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The potential direct and indirect effects of grey seal on Baltic cod

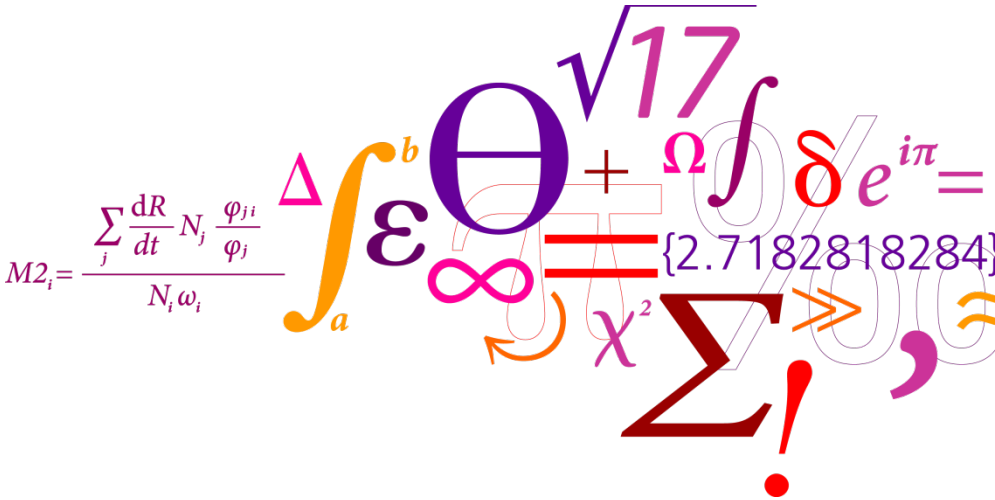
Jane W. Behrens[1], Niels G. Andersen[1], Kurt Buchmann[2], Anders Galatius[3], Jakob Hemmer-Hansen[1], Bastian Huwer[1], Per W. Kania[2], Anne-Mette Kroner[1], Uwe Krumme[4], Karl Lundström[5], Morten Tange Olsen[6], Marie Plambech[1], Peter Skov[1], Maria Sokolova[1] & Lotte Kindt-Larsen[1].

1: DTU Aqua, 2: KU-SUND, 3: AU, 4: Thünen Institute 5: SLU, 6: KU

During the past few decades, the Baltic grey seal (*Halichoerus grypus grypus)* population size has increased significantly. The grey seal is a top predator known to consume a wide range of fish species depending on prey availability, geographical area and season. Grey seal is also final host to the nematode parasite *Contracaecum osculatum* (commonly referred to as cod liver worm), to which cod (*Gadus morhua*) is one of several transport hosts. Here we present data on the spatial occurrence of *C. osculatum* in cod livers in 321 fish sampled from Skagerrak to south of Gotland. Prevalence of infection was high (90-100%) in the three most eastern areas, decreasing towards the west and northwestward. Abundance of infection (number of parasites per infected fish) was likewise highest in the most eastern areas, mean abundances varying from 27 to 40 parasites. Preliminary analysis suggests that the nutritional status of the fish (evaluated by protein, water, oil and energy content of fish and liver) is affected when the parasite load is high. Several countries have now initiated visual registrations of *C. osculatum* in cod livers during monitoring surveys. We evaluate the applicability and pitfalls of these routine registrations of liver worm. At present also the direct – through consumption – effect of grey seals on cod in the central and western Baltic is unknown. To investigate this, 820 scats were collected at Måkläppen, Tat, Rødsand, and Utklippan. Two methods were used to assess the prey composition – molecular analysis and otolith analysis of scats. The DNA analysis suggests that cod, garfish, herring, sprat, flatfishes and sandeel comprise a major part of the grey seal diet when estimated as frequency of occurrence. Cod was likewise found to be the most frequently occurring species in the otolith analysis, followed by flatfishes, sandeel, unidentified codfishes (Gadidae), herring and whiting. However, in terms of biomass, cod comprised 83% of the total consumption by grey seals – more than ten times the amount of flatfishes (8%) as the second most abundant prey. In total, grey seals in the south Central and Western Baltic had an annual consumption per individual of 1370 kg cod. This high proportion of cod in the diet of grey seals in the central and western Baltic calls for further assessments of the impact of the seals on the Baltic cod stock.

