Food availability and predator/prey relationships in a dynamic ecosystem

Kurt Buchmann

University of Copenhagen, Denmark

Mundo Matongé (Mundo-b)
Rue d'Edimbourg 26, 1050 Ixelles
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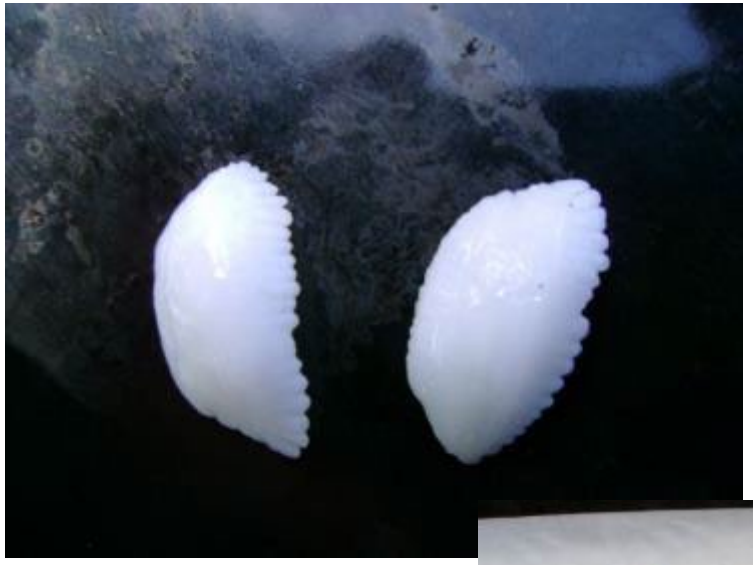
KØBENHAVNS UNIVERSITET

The Baltic cod population and Baltic fisheries - Trends

- A view from 1970s to 2024 from a look-out in a cross-tree standing in the main spawning area – The Bornholm Basin
- Factors explaining the variations can be deducted by looking into historical documents about fisheries and fishermen on the island of Bornholm and the Christiansø (islets next to the spawning zone)

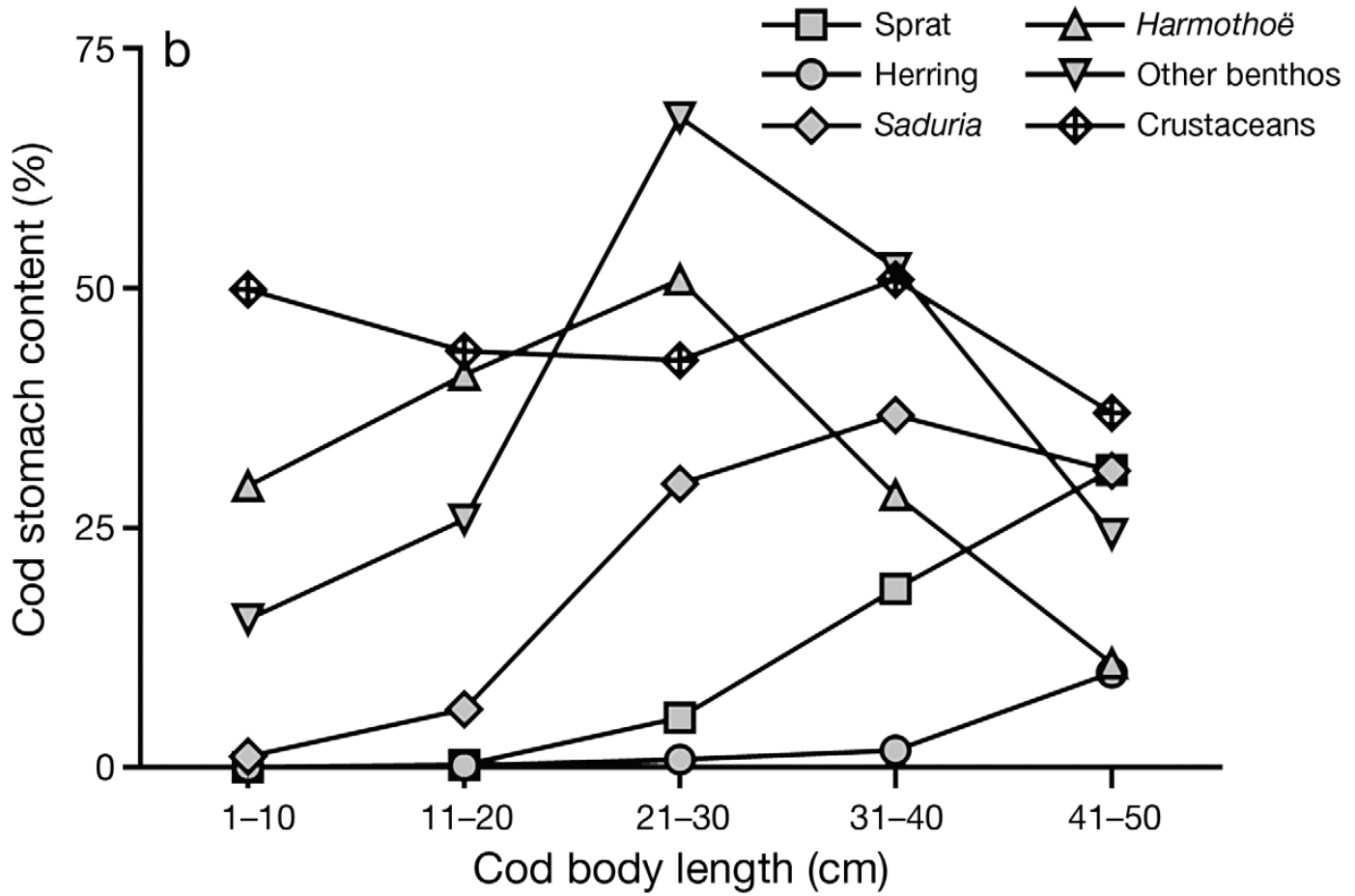
Since the 1970s I have had the opportunity to conduct examinations of Baltic cod from the Baltic Sea – both juveniles and adult spawners. The investigations have elucidated both food availability/preferences and parasites.

