SCIENTIFIC OPINION

Scientific Opinion on assessment of epidemiological data in relation to the health risks resulting from the presence of parasites in wild caught fish from fishing grounds in the Baltic Sea [1]

EFSA Panel on Biological Hazards (BIOHAZ)[2, 3]

European Food Safety Authority (EFSA), Parma, Italy

ABSTRACT

For fishery products caught from fishing grounds in the Baltic Sea, four groups of viable parasites present possible health risks, *Anisakis simplex* (*sensu stricto*), *Contracaecum osculatum* (*sensu stricto*), *Pseudoterranova decipiens* (*sensu stricto*) and *Diphyllobothrium* spp. Since *A. simplex* and *Pseudoterranova decipiens* have been found in fishery products in International Council for the Exploration of the Sea (ICES) subdivisions 22, 23, 24, 25, 26, public health risks due to the presence of these parasites cannot be excluded in any fishery products caught from these areas. Migrating fish from areas where *A. simplex,* and to a lesser degree *P. decipiens,* occur may carry these parasites and reach the northern Baltic, therefore, public health risks due to parasites in all migrating fish (including salmon) in Baltic Sea cannot be excluded. *C. osculatum* occurs in fish throughout all areas of the Baltic Sea. However, at present it is not possible to assess the public health importance of viable *C. osculatum* larvae in fishery products. *Diphyllobothrium* spp. occurs in fish species in brackish waters of Baltic Sea. Hence all freshwater fish as well as migrating fish, including sea trout and whitefish, are of public health importance if consumed raw, since they may carry viable parasites. More research is needed to elucidate the importance of *C. osculatum* from fish as a source of human infection, including pathogenicity of this parasite and the anatomic distribution of the parasite in edible parts of the fish. In order to definitively identify species of anisakids, genetic/molecular methods should be more widely applied to material from all hosts of the Baltic Sea. Surveillance of anisakiasis and other parasitic infections in the human population in Baltic Sea countries should be improved.

KEY WORDS

Fishery products, parasites, biological hazards, Baltic Sea

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SUMMARY

Following a request from the Health and Consumers Directorate-general (DG SANCO), the EFSA Panel on Biological Hazards was asked to deliver an assessment on whether certain fishery products from certain fishing grounds in the Baltic Sea do not present a health risk with regard to the presence of viable parasites. If so, the Panel was to identify for which geographically areas of the Baltic Sea and for which species this would apply. The mandate was further clarified to include fishery products of wild catches from both salt and brackish water, and to exclude farmed fish. A main focus should be on anisakids in sprat and herring from fishing grounds in the Baltic Sea.

The fish fauna in the Baltic Sea can be classified into three different communities, all of which may overlap: a pelagic community, a benthic community, and a littoral or coastal community. Various marine fish species from the North Sea migrate into the Baltic Sea and spawning or feeding migrations may bring parasites acquired in one area into other locations. The Baltic Sea fish biomass is dominated by three species, i.e.: cod (*Gadus morhua*), herring (*Clupea harengus*), and sprat (*Sprattus sprattus*), which amounted to 1,800,000 tons in 2010 and accounts for 85% of total catch. Anadromous and catadromous species, such as salmon (*Salmo salar*), trout (*Salmo trutta*), eel (*Anguilla anguilla*), vimba bream (*Vimba vimba*), smelt (*Osmerus eperlanus*) are also of considerable commercial value. Raw and lightly cured fish is eaten commonly in many countries in northern Europe including Baltic countries.

The BIOHAZ Panel concluded that for fishery products caught from fishing grounds in the Baltic Sea, four groups of viable parasites present possible health risks, and these are *Anisakis simplex* (*sensu stricto*), *Contracaecum osculatum* (*sensu stricto*), *Pseudoterranova decipiens* (*sensu stricto*) and *Diphyllobothrium* spp. Since *A. simplex* and *P. decipiens* have been found in fishery products in International Council for the Exploration of the Sea (ICES) subdivisions 22, 23, 24, 25, 26, public health risks due to the presence of these parasites cannot be excluded in any fishery products caught from these areas. Since migrating fish from areas where *A. simplex* and to a lesser degree *P. decipiens* occur may carry these parasites and reach the northern Baltic, public health risks due to parasites in all migrating fish (including salmon) cannot be excluded. *C. osculatum* occurs in fish throughout all areas of the Baltic Sea. However, at present it is not possible to assess the public health importance of viable *C. osculatum* larvae in fishery products. *Diphyllobothrium* occurs in fish species in brackish waters of Baltic Sea. Hence all freshwater fish as well as migrating fish, including sea trout and whitefish, are of public health importance if consumed raw, since they may carry viable parasites.

It is recommended that more research is needed to elucidate the importance of *C. osculatum* from fish as a source of human infection, including pathogenicity of this parasite and the anatomic distribution of the parasite in edible parts of the fish. In order to definitively identify species of anisakids, genetic/molecular methods should be more widely applied to material from all hosts in the Baltic Sea. Surveillance of anisakiasis and other parasitic infections in the human population in Baltic Sea countries should be improved.

TABLE OF CONTENTS

BACKGROUND AS PROVIDED BY EUROPEAN COMMISSION

In April 2010 EFSA published a scientific opinion on the risk assessment of parasites in fishery products (EFSA Journal 2010; 8(4):1543), based on a request from the Health and Consumers Directorate-General (DG SANCO).

One of the requests was to specify criteria for determining when epidemiological data indicate that a fishing ground does not present a health hazard with regard to the presence of viable parasites, if the fishery products are to be eaten raw or almost raw.

EFSA responded that

"Criteria to determine whether fishery products from fishing ground are likely to present a health hazard take into account information on the prevalence, abundance, as well as species and geographical distributions of the parasites and their hosts together with results from monitoring systems and trends in parasite presence and abundance."

Furthermore, EFSA concluded in the scientific opinion that

"No sea fishing grounds can be considered free of *A. simplex* larvae" and

"All wild caught seawater and freshwater fish must be considered at risk of containing viable parasites of human health hazard if these products are to be eaten raw or almost raw".