The potential direct and indirect effects of grey seal on Baltic cod

Jane W. Behrens



DTU Aqua
National Institute of Aquatic Resources

Cod liver worm (*Contracaecum osculatum*) lifecycle

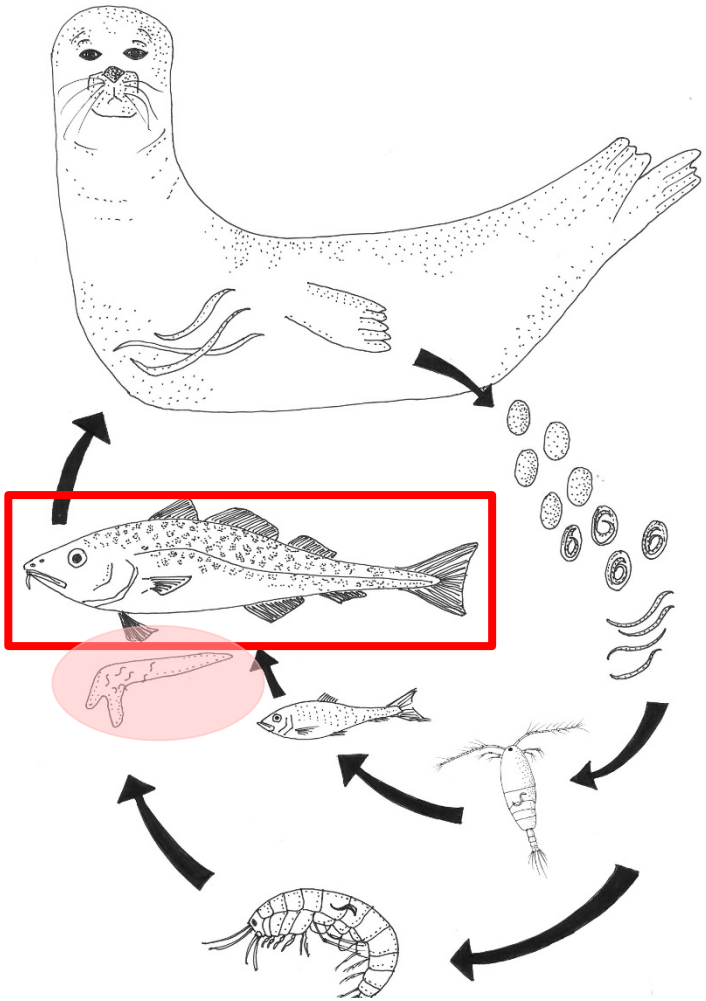


Illustration by Kurt Buchmann, copyright International Wildlife Association, from Haarder et al 2014

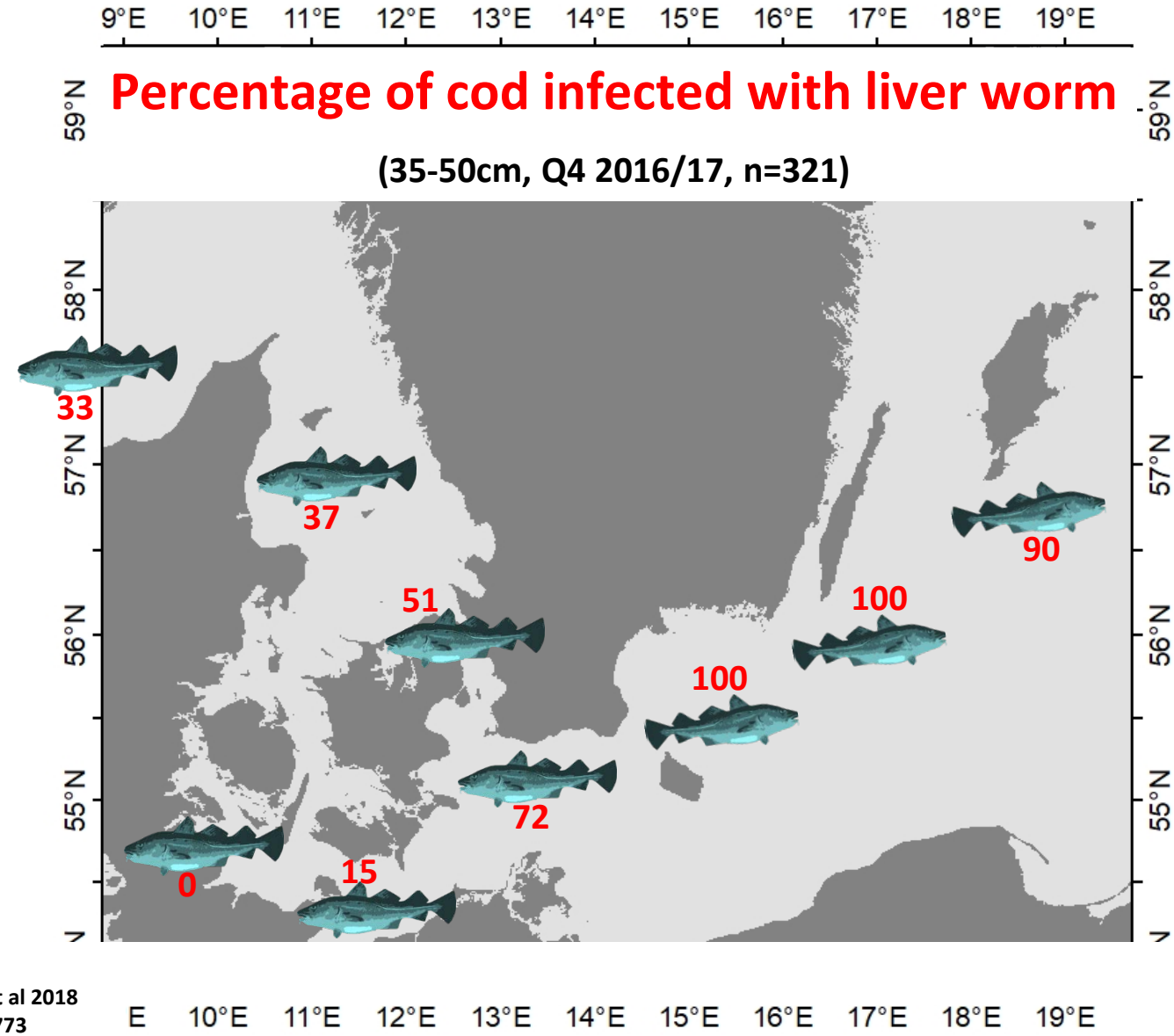
?? May liver worm affect the nutritional status of the fish??

central to many metabolic processes

storage site for energy

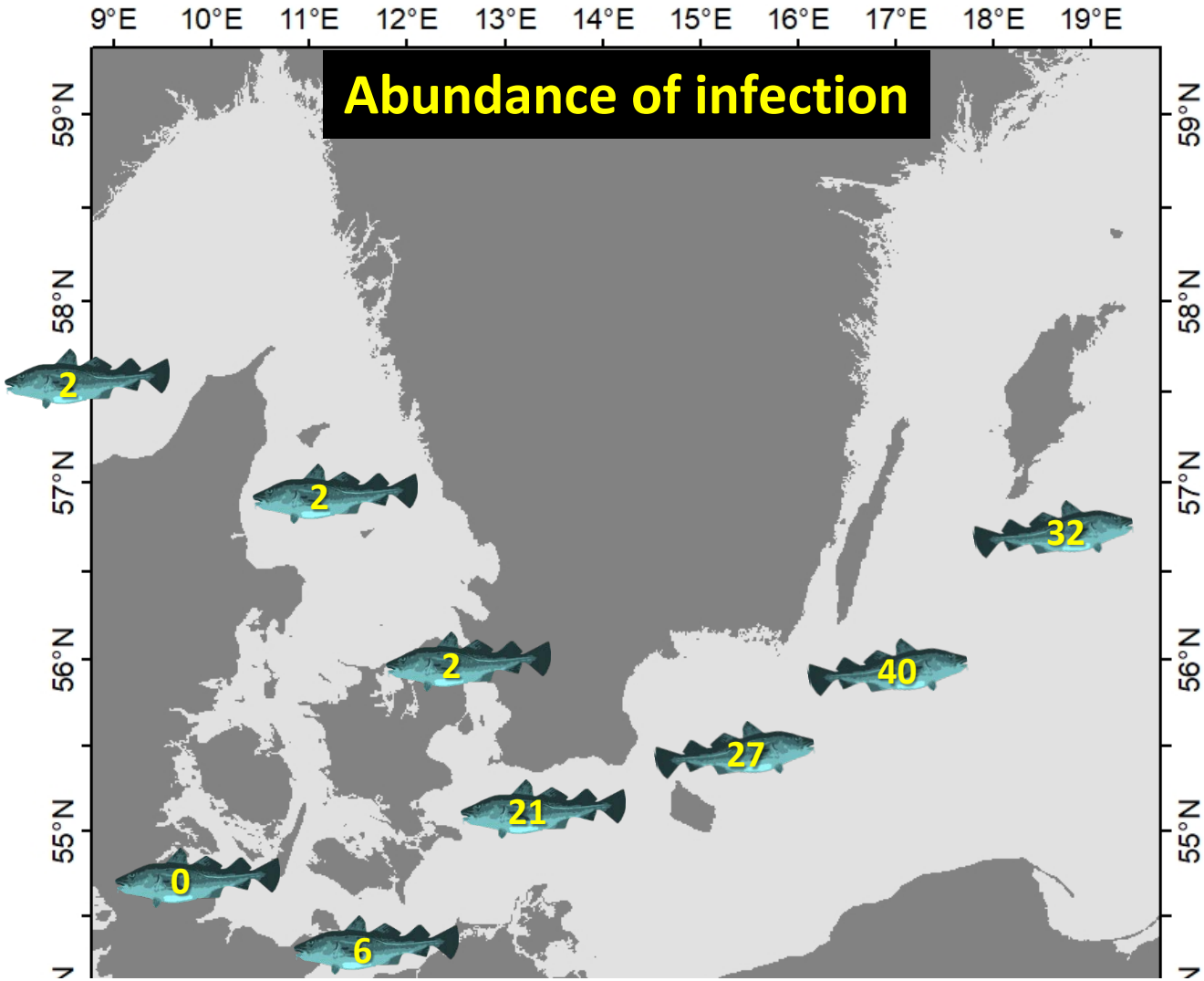
responsible for enzyme production relating to digestion and lipid uptake

Spatial occurence of liver worm in cod



Adapted from Sokolova et al 2018
doi.org/10.3354/meps12773

Spatial occurence of liver worm in cod



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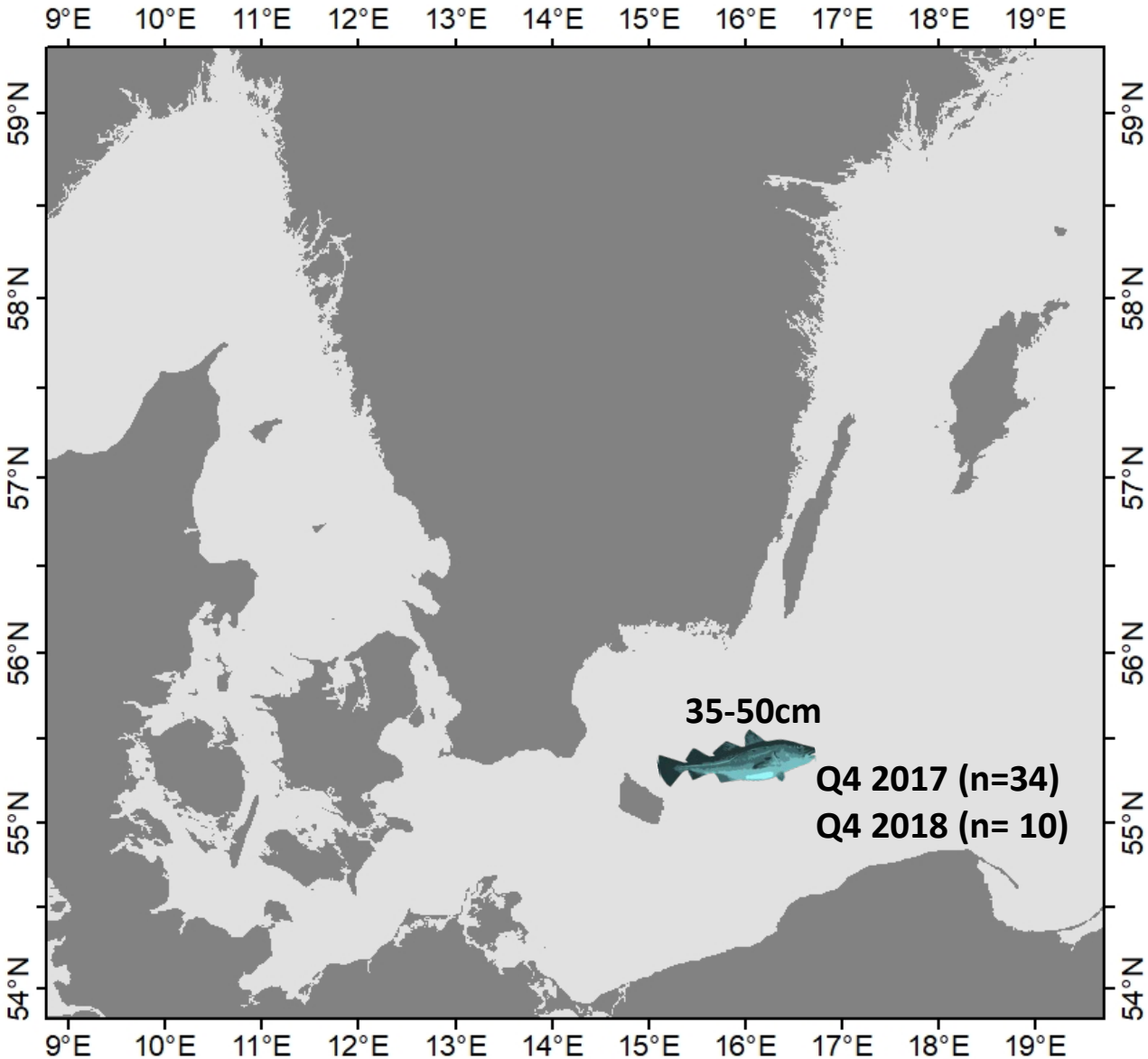
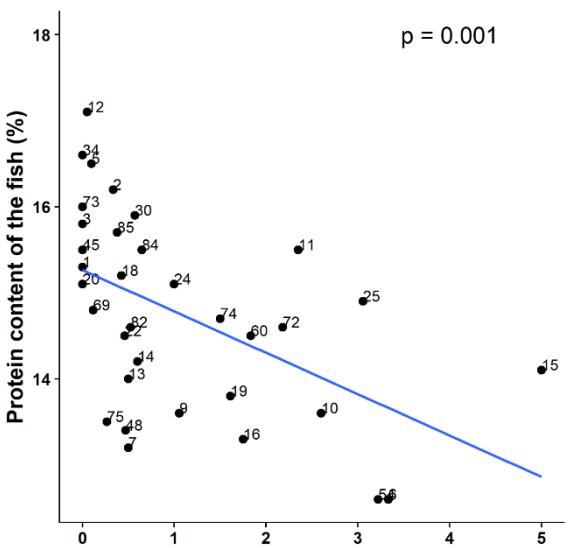
Is nutritional status affected by liver worm?

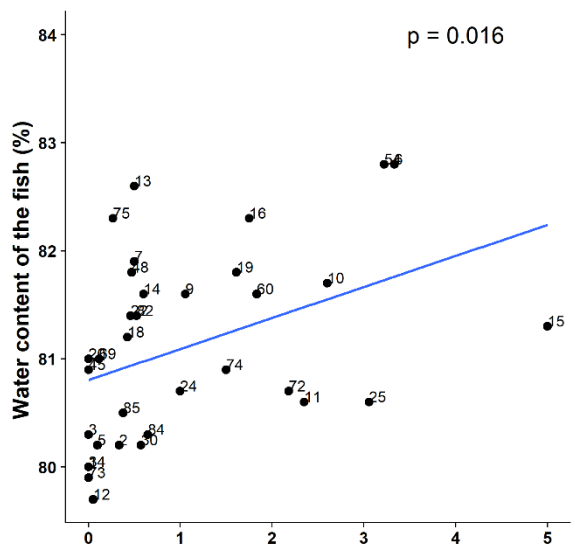


Is cod nutritional status affected by liver worm?

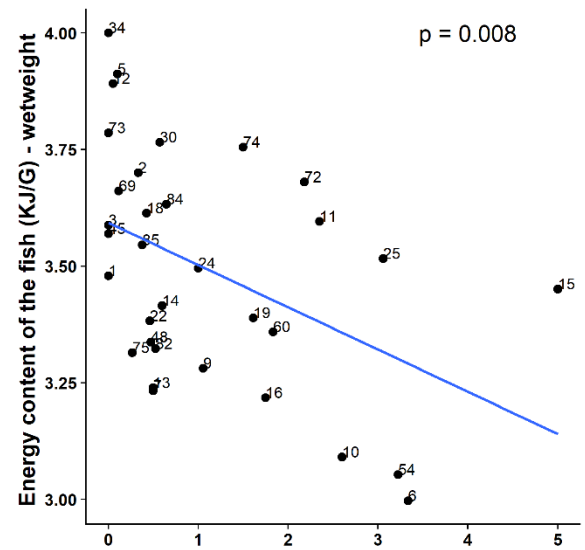
Fish protein content



Fish water content



Fish energy content

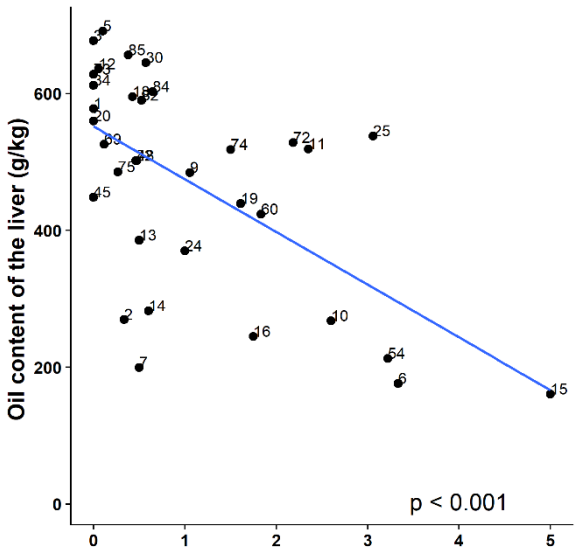


Infection rate (number of worms/ gram liver)

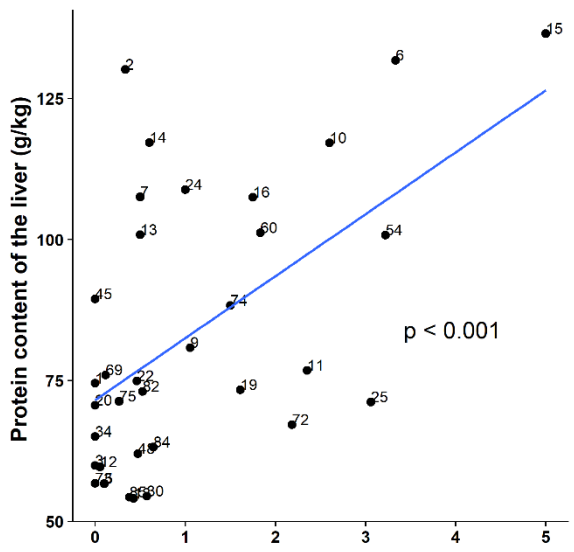
No change in oil content of the fish

Is cod nutritional status affected by liver worm?

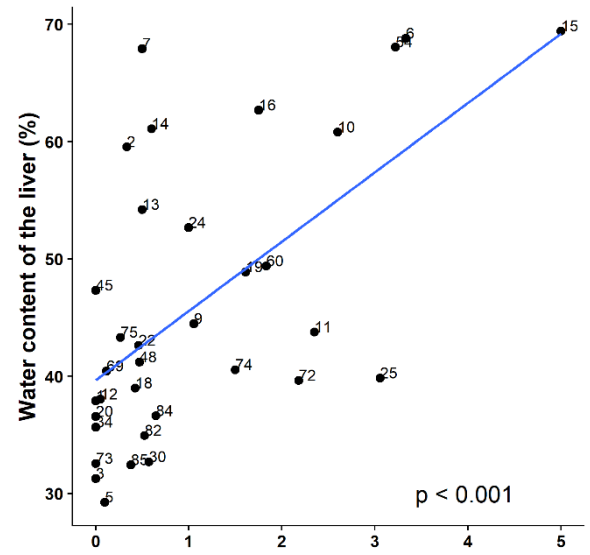
Liver oil content



Liver protein content



Liver water content

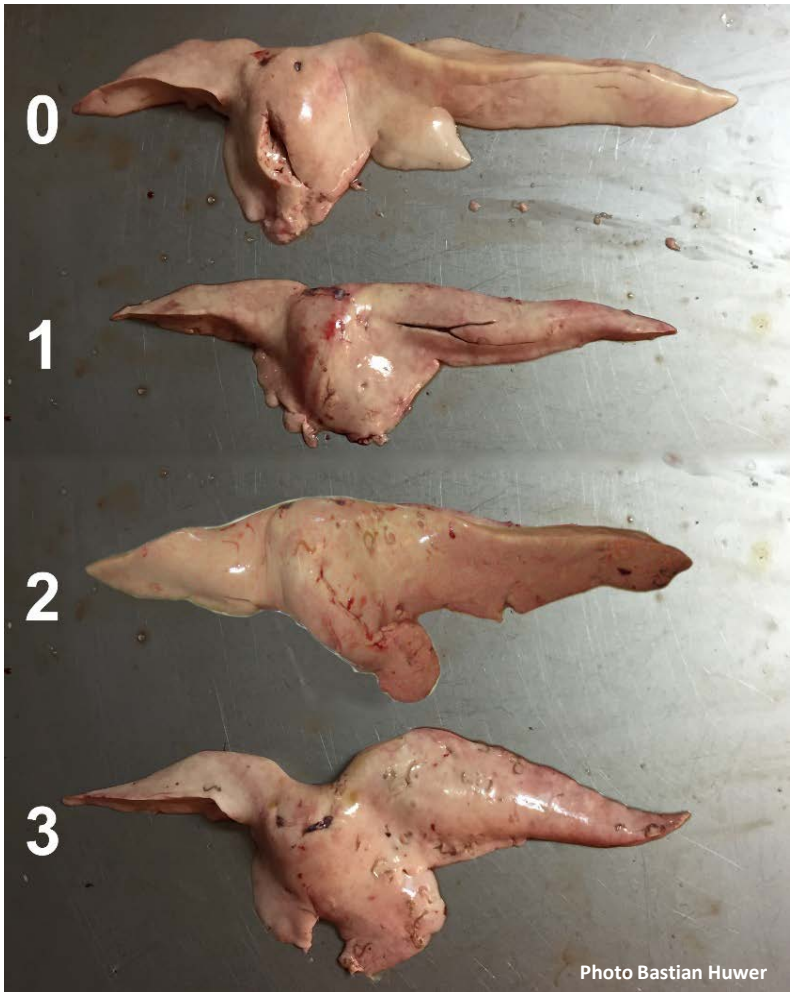


Infection rate (number of worms/ gram liver)

Visual registrations of liver worms on surveys

Category	# of parasites
0	0
1	1-10
2	11-20
3	>20

Institute/country	Registrations initiated
Poland	2013
Thünen	2015
DTU Aqua	2017
IHF Hamburg	2017
Estonia	2018
GEOMAR	2018
Latvia	2018
SLU	2018 (test)

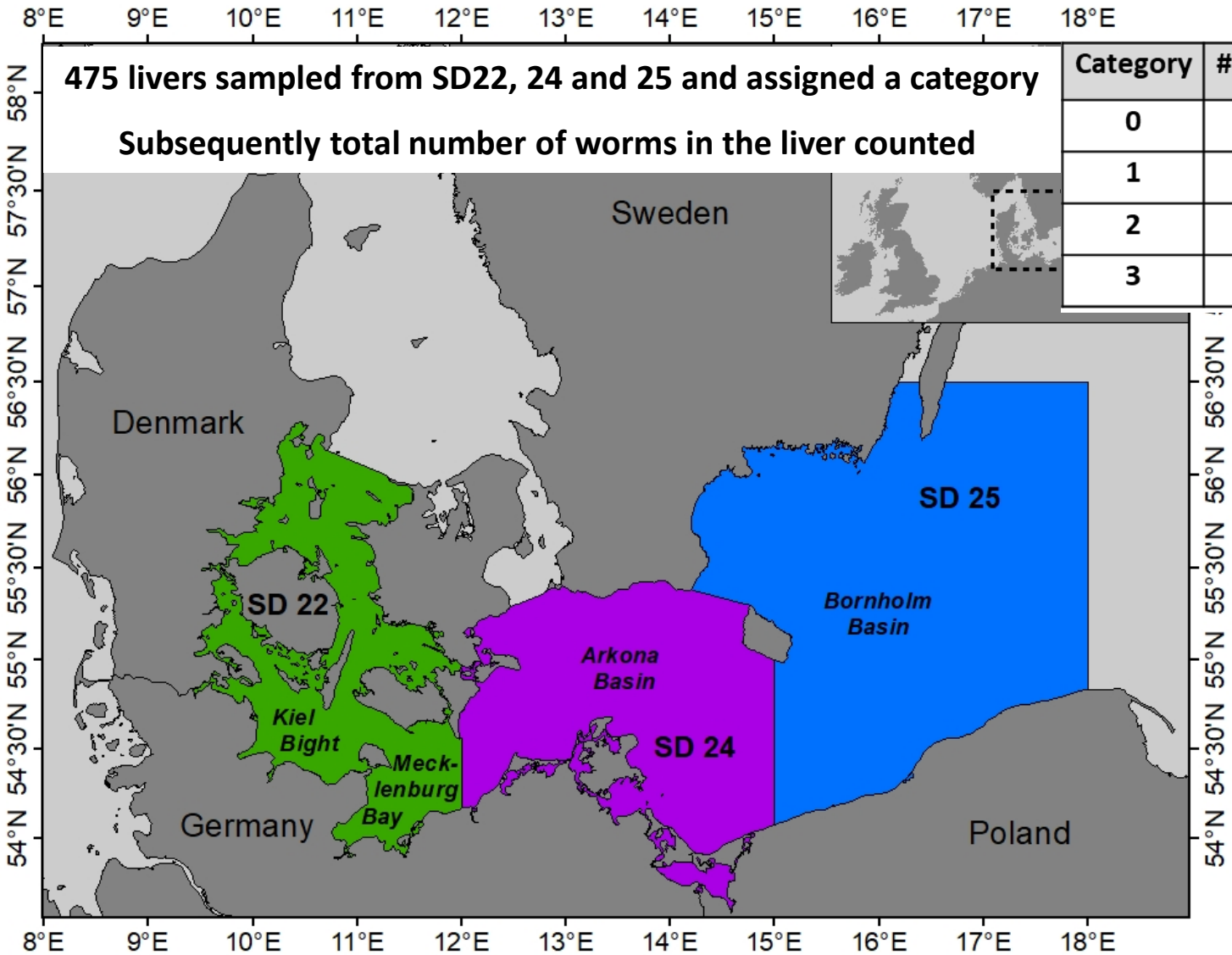


How (im)precisely do we predict total number of worms from categories?

475 livers sampled from SD22, 24 and 25 and assigned a category

Subsequently total number of worms in the liver counted

Category	# of parasites
0	0
1	1-10
2	11-20
3	>20



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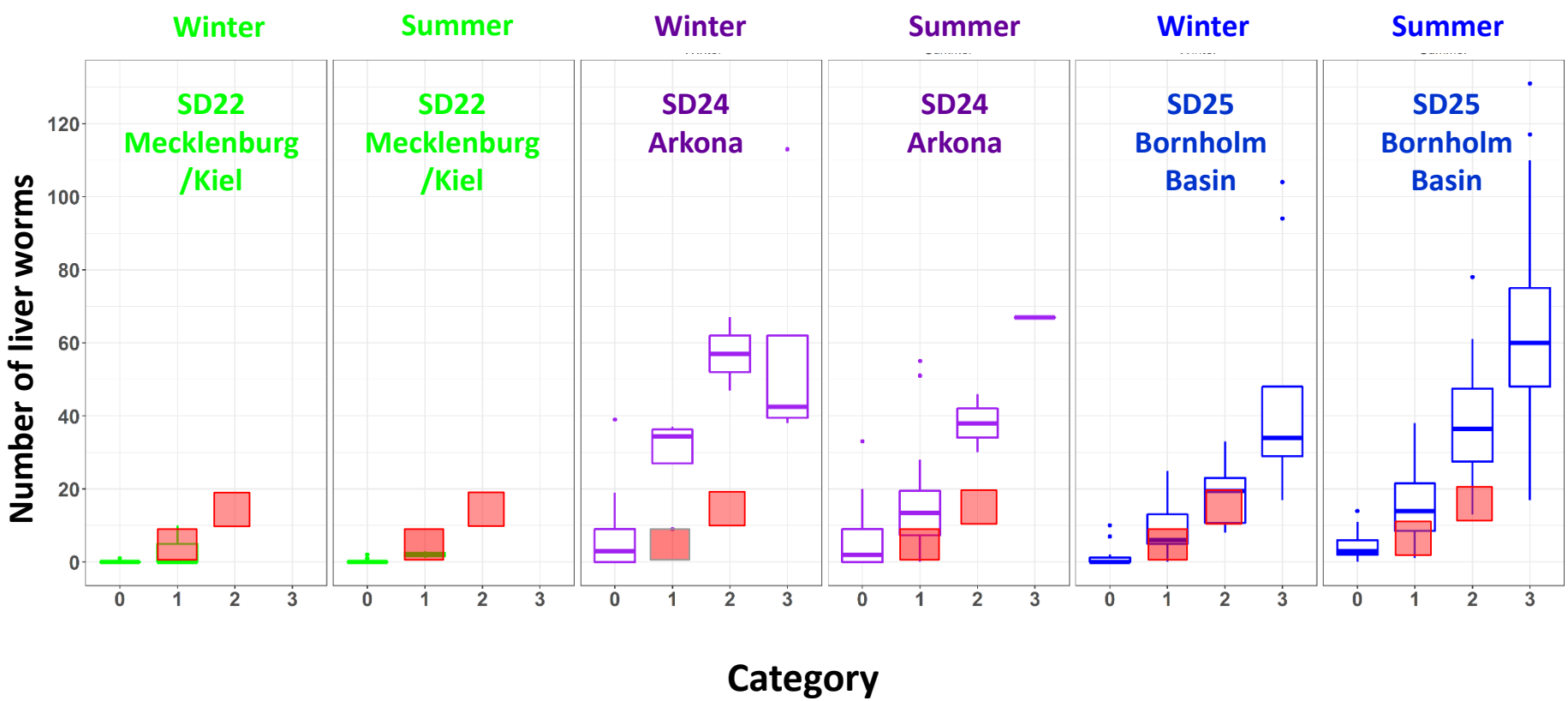
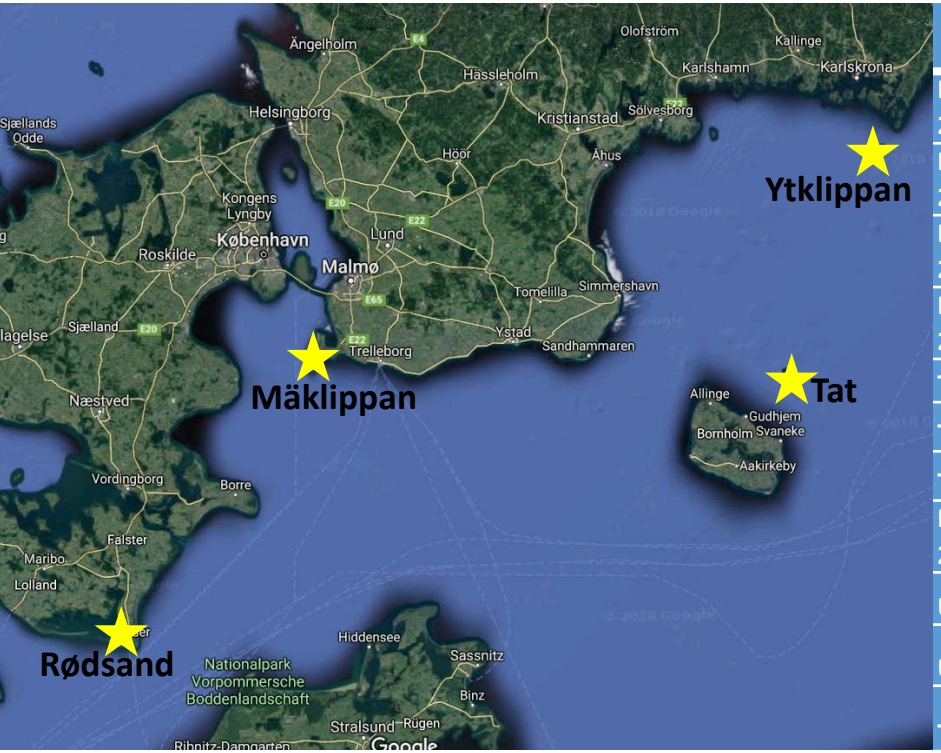


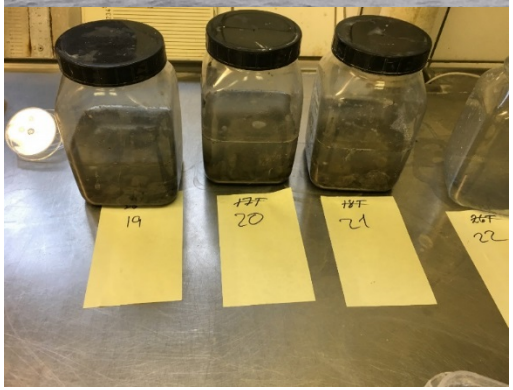
Collection sites for investigations of seal consumption

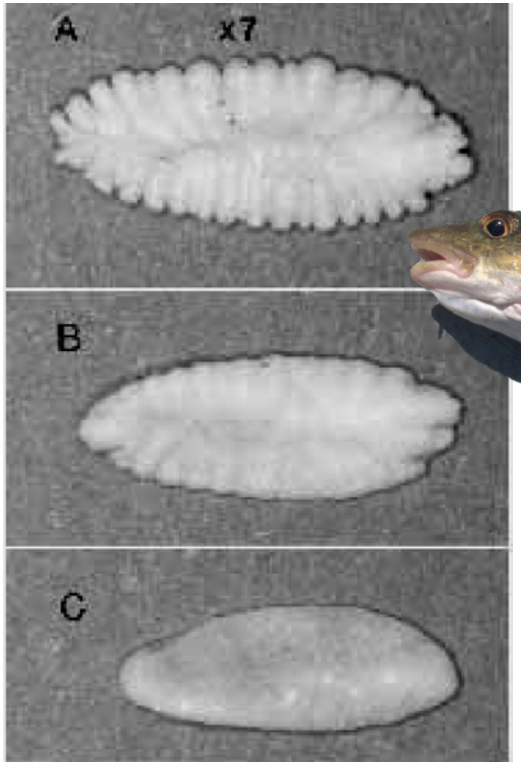


	Jan	Feb	Mar	Apr	Maj	Jun	Jul	Aug	Sep	Okt	Nov	Dec	Total
MÅK 2014				16	32		6	2	4		16		76
MÅK 2015				66	30	4				24			124
MÅK 2016	17			30	32	16		16					111
MÅK 2017	3				47	5							55
TAT 2015					5	10		10	5	19			49
TAT 2016	18	18	18	28		6	5	3			30		126
TAT 2017			9										9
RØD 2017			32		21		6	76		24			159
UTK 2016				4	29	1		5	2				39
UTK 2017			17	17	24	5	2	5					70
Total	38	18	76	161	218	47	19	117	11	67	46	0	820

Collaborative project SLU, KU, DTU

Seal scats for DNA and otoliths



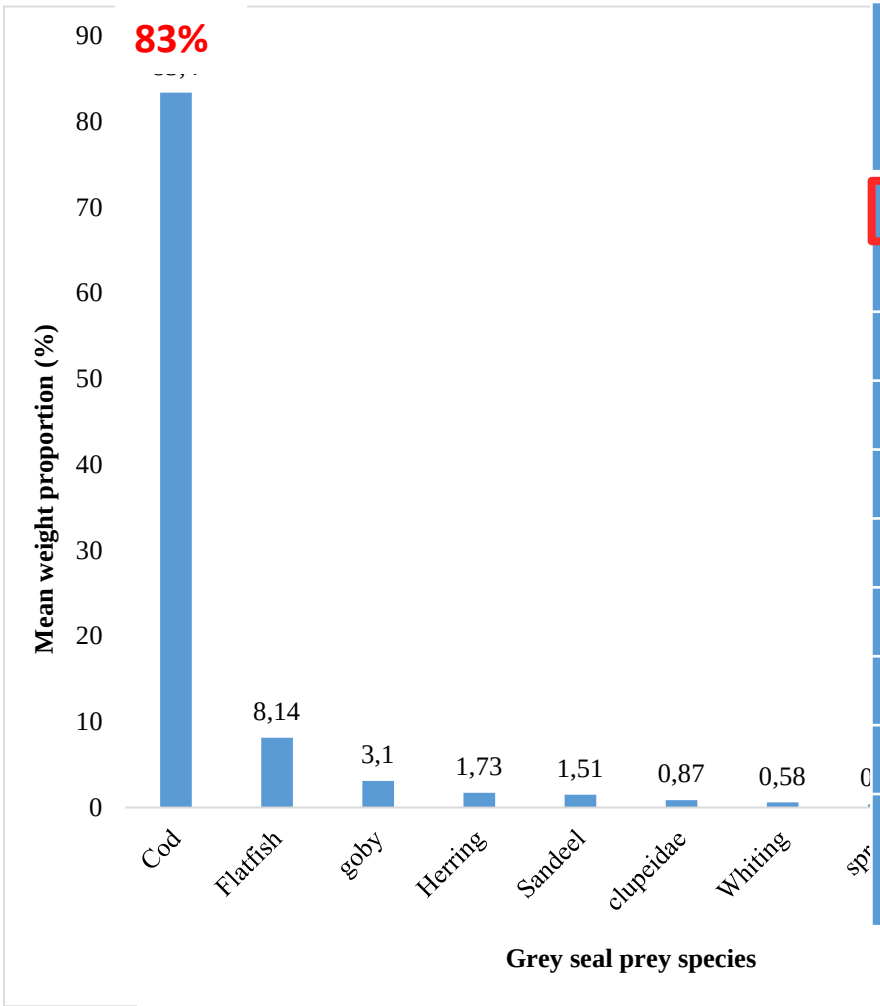


Family	Species	Common name	FO_{DNA}	$FO_{Otoliths}$
Gadidae	Gadus morhua	Atlantic cod	64.83	65.60
Belonidae	Belone belone	Garfish	38.62	
Clupeidae	Clupea harengus	Atlantic herring	37.24	10.55
Clupeidae	Sprattus sprattus	European sprat	33.79	4.13
Pleuronectidae	Pleuronectes/Platichthys	Flatfishes	18.62	21.10
Ammodytidae	Hyperoplus lanceolatus	Great sand eel	11.03	
Zoarcidae	Zoarces viviparus	Viviparous eelpout	7.59	
Lotidae	Enchelyopus cimbrius	Fourbeard rockling	5.52	3.21
Gadidae	Merlangius merlangus	Whiting	4.14	10.09
Cyclopteridae	Cyclopterus lumpus	Lumpsucker	3.45	
Ammodytidae	Ammodytes tobianus	Lesser sand eel	3.45	
Scophthalmidae	Scophthalmus rhombus	Brill	2.07	
Anguillidae	Anguilla anguilla	European eel	2.07	
Salmonidae	Salmo salar	Atlantic salmon	2.07	
Salmonidae	Salmo trutta	Brown trout	1.38	
Gasterosteidae	Gasterosteus aculeatus	Three-spined stickleback	1.38	
Gobiidae	Pomatoschistus minutus	Sand goby	1.38	
Gadidae	Pollachius virens	Saithe	0.69	
Gobiidae	Neogobius melanostomus	Round goby	0.69	
Esocidae	Esox lucius	Northern Pike	0.69	
Percidae	Perca fluviatilis	European Perch	0.69	
Gobiidae	Gobiusculus flavescens	Two-spotted goby	0.69	
Gobiidae	Gobius niger	Black goby	069	
Ammodytidae	Hyperoplus/Ammodytes	Sandeel		13.76
Gadidae	Gadus/Merlangius	Cod or whiting		12.84
Clupeidae	Clupea/Sprattus	Herring or sprat		7.34
Gobiidae	Gobius/Neogobius	Goby		5.05
Pleuronectidae	Limanda limanda	Common dab		1.83

Otoliths found in 218 of the 820 samples

145 samples analysed for **DNA (**Mäklippan and Tat) - ongoing

Weight proportions and consumed biomass



Prey species	Daily consumption (kg)	Annual consumption per seal (kg)
Cod	3.8	1370
Flatfish	0.4	134
Goby	0.1	51
Herring	0.1	28
Sandeel	0.1	25
Clupeidae	0.03	14
Whiting	0.03	10
Sprat	0.02	6
Dab	0.01	3
Cod/Whiting	0.004	2

Contributors

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Uwe krumme - Thünen Institute

Morten Tange Olsen – KU

Anders Galatius - AU

Karl Lundström - SLU

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BONUS