 18-30 cm n=24		Size class 31-40 cm n=18		Size class 41-50 cm n=46		Size class 51-71 cm n=7	
Lernaeocera	6	25,00%	10	55,56%	30	65,22%	3	42,86%
Clavella	1	4,17%	1	5,56%	--	----	--	----
Spinal shortening	4	4,21%						
Pseudobranchial tumours	1	1,05%						
Brachial ulcers	1	1,05%						

Parasite	Size class 20-41 cm n=46	
Lernaeocera	14	30,43%
Spinal shortening	2	4,17%

Tab.8: Diseases and infestation rates with parasites, all fish in length class considered. On the top: "Tiefe Rinne" 22.06.1988, on the bottom: "North Helgoland" 21.06.1988.

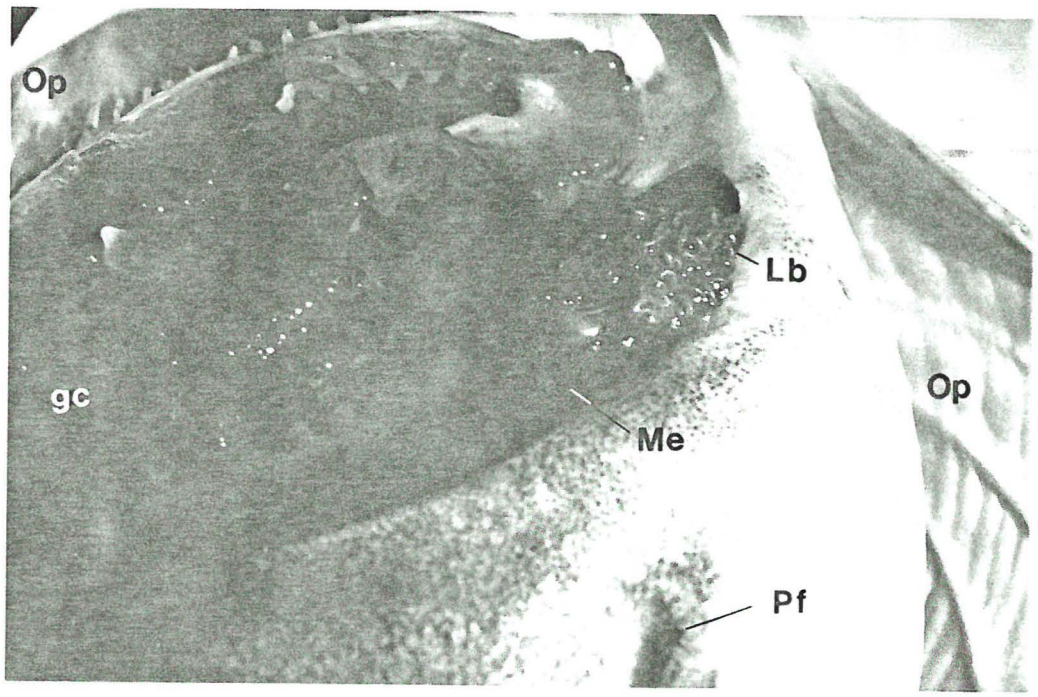

Fig.2: Lateral ventral view of G. morhua with Mytilus edulis on Lernaeocera branchialis parasites in the gill cavity. Size of cod: 34 cm body length, maximal length of M. edulis: 26 mm, maximal width at widest point: 14 mm. gc=gill cavity, Lb=Lernaeocera branchialis, Me=Mytilus edulis, Op=operculum, Pf=Pelvic fin.