Some Member States claim that sprat and herring from certain fishing grounds in the Baltic Sea are free of parasites that may present a health hazard if eaten raw, or almost raw. The Commission has been provided with documentation to in support of this claim.

EFSA is requested to assess this additional information, together with any other available information, with regard to the public health risk relating to the presence of parasites in wild caught fish from fishing grounds in the Baltic Sea.

TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

Based on the documentation provided by Member States, and other available documentation, assess whether certain fishery products from certain fishing grounds in the Baltic Sea do not present a health hazard with regard to the presence of viable parasites. If so, identify for which geographically areas of the Baltic Sea and for which species this apply.

ASSESSMENT

1. Introduction

The scientific opinion published by EFSA in 2010 about risk assessment of parasites in fishery products was one of the first EFSA output on this hazard category. This opinion considered different issues of public health importance related to parasites in fishery products, mainly related to allergic reactions to parasites in fishery products, an assessment of the killing treatments of parasites, and criteria for assessing health hazard related to the presence of parasites from fishery products of different origins and production methods.

EFSA was requested to set criteria for when fishery products do not present a health hazard related to the presence of parasites. It was concluded that criteria to determine whether wild caught fishery products are likely to present a health hazard include information on the prevalence, abundance, as well as species and geographical distributions of the parasites and their hosts together with results from monitoring systems and trends in parasite presence and abundance.

As there is a lack of adequate data on the geographical distribution, prevalence, intensity, and anatomical distribution of parasites of public health importance in fishery products, EFSA also concluded that all wild caught seawater and freshwater fish should be considered at risk of containing viable parasites of human health hazard if these products are to be eaten raw or almost raw.

In the present Regulation (EC) No 853/2004 a freezing treatment has to be carried out, if a) fishery products are eaten raw or almost raw, b) herring, mackerel, sprat or (wild) Atlantic and Pacific salmon are cold smoked and c) fishery products are marinated and/or salted in a way which is insufficient to destroy nematode larvae. For wild catches, the competent authority of the Member States may authorise an exemption from the freezing treatment if epidemiological data shows that the fishing grounds do not present a health hazard with regard to the presence of parasites.

Based on EFSA’s conclusions the European Commission presented in May 2010 for discussion with the Member States a draft proposal to suspend the possibility to authorise exemptions from the freezing requirement for wild catches of fishery products to be eaten raw or almost raw, etc.

The proposal was not supported by the Member States. While referring to the specific conditions in the Baltic Sea, some Member States suggested maintaining the possibility to derogate from the freezing requirement for wild catches of fishery products to be eaten raw or almost raw from certain fishing grounds. Sprat and herring from the Baltic Sea were mentioned as species where it should be possible to derogate based on epidemiological data. However, the majority of the Member States considered that such derogation could only be deemed acceptable following a favourable assessment by EFSA.

After submission of the present mandate to EFSA, the European Commission further clarified the remit of the mandate in the following way:

- Parasite species of human health concern to be found in fishery products from the Baltic Sea, considering both salt water and brackish water;
- Wild catches, consequently excluding farmed fish;
- All viable parasites of public health importance shall be included, although main focus should be on anisakids in sprat and herring from specified fishing grounds in the Baltic Sea.

2. Ecological factors in the Baltic Sea related to the parasite distribution

The epicontinental and enclosed non-tidal Baltic Sea is one of the largest brackish water areas in the world, with a surface area of about 42,610 km^2 and a volume of about 22,610 km^3, representing about 0.1% and 0.002% of the world's ocean area and volume, respectively. The Baltic Sea has a maximum depth of 460 m and mean depth of 60 m. It was formed after the last glaciation (roughly 10,000–15,000 years ago) and has undergone shifts in basic physicochemical characteristics during a geologically short time. The contemporary ''ecological age'' of the Baltic Sea is about 8,000 years. According to the subdivision of the International Council for the Exploration of the Sea (ICES) the Baltic Sea is composed of eleven regions (Figure 1), numbered from 22 to 32, which correspond to the areas as indicated in Table 1. Nine countries border on the Baltic Sea: Denmark, Finland, Estonia, Germany, Latvia, Lithuania, Poland, Russia, and Sweden. The catchment area is much wider and includes 14 countries with the total area over 1.7 x 10^6 km^2 and about 85 million people (Ojaveer et al., 2010).