Food, health, quality and parasites of the Baltic cod

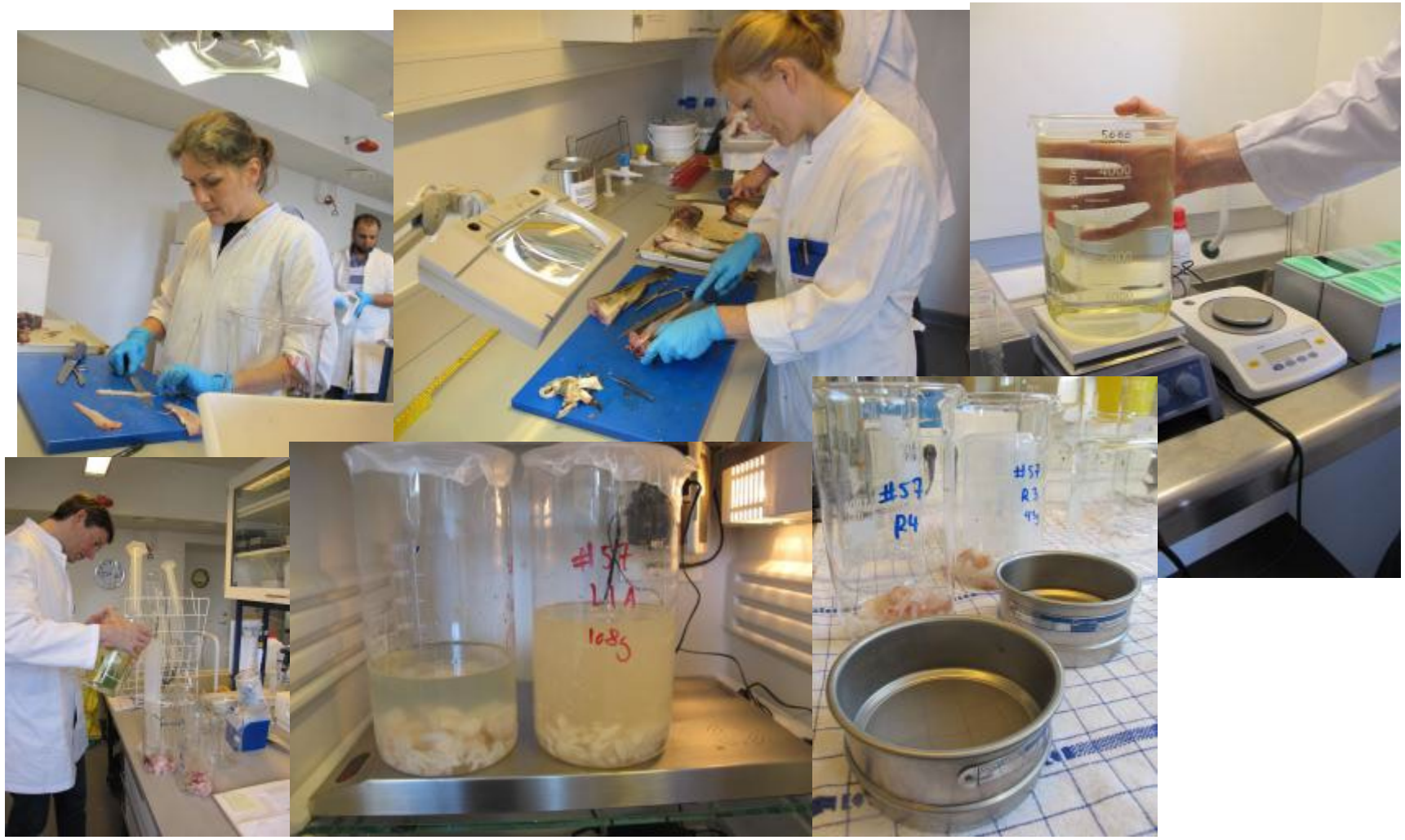


Baltic cod food preferences

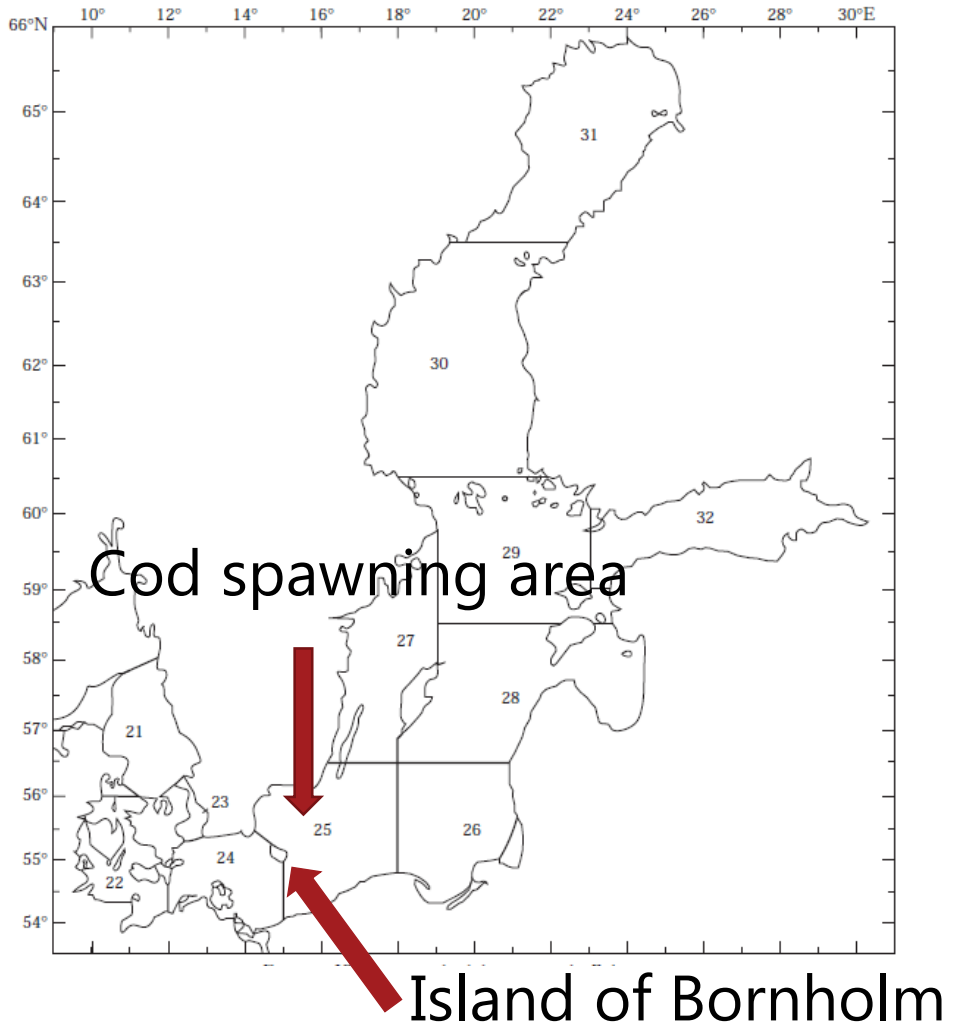
Food items preferred in different size classes of Baltic cod (Zuo et al. 2016). Sprat and herring becomes more important and crustaceans become less important at 30 cm body length.



This is reflected by the parasitic infections. Parasites in fish, including the cod, are bio-indicators and tell us about the cod – past, present and future

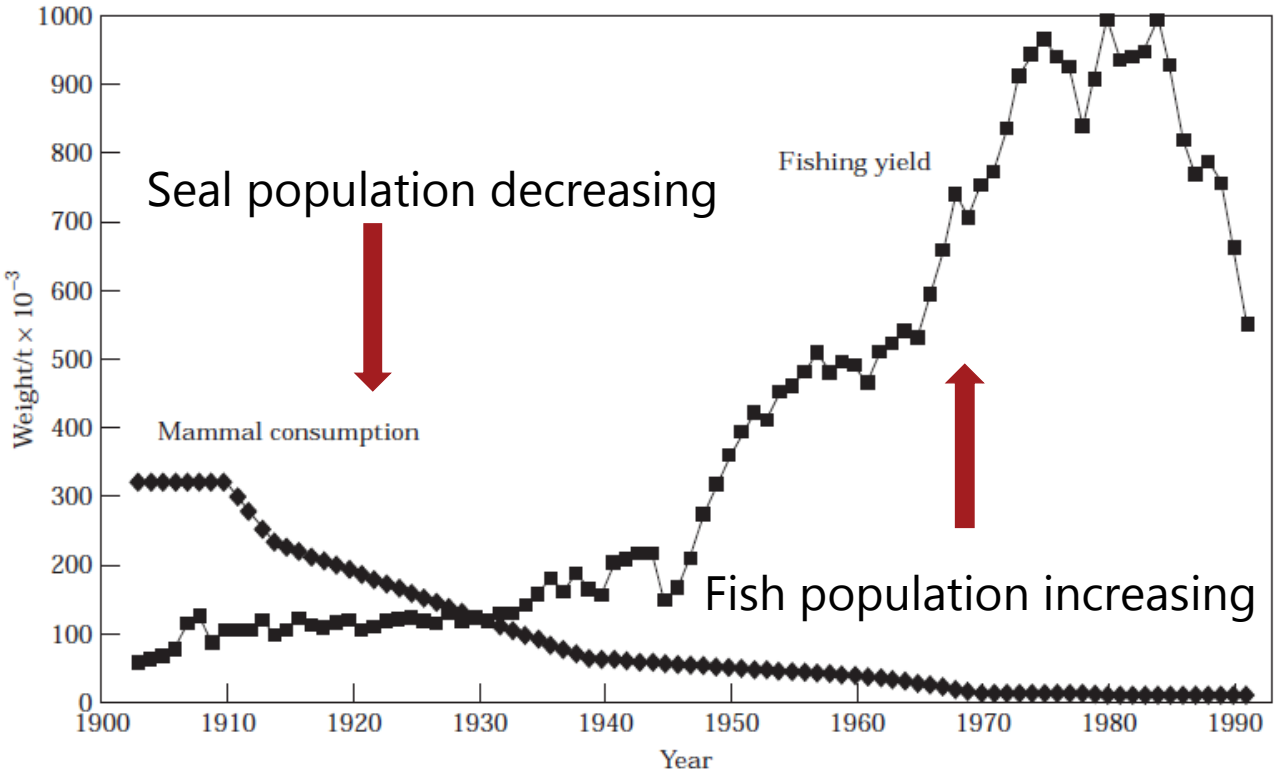


Baltic cod and biological factors affecting quality in the main spawning ground East of Bornholm ICES SD25

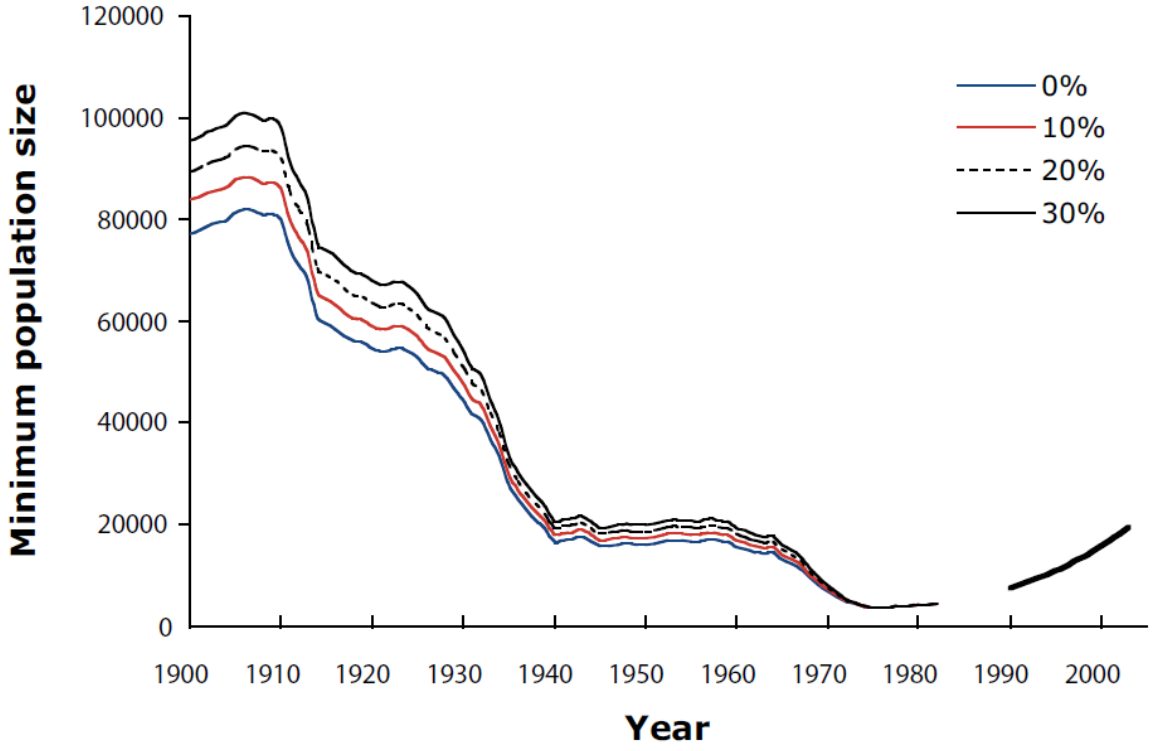


- Please note that any biological changes – including presence of predators in this specific site – will have a far higher impact on the Baltic cod population than changes in any other Baltic areas

We know that the grey seal population 120 – 140 years ago was considerable and had a major impact on local fisheries. Culling efforts (bounty hunting) then reduced the seal population, which was then kept at a level until protective legislation allowed the population to increase. The decreased seal population was associated with a marked fishing yield maximizing between 1970 and 1990 (from Thurow 1997).



Since the 1990-2000 period the Baltic grey seal population started to increase again as here nicely illustrated by Harding et al. 2008



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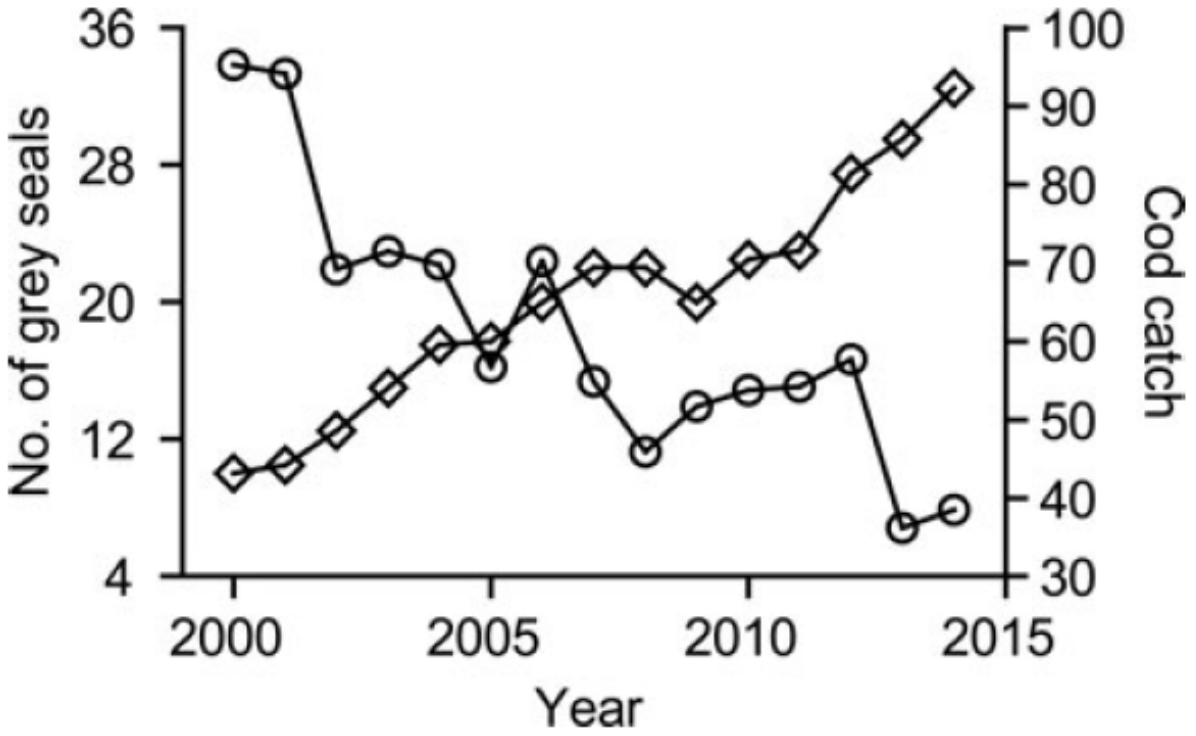
According to Hårding and Ahola 2023:
In 2023: 45,000 grey seals
In 2024: 47,250 grey seals
In 2025: 49,612 grey seals

Harbour seal populations at a lower level – but increasing in all regions

Baltic cod catches decreased along with the latest grey seal population increase – a clear negative correlation (Zuo et al. 2018)



Data from Helcom og ICES

The grey seal *Halichoerus grypus* is now extremely prevalent in the main spawning ground east of the island Bornholm. When counting the number of seals on the rocky islet TAT an increase **from 1 seal in 1999 to more than 440 seals already in 2012 (own obervations). In 1880s the number was 100 on the same spot!** This indicates that the seal occurrence in this specific region at present is much higher compared to the last seal population peak (1880-1900). This should be taken into account when it is claimed that the Baltic seal population is lower today (2024) when compared to the the year 1900 (Buchmann 2023).

The seal population present in the spawning area is of course more critical for the cod than seals in the Northern Baltic.

The grey seal

- Intelligent mammal
- Effective hunter
- Huge appetite

One marked sign of the increasing seal population was the increased predation of fish. This was particularly evident when looking at fishing gear of fishermen at Bornholm since the year 2000 (Photos: Kurt Buchmann)

Baltic salmon

Baltic cod

Baltic seatrout

Baltic cod

Often 70 % of the Baltic salmon in fishing gear would end up as these Christmas salmon from December 2013 (east coast of Bornholm)

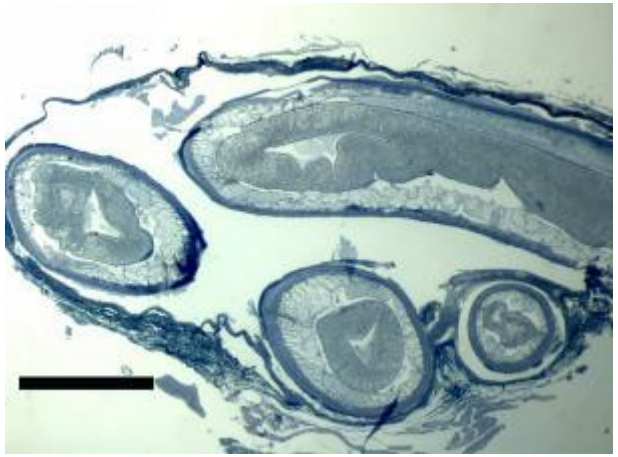
This is not a surprise. Seals are predatory animals. The teeth of the grey seal illustrate the hunting effectiveness. Cranium from the coast of the Bornholm island 2018.

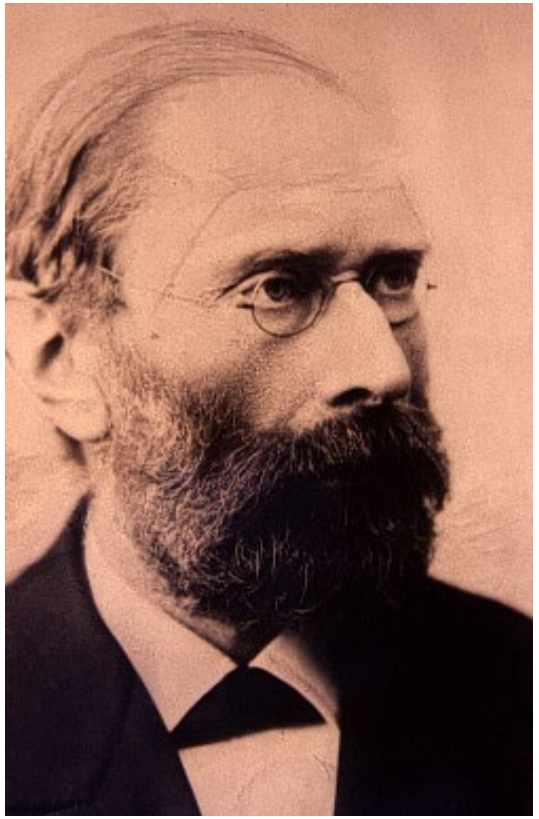
Kurt Buchmann photo

Other biological signs on the high occurrence of grey seals were the increasing worm infections associated with seals (Buchmann & Kania 2012; Buchmann & Mehrdana 2016).

Phocanema (syn. Pseudoterranova) decipiens

Codworm – Sealworm – *Phocanema* (syn. *Pseudoterranova) decipiens* suddenly very prevalent since 2000





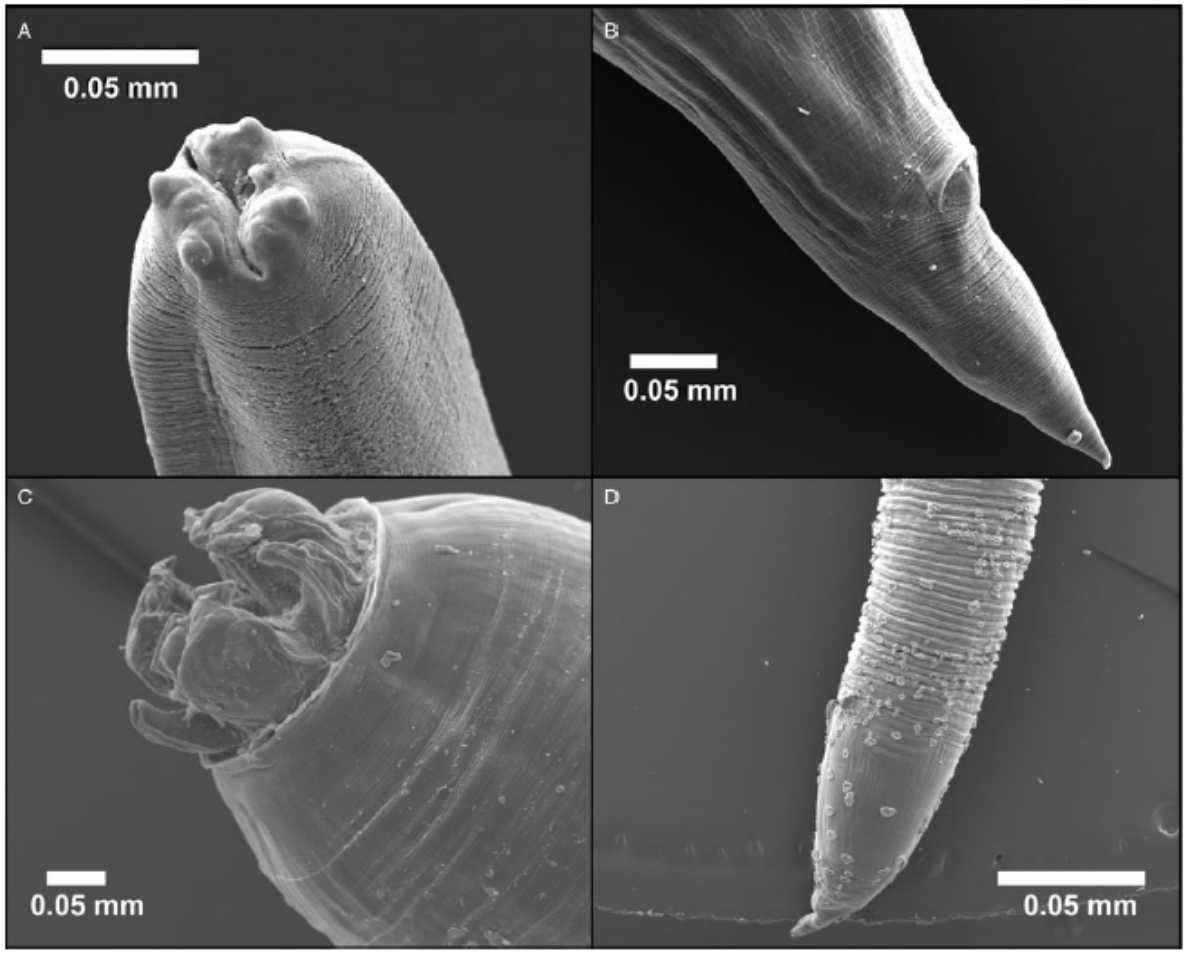
Described by
Harald Krabbe in 1878 –
known from areas with seals
Iceland, Norway, Canada,
Greenland

Another seal parasite – The liver worm *Contracaecum osculatum* in cod became in the same period extremely prevalent as well - here a liver from cod 40 cm body length, Bornholm 2019)

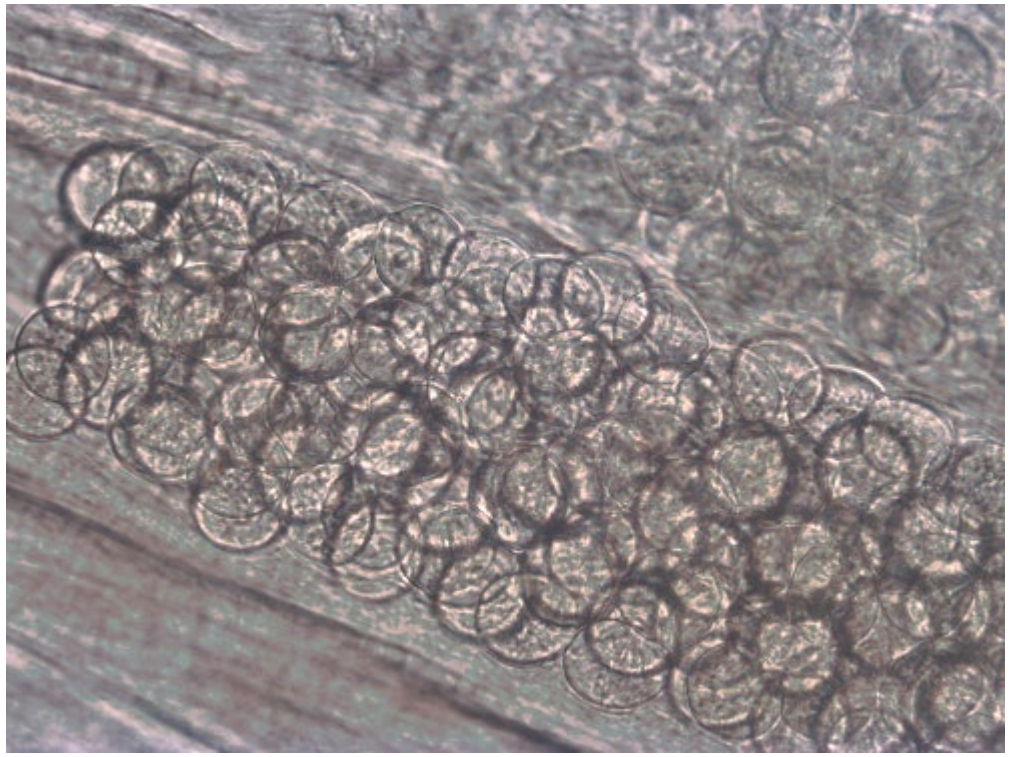
Photo by Kurt Buchmann

The life cycle of the liver worm *Contracaecum osculatum* is illustrated below. Adult parasites in the seal stomach and third stage larvae in crustaceans and fish

Contracaecum osculatum from larva to adult stage (Zuo et al. 2018)



An enormous reproductive potential of the different seal worms including *Contracaecum osculatum.* Each female worm with thousands of eggs, which are continuously released to the aquatic environment with seal faeces. Considering that one seal carries 1000 worms the possible number of infection of crustaceans and then fish is astronomic.

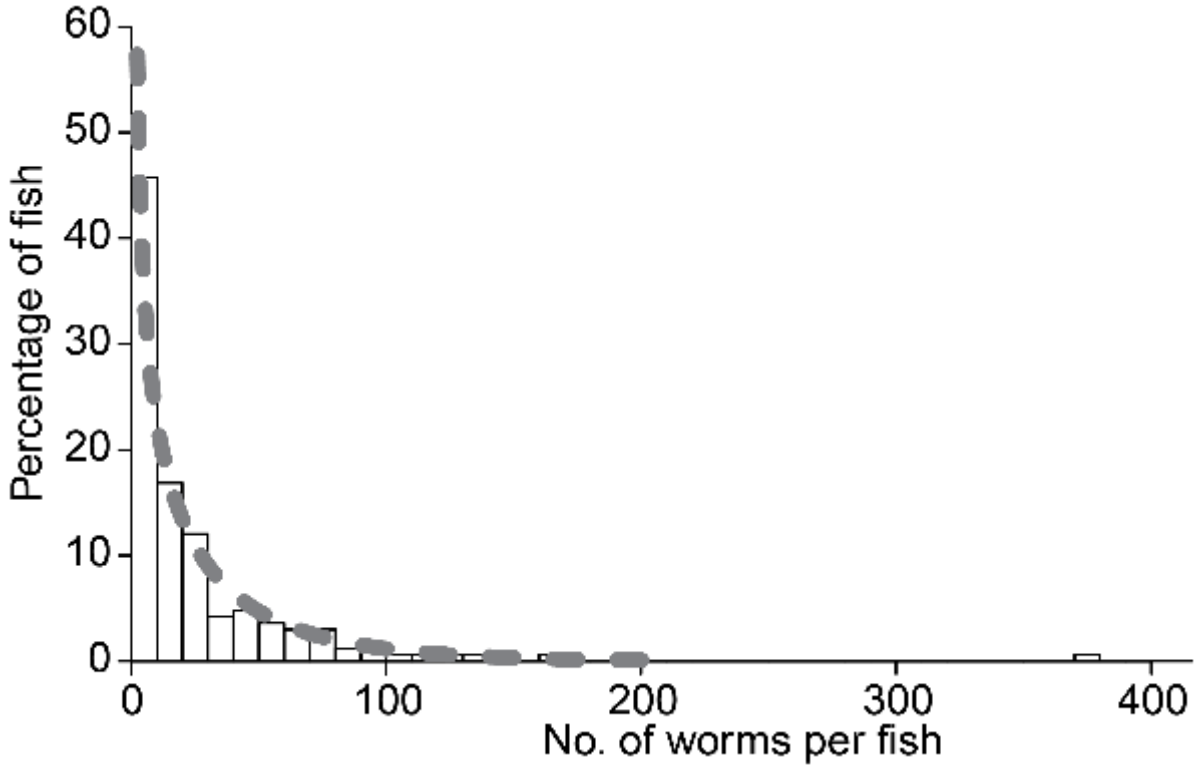


Originally isolated from a Baltic seal in 1800 and described by Karl Asmund Rudolphi in 1802

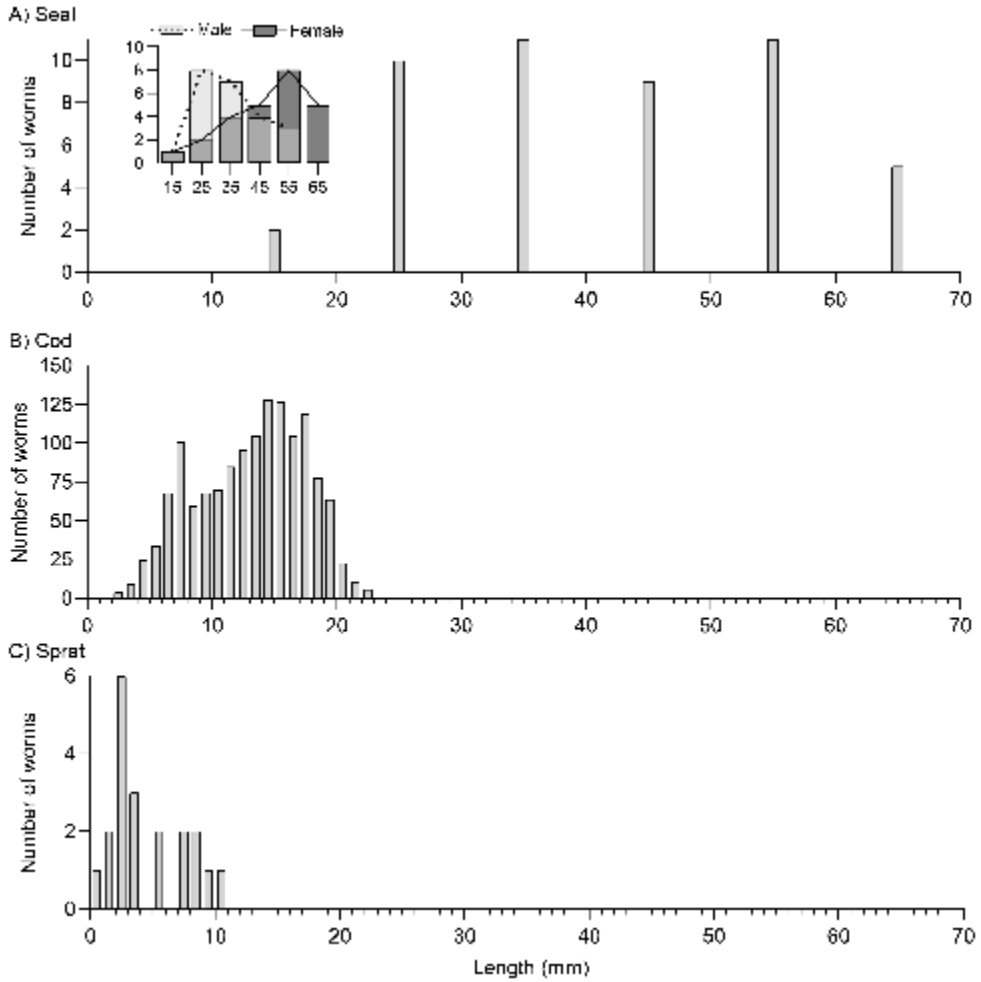
Illustration: Kurt Buchmann

Contracaecum osculatum larvae invade the cod liver and often several hundred parasites are found in a single cod liver even from small cod (35-50 cm body length)

Liver worm larvae in cod from the Baltic Sea east of Bornholm (ICES SD 25) in the period 2014-2019 (Mohamed et al. 2020)



The cod get infection by the worm by eating infected intermediate hosts (e.g. sprat, invertebrates e.g. crustaceans). These are infected by larvae hatching from parasite eggs delivered by adult worms in the seal stomach and passed with seal faeces to the sea (Mohamed et al. 2020)

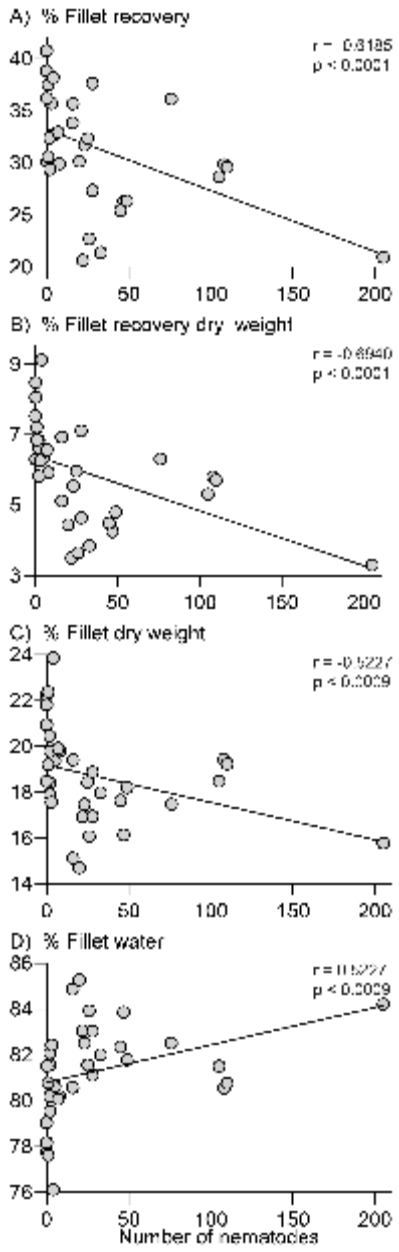


When considering the well known high grey seal population in the Baltic Sea in the 19th century some old reports are compelling:

- Schneider (1862) reported that Baltic cod could not be sold and marketed in Copenhagen due to the huge amounts of nematodes found in the body organs. Remarkable similarity to the situation today - when we link seals with the cod population through the parasitological investigations.

The number of worm larvae are associated with decreasing muscle mass (Mohamed et al. 2020)

- Fillet-recovery and quality decreases with increasing number of worms in the liver – up to 50 %



Some numbers

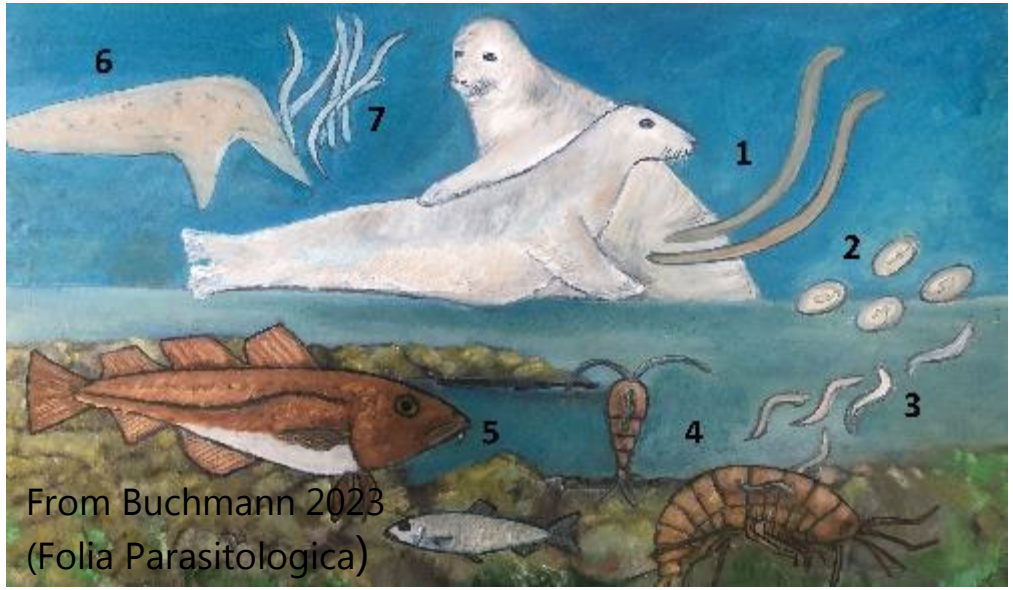
- In 1982-1983 one should examine 5 cod (35-45 cm body length) in order to find one single *C. osculatum* larva! Now all cod are infected with up to several hundred larvae!
- This worm species is a strong bio-indicator - as cod and seals are ecologically connected and cod a preferred prey species.
- When the cod muscle mass decreases (up to 50 %) the seal will more easily be able to capture the infected fish. This is a natural part of the parasite's life cycle strategy.
- One seal may ingest varying amounts of cod - but even a few kg cod a day per seal will result in a predation of thousands of tonnes per year. Worst case scenario may reach a seal harvest around 90,000 tonnes – provided the seal population is around 40-50,000 individuals.

Food availability for the cod – a range of factors may influence the amount of crustaceans and prey-fish

- Oxygen depleted zones. Yes – this is a problem - but this has been known since 1450 and it varies dependent on meteorological factors and inflow of North Sea water (cf. G. Otterlind). History shows that the cod stock will raise after meager years. Setyawan et al. 2020 showed that the faunistic elements are still present. One recent example: Severe oxygen depletion was seen in the early 1970s – and urged fishermen to use pelagic trawl for cod fishery - but after inflow of fresh oxygen rich water from the North Sea the situation was normalized. The year class 1978 was highly successful and basis for the marked fishing catches in the 1980s.

The impact of grey seals on the Baltic cod population

- Predation in general
- Decreased health of cod
- Parasite induced elevated predation
- Parasite induced suppression of cod immunity

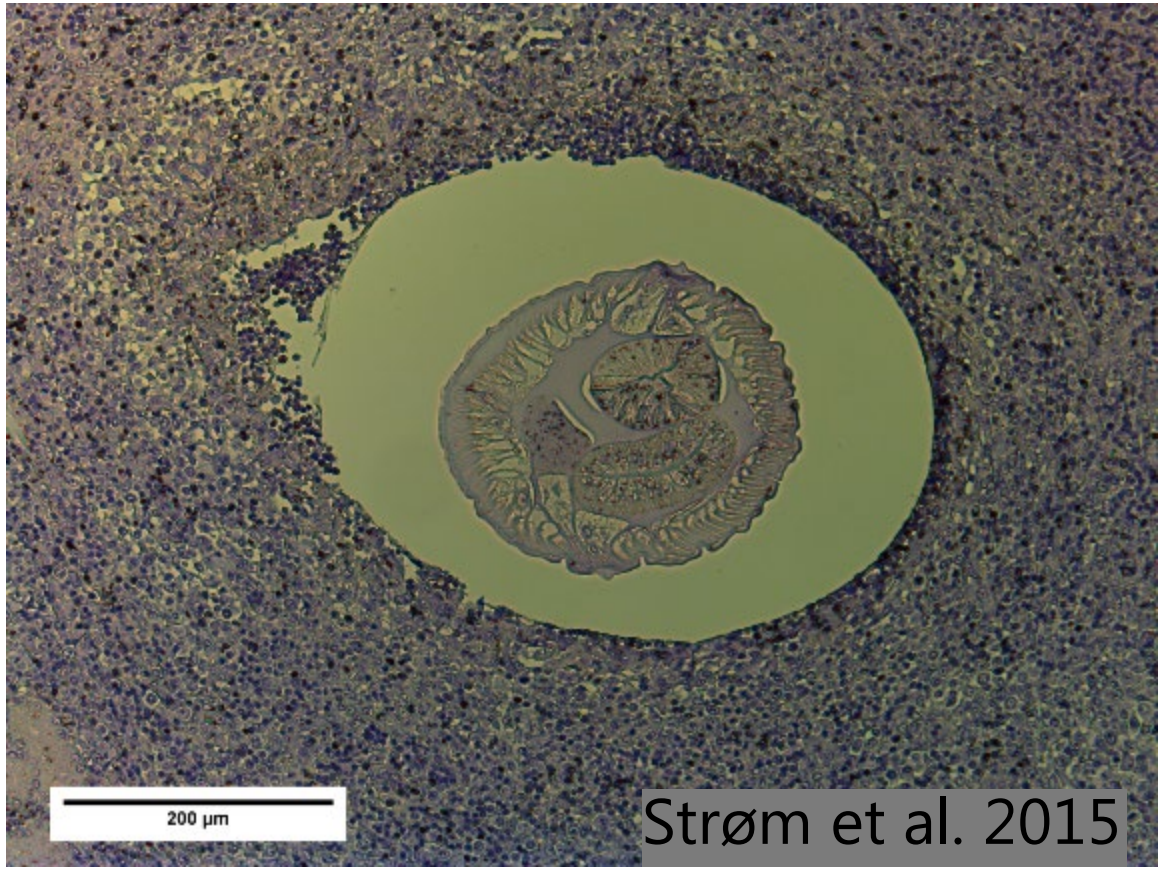


From Buchmann 2023
(Folia Parasitologica)

Another aspect is that the seals transfer zoonotic parasites to fish. Experimental infection of pigs (Strøm et al. 2015) indicates a zoonotic potential of *Contracaecum osculatum*

Experimental studies on *Contracaecum osculatum* infectivity in pigs. Penetration of stomach mucosa.

Contracaecum osculatum induces an eosinophilic granulomatous reaction when penetrating pig stomach mucosa



Same pathology as seen with *Anisakis* and *Pseudoterranova*

The seal population will also affect other types of parasites in Baltic fishes. Not only nematodes but also acanthocephalans and trematodes

First the spiny headed worms

Acanthocephalans

The acanthocephalans *Corynosoma semerme* and *C. strumosum* Life cycle with seals, crustaceans and fish.

From Buchmann & Karami 2024

Then the trematodes

Pseudamphistomum truncatum

The liver fluke

The liver fluke *Pseudamphistomum truncatum* in otters and mink – but also in Grey seals in the Baltic sea

Solutions – how to get more fish – how to get healthy cod and how to get better food safety?

- Regulation of seal populations?
- When?
- Can it be done?
- How?

- Yes
- 2024 – 2030
- Yes – in selected regions
- Targeted fisheries and hunting

Thanks for listening