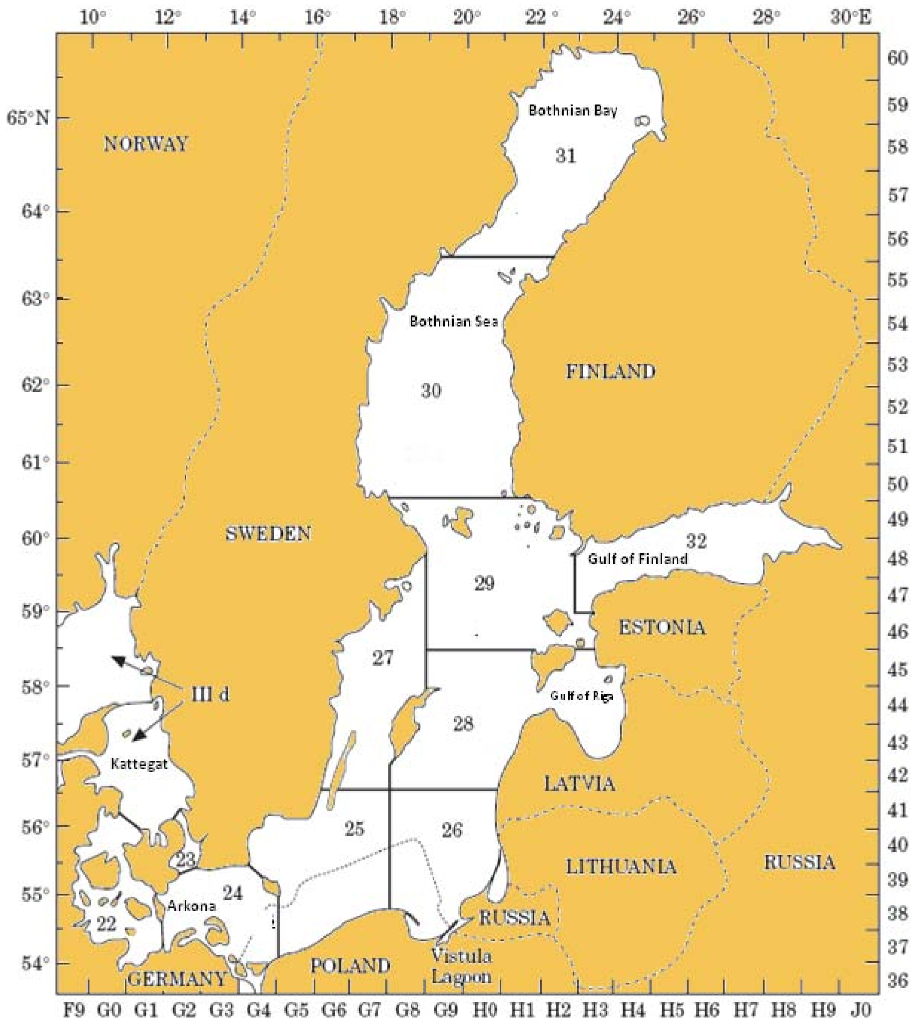

Figure 1: Map of ICES regions of the Baltic Sea (Horbowy and Podolska, 2001) modified.

Table 1: Subdivision, regions and macroregions in the Baltic Sea.

Macroregion	Regions	ICES
Transition area	Kattegat	22
	Belts and Sound	23
	Arkona	24
Baltic Proper	South West Baltic Proper	25
	East Baltic Proper	26 28
	North West Baltic Proper	27 29
Large Gulfs	Bothnian Sea	30
	Bothnian Bay	31
	Gulf of Finland	32

For fishery products caught from fishing grounds in the Baltic Sea, four groups of viable parasites present a potential health hazard, and these are *Anisakis simplex* (*sensu stricto*), *Contracaecum osculatum* (*sensu stricto*), *Pseudoterranova decipiens* (*sensu stricto*) and *Diphyllobothrium* spp.

Several factors influence the geographical distribution of parasites of fish species in the Baltic Sea. These factors influencing the number and abundance of parasites depend on the presence and the diversity of intermediate and final suitable hosts, which are related to abiotic and biotic factors such as the salinity rates (particularly low in the Large Gulfs of the Baltic Sea, i.e. Bothnian Bay and Gulf of Finland, ranging from 3 to 5 mg/kg, compared to salinity rates in North Sea that are, on average, ten fold higher), nutrient availability, oxygen availability and the degree of pollution.

Pollution is a major issue in the Baltic Sea, and this has a great impact on the survival and structure of fish communities, thus affecting the availability of intermediate, final and paratenic hosts. Along many of the coasts around the Baltic Sea there are areas of eutrophication and/or increased heavy metal concentrations. Fresh water species, which occur mainly in the archipelagos, may be subjected to considerably more pollutants than the marine species. The effects of eutrophication are limited to observations on phytobenthos. Two processes in particular have been noted: a change in the species composition and a restriction of the depth range of the vegetation zone. Both processes have had negative impacts on the coastal fish populations.

The effects of eutrophication in the archipelago areas are well documented outside Helsinki, where herring have disappeared from the most polluted areas. Changes in fresh water species correspond well with changes observed in eutrophied lakes. In the Stockholm archipelago, similar changes have also been noted. In the Polish coastal waters, where oxygen levels have declined drastically due to pollution, this has resulted in considerable decreases in the abundance of cod. In some shallower parts of the Polish coast, there has been a decreasing trend in the appearance of whitefish. In many river systems in the Baltic Sea catchment area, salmonid species have disappeared. A common feature in the shifts of the fish communities due to environmental degradation is a decrease in the abundance of the commercially more important fish species.

Oxygen deficiency in the bottom waters during the summer and autumn has had serious effects on the stock of Norway lobsters in the Kattegat and on commercial demersal species in the Belt and Arkona Seas. Oxygen deficits may also be linked to an increased occurrence of certain viral diseases in the dab population in the Kattegat.

It is difficult to distinguish between the effects of pollution, fishing and natural factors on fish stocks in the open Baltic Sea. Fish populations are known to be influenced by changing salinity and by oxygen conditions in the deep waters. This applies particularly to cod. This species, spawning in deep waters in the Bornholm Sea, Gotland Deep and Gdansk Deep has been seriously affected by the decreasing salinity of the Baltic Sea and the low oxygen concentrations of the bottom waters. The pelagic cod eggs require a minimum salinity of 11‰ to float and an oxygen level of at least 3 ml/l to survive. The northern border for reproduction is the Gotland Deep and successful spawning is dependant on an influx of saline water from the North Sea. Successful reproduction of cod in the Baltic Sea has not been observed over the last 10 years except in the Bornholm Basin which is the only area where salinity levels and oxygen conditions are conducive to cod spawning (HELCOM, 1993).

3. Fish species in Baltic Sea

The fish biodiversity in Baltic Sea has been recently well described by Ojaveer (2010). Overall, the Baltic Sea (including the Kattegat) fish community comprises approximately 200 species, but only include about 100 species if the Kattegat is excluded. There are around 70 species in several sub-basins in the NE Baltic, but less than 50 species in Bothnian Bay. The biomass of fish in the Baltic is dominated by three species (i.e.: cod (*Gadus morhua*), herring (*Clupea harengus*), and sprat (*Sprattus sprattus*). The abundance and biomass of landed cod, herring, and sprat (respectively in management subdivisions 25–32, 25–29, excluding the Gulf of Riga, and 22–32) have fluctuated substantially in the past 30–40 years. Cod was at intermediate levels in the 1960s and then increased strongly in the late 1970s and early 1980s, before declining over the following 15–20 years. The changes are linked to fisheries mortality and reproductive success, which itself is related to climatic and hydrographic variations and abundance of predators particularly for cod eggs and larvae. The recent increase in cod stocks is due to both lower fishing and mortality, and improved hydrographic conditions for reproduction. Sprat and herring biomass has also fluctuated, in part because of fluctuation in the abundance of one of their predators, cod. Additional factors that have contributed to variations in sprat and herring biomass are climatic conditions, particularly temperature, and competition among the species for similar prey. Some flatfish species (e.g., flounder (*Platichthys flesus*)) are also commercially important.

Various marine fish species from the North Sea migrate into the Baltic Sea. These include whiting (*Merlangius merlangus*), European anchovy (*Engraulis encrasicolus*), mackerel (*Scomber scombrus*), grey mullet (*Liza ramada*), and thicklip mullet (*Chelon labrosus*). However because of unfavourable environmental factors, these fish are unable to form self-sustaining populations in the Baltic. Several anadromous and catadromous species, such as salmon (*Salmo salar*), trout (*Salmo trutta*), eel (*Anguilla anguilla*), vimba bream (*Vimba vimba*), smelt (*Osmerus eperlanus*) are of high commercial value. Decline and/or disappearance of the natural salmon stocks has been especially rapid since the late 1940s, mainly due to construction of hydroelectric power plants and river damming. However, some recent improvement is evident for the natural smolt production in the northern Baltic rivers. Sea trout populations are currently in a precarious state in the north-eastern Baltic, while some improvement has been recorded in the western Baltic. The most common and abundant freshwater species found in a majority of coastal areas of the Baltic Sea are perch (*Perca fluviatilis*), roach (*Rutilus rutilus*), bream (*Abramis brama*), bleak (*Alburnus alburnus*), ruffe (*Gymnocephalus cernuus*), ide (*Leuciscus idus*), pike (*Esox lucius*), and whitebream (*Blicca bjoerkna*) (Ojaveer et al., 2010).

4. Fish migration in the Baltic Sea

Host migrations may have major effects on the distribution of parasites in the Baltic Sea. Spawning or feeding migrations may bring parasites acquired in one area into other locations. This can maintain parasite populations either by prey-predators relationship and transmission to new hosts, or by transmission between individuals of the various fish host species. In the case of anisakid nematodes this could maintain a parasite population in resident fish even though the complete parasite life cycle does not occur.

In a comprehensive review of fish in the Baltic Sea, Aro analyzed the migration patterns (Aro, 1989). The fish fauna in the Baltic Sea may be classified into three different communities, all of which may overlap: a pelagic community, a benthic community, and a littoral or coastal community. The borders between them are not sharp and they frequently contain specimens from neighbouring communities. The littoral and coastal communities, in particular, serve the pelagic community as a spawning and nursery area. In the Gulf of Bothnia the littoral and coastal community is dominated by freshwater species which very seldom migrate outside this environment; the Baltic herring is actually the only native pelagic species using this environment as a spawning and nursery area. The migration and movements of the Baltic Sea fish species occur in micro and macro scale inside and between these communities having annual and diurnal horizontal and vertical patterns.

There may be migrations of herrings out of the North-eastern Baltic to the south with different intensities from year to year depending on feeding conditions in these areas. Mixing of the herring stocks has been observed, which indicates different migration patterns. Because of a lack of tagging, the migration patterns have not been very well documented. A preliminary genetic study based on allozymes and mtDNA analysis have shown no genetic differentiation among northern (Airisto herring) and the southern (Rugen herring) populations; the population data suggested that salinity conditions are responsible of the modification of some biological characteristics of this fish in the northern Baltic Sea, despite the genetic homogeneity so far observed (Rajasilta et al., 2006).

4.1. Herring in the northern Baltic Sea Proper, the Archipelago Sea, and the Gulf of Riga (Subdivisions 28 and 29)

The feeding migration of older aged herring groups may extend to central parts of the Baltic, to the Swedish east coast and sometimes even to the southern Baltic (Parmanne and Sjoblom, 1982, 1986). Migration from the Archipelago Sea provides connections to, the Bothnian Sea stocks, the western parts of the Gulf of Finland, the Aland Sea, and to the Stockholm Archipelago. Therefore, although the migration of herring from the southern Baltic to Finnish waters is very limited, it cannot be totally excluded. Some spawning migration from the eastern Baltic Sea (Bay of Riga) to the Archipelago Sea occurs, and herrings infected with *Anisakis* are known to occur near this area.

Further information on the sub-stocks of Baltic herring was given by Grabda (Grabda, 1974). This author pointed to the fact that several sub-stocks with different migration patterns occurred in the Baltic. Thus, some northern populations migrated to the south Baltic for feeding and some stocks were autumn spawners whereas others were spring spawners. These facts were also presented by Aro (1989).

4.2. Herring in the Bothnian Sea (Subdivision 30)

The feeding migration extends to the southern parts of the Bothnian Sea and inside the Archipelago Sea, in the Quark and sometimes inside the Bothnian Bay. There is also some exchange between the Finnish and Swedish coasts (Aro, 1989). The spring-spawning coastal herring in the east coast of the Bothnian Sea has a clear homing behaviour and about 95% of recaptures have been obtained within 150 km from their original tagging location.

4.3. Herring in the Bothnian Bay (Subdivision 31)

The feeding migration occurs mainly inside the Bothnian Bay and there is a certain exchange between the Swedish and Finnish coasts, especially near the Quark.

4.4. Herring in the Gulf of Finland (Subdivision 32)

The migration out from the Gulf of Finland seems generally to be insignificant.

4.5. The Baltic Sea sprat

The migration of the Western Baltic stock is directed to the Bornholm Basin and sometimes to the Gdansk Basin, where these stocks mix when feeding. From the Gulf of Gdansk there is a northward migration pattern to the central parts of the Gotland Deep even though the main part of the stock feeds and winters in the vicinity of Gulf of Gdansk. Very dense shoals and concentrations of sprat have been observed during the feeding and wintering period (and sometimes in the spring) in the Gotland Deep area.

4.6. The Baltic Sea cod

Cod tagging studies were reviewed by Aro (1989). In the Baltic Sea there are two cod stocks which have been shown to differ from each other: The Western Baltic cod stock (*Gadus morhua morhua* (subdivision 22-24); the Eastern Baltic cod stock (*Gadus morhua callarias*) is distributed east from the Bornholm area up to the northern parts of the Bothnian Sea and to the eastern parts of the Gulf of Finland. The border between these two main stocks is diffuse and mixing of stocks is evident in the Arkona basin and in the Bornholm Basin

It is clear from these studies that adult cod from the southern Baltic may migrate both to the Gulf of Finland and into the Bothnian Bay

4.7. The Baltic Salmon

Aro showed how *Salmo salar* performs extended migration within the Baltic even from the southern Baltic to the North into Finnish waters.
Other authors supported this evidence and clearly show that salmon from the southern Baltic migrate to Finnish waters (Åland area, Finnish Bay) where they are caught by local fishermen (Pedersen et al., 2007).

5. Volume of catches in the Baltic Sea

In the brackish water of the Baltic Sea, fish are a mixture of marine and freshwater species. Marine species such as herring, sprat and cod dominate in open waters, while both marine and freshwater species inhabit coastal areas. Extreme increases in catches have occurred during the last 50 years, when the annual yield has grown from some 100,000 to 1,000,000 tons. Between 1965 and 1975, there was an apparent increase in the productivity of fish in the Baltic Sea. Herring, sprat and cod represent about 90% of the total catch. Salmon and eel are also economically important.

The value of the catches, amounts today to about 540 million Euros per year, is an indication of the considerable economic importance of these living resources. Another important aspect is the fact that considerable quantities of nitrogen and phosphorus are removed from the Baltic via this activity.

Currently the situation of the pelagic and demersal stocks of the Baltic Sea as a whole varies considerably. While herring and sprat stocks are in good condition and even underexploited, there has been a drastic decline of the two cod stocks (the eastern stock more depleted than the western) mainly because of naturally caused poor recruitment and high fishing pressure during the last decade. The year-catches since 1986 are believed to be among the lowest on record. The International Baltic Sea Fishery Commission was obliged to drastically reduce the Total Allowable Catch (TAC) for the entire

Baltic Sea. In Figure 2 the amount of total fish catch of the last ten years in the Baltic Sea for the countries indicated is reported.

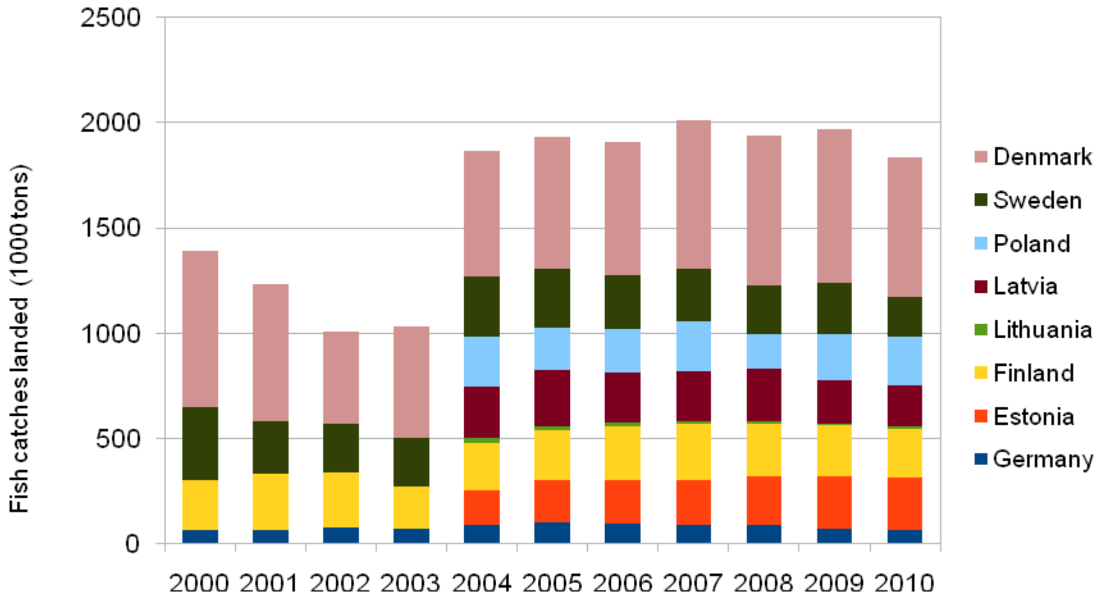

Figure 2: Total catches n the Baltic Sea (subdivisions 22-32) of cod, herring and sprat from 2000-2010 in the different Baltic countries (Source: DG Mare, EC).
*For 2000-2003 data from Poland, Latvia, Lithuania, Estonia are not available

Of great importance to the fishery are the coastal areas of the Baltic Sea which serve as spawning, nursery and feeding areas for several species of fish. Data on the state of the coastal waters, mainly with regard to eutrophication and metal contamination, have recently been compiled by HELCOM.

In Figure 3 the fishery catches of cod, herring and sprat per Member States (Denmark, Finland, Estonia, Germany, Latvia, Lithuania, Poland, and Sweden) in the Baltic Sea subdivisions is shown for the year 2010

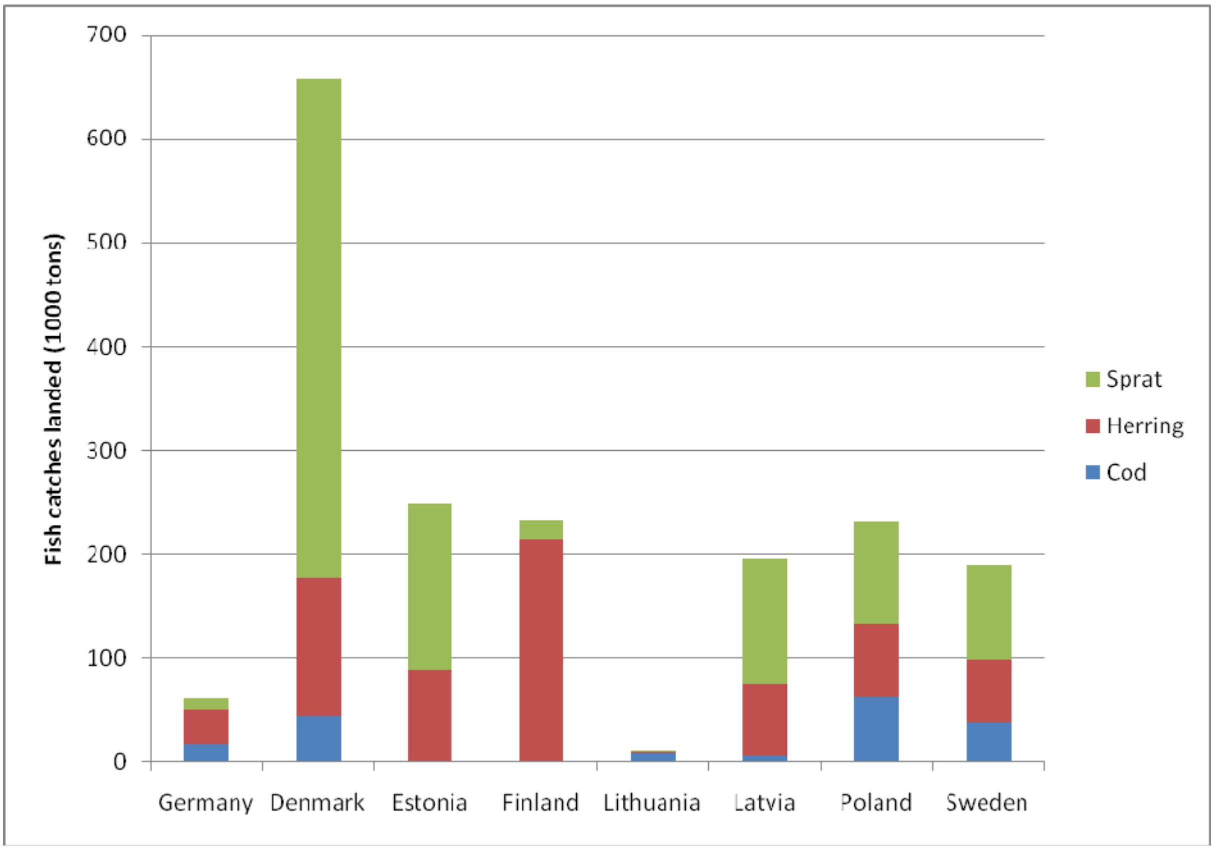

Figure 3: Total catches for cod, sprat and herring per Member State in the Baltic Sea areas (ICES 22-32) in 2010, volume in thousands of tonnes live weight (Source: DG Mare, EC).

Fishing in Baltic Sea is focused on three main species: sprat, herring and cod account for 85% of the total catch and are overexploited (Lindegren et al., 2010). Catches of these species amount to 1,800,000 tons in 2010.

In Figure 4 the total catches of herring, sprat and cod in the Baltic Sea from 2000 to 2010 are shown.

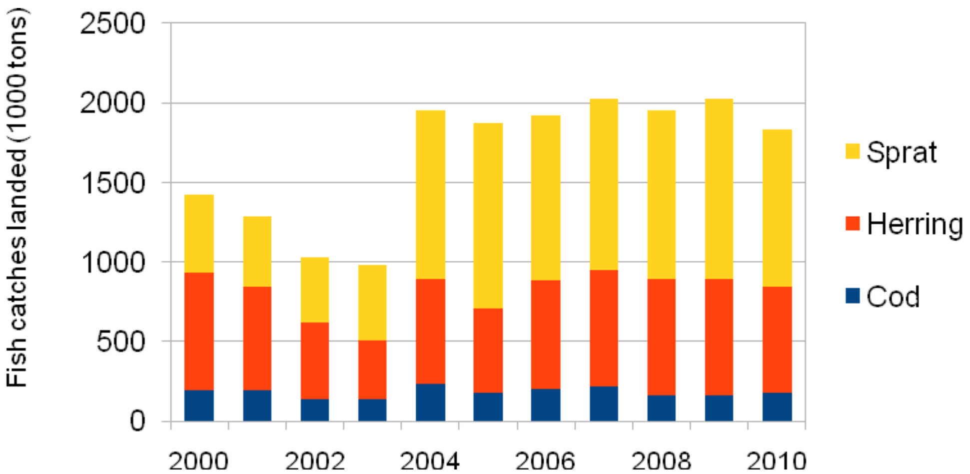

Figure 4: Catches landed of the main target species cod, sprat, herring in the Baltic Sea (data from Germany, Denmark, Estonia, Finland, Lithuania, Latvia, Poland, Sweden) in subdivisions 22-32 in the years 2000-2010 (Source: DG Mare, EC).

In the EU Regulation 1124/2010, the amount of wild salmon caught in the Baltic Sea is expressed in number of fish[4], thus this data is reported in a separate graph (Figure 5).

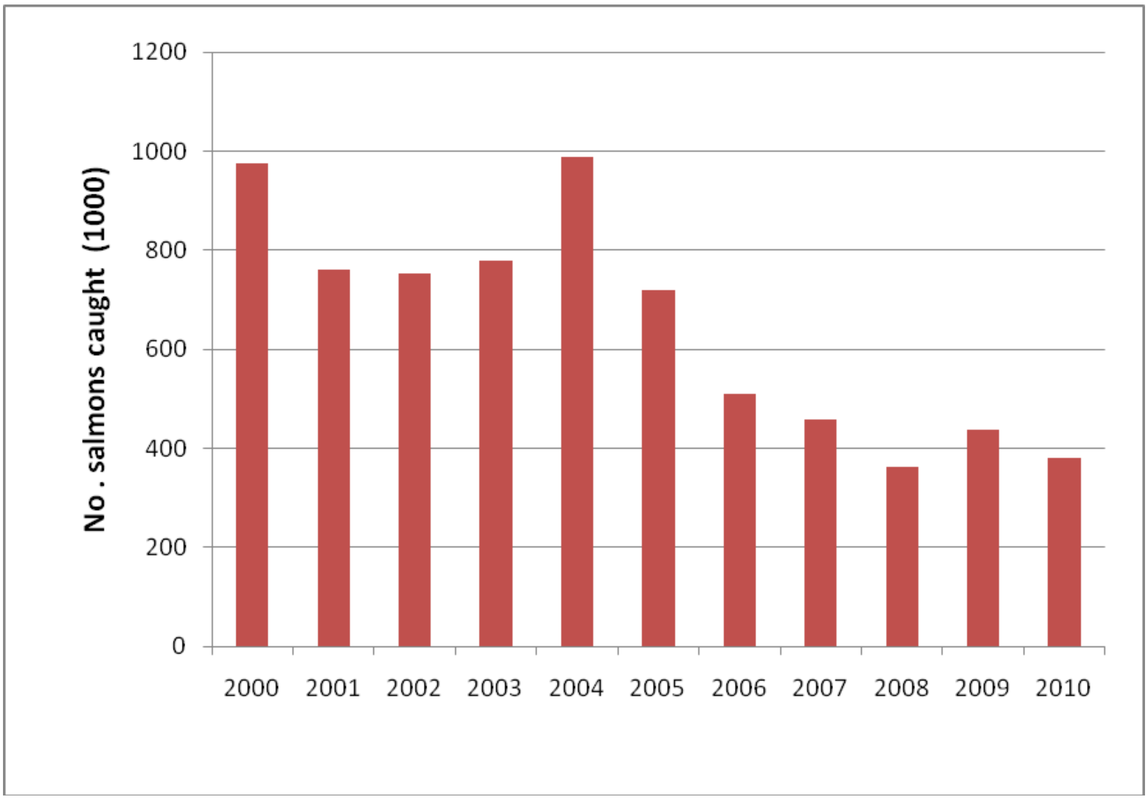

Figure 5: Catches landed of wild salmon in the Baltic Sea (data from Germany, Denmark, Estonia, Finland, Lithuania, Latvia, Poland, Sweden) in subdivisions 22-32 in years 2000-2010 (Source: DG Mare, EC).

The Table 2 below shows where the fleets of some of the Baltic countries catch herring cod and sprat in the different ICES subdivisions. This may provide a useful picture, because the risk related to fish parasites may be linked to certain fishing grounds.

[4] COUNCIL REGULATION (EU) No 1124/2010 of 29 November 2010, fixing for 2011 the fishing opportunities for certain fish stocks and groups of fish stocks applicable in the Baltic Sea

Table 2: Overview of major fish species (herring (HER), cod, sprat (SPR), salmon (SAL)) caught by Denmark, Estonia, Finland, Latvia, Poland and Sweden in the eleven regions of the Baltic Sea in the years 2006-2011 (values in 1,000 tons, except for salmon which is indicated in number (1,000) of fish).

	ICES subdivision in the Baltic Sea										
	22	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**
Denmark	COD (48.4); HER (18.5); SPR (143.5); SAL (20.8)*	COD (21.6); HER (44.9); SPR (7.8); SAL (0.3)*	COD (87.5); HER (58.3), SPR (57.2); SAL (94.2)*	COD (111.1); HER (35.1); SPR (446.3); SAL (220.8)*	COD (2); HER (160); SPR (742.3); SAL (42.5)*	HER (63.2); SPR (139.7); SAL (5)*	HER (183.1); SPR (595)	HER (11.5); SPR (300.9)	HER (27.7); SPR (2.9)		HER (4.4); SPR (9.2)
Estonia							HER (167.7); SPR (50); SAL (2.7)*	HER (47.2); SPR (240.4); SAL (2.2)*			HER (159.1); SPR (439.4); SAL (11.7)*
Finland				SAL (5.2)*	SAL (4.2)*		SAL (4)*	HER (148.8); SPR (51.4); SAL (32.1)*	HER (901.9); SPR (63.2); SAL (100.7)*	HER (34.7); SAL (267)*;	HER (20.7); SPR (34.3); SAL (130.4)*
Latvia			COD (0.7)	COD (11.9) SPR (0.1); SAL (1)*	COD (30.2) HER (3.9) SPR (85.7); SAL (13.4)*		COD (2.9) HER (338) SPR (654); SAL (20)*				
Poland			COD (19); HER (60.6); SPR (13.2); SAL (3.6)*	COD (148.8); HER (179.1); SPR (144.7); SAL (41.1)*	COD (95.9); HER (69.2); SPR (318.7); SAL (163.7)*						
Sweden		COD (7) HER (5.5)	COD (9.2); HER (78.2); SPR (94.6); SAL (43.5)*	COD (80); HER (77.6); SPR (136); SAL (167.5)*	COD (84.8); HER (6); SPR (17.8); SAL (70.9)*	COD (2.3); HER (85.2); SPR (192.8); SAL (12)*	COD (1); HER (45.4); SPR (98.8); SAL (25.9)*	COD (2.2.); HER (37.9); SPR (52.7); SAL (53.2)*	COD (3.8); HER (49.1); SAL (108.2)*	HER (0.4); SAL (415)*	

∗ No. of fish

HER = herring, SPR = sprat, SAL = salmon

6. Ways and amount of raw fish consumption

Fish consumption and fish preparation data from some Baltic countries relevant for considering risks from parasite transmission are reported in Table 3 and Figure 6. These data originate from the EFSA Comprehensive European Food Consumption Database which has been built from existing national information on food consumption at a detailed level. Competent organisations in the European Union’s Member States provided EFSA with data from those most recent national dietary survey in their country, at the level of consumption by the individual consumer (EFSA, 2011).

Table 3: Fish consumption in adult population in some Baltic countries collected from the EFSA Comprehensive European Food Consumption Database (EFSA, 2011)

Country (sample size, source)	Pickled herring g/day*	% cons.	Salted herring g/day	% cons.	Smoked herring g/day	% cons.	Whitefish[5] g/day	% cons.	Cod and whiting g/day	% cons.	Sprat g/day	% cons.
Finland (1575, Findiet_2007)	13.8	1.1	15	0.1	14.7	0.1	78.8	1.8	n.a.	n.a.		
Poland (2527, FAO_2000)	115.5	1.2	76	1.4	n.a.	n.a.	n.a.	n.a.	163.2	4.2		
Estonia (1866, NDS_1997)	n.a.	n.a.	96.3	1.9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	96.4	0.6
Latvia (1384, EFSA test)	n.a.	n.a.	29.5	0.5	35	0.1	n.a.	n.a.	82.8	0.7	34.8	1.4
Sweden(1210, Riksmaten_97-98)	5.3	6	7.15	0.1	9.3	0.1	7.1	0.1	13.9	0.8	2.1	0.8

* mean fish consumption
% cons = % of subjects consuming the indicated food within the survey period
n.a. = not available.

[5] Fish belonging to the family of Coregonidae

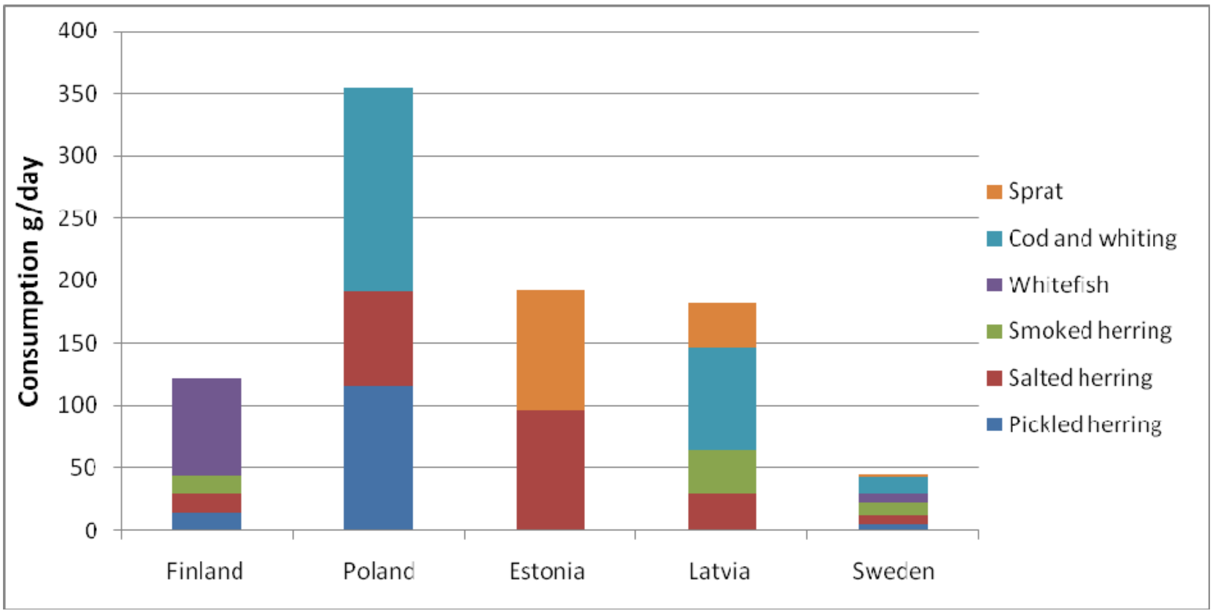

Figure 6: Mean fish consumption in adult population in some Baltic countries collected from dietary survey (source: Comprehensive European Food Consumption Database (EFSA, 2011)

Raw fish is eaten commonly in many countries in northern Europe and America. Gravlax (raw salmon or other salmonid fish cured for 1-2 days in salt, sugar and dill) is one of Scandinavia's and Finland's most distinctive dishes. Other fish including herring are eaten raw or pickled in the Nordic countries and in other Baltic countries. In order to get a gourmet product, the use of unfrozen fish is preferred, because it preserves the desired texture of the fish.

As in other parts of the world, there is increasing popularity of sushi in Finland. For culinary and aesthetic reasons, fish eaten as sushi dishes (sashimi) must be of similarly fresh and of high quality as that used for gravlax.

The amount of domestic fish used as raw material for fillet and other fresh fish products in the fish processing enterprises in 2009 in Finland was 14,958 ± 4,615 tons (95% confidence interval), most of it Baltic herring and sprat and farmed rainbow trout. The amount of imported fish used for the same purpose in 2009 was 11,762 ± 3,765 tons, comprising almost exclusively farmed salmon. More detailed information can be found from the Table 4 (Finnish Game and Fisheries Research Institute 2011). The amount eaten after preparation of food in ways which will not kill the zoonotic parasites, can not be accurately estimated. In addition, there is very intensive recreational fishery in Finland, the total finfish catch being 32,867 ± 3,838 tons in 2008. 7,768 ± 2,390 tons of this was caught from the sea areas of Finland (Finnish Game and Fisheries Research Institute 2009). There are no statistics on the proportions of the recreationally caught fish consumed raw.

Table 4: Raw material weight of domestic fish used for deep frozen and fresh products in Finland, by species and end-product group (1000 kg ± 95% confidence interval). Source: Finnish Game and Fisheries Research Institute, 2009.

Fish species	**Deep frozen**		**Fresh**			
	Ungutted	**Fillet**	**other**	**Fillet**	**Other**	**Total**
Baltic herring and sprat	28,277	1,709	-	5,689	50	35,724 +- 3,530
Cod	-	-	-	14	2	16
Wild Salmon	-	160	-	11,341		11,500

7. Fish parasites of public health importance in the Baltic Sea

For fishery products caught from fishing grounds in the Baltic Sea, four groups of viable parasites present a possible health risks: *Anisakis simplex* (*sensu stricto*), *Contracaecum osculatum* (*sensu stricto*), *Pseudoterranova decipiens* (*sensu stricto*) and *Diphyllobothrium* spp.

7.1. Importance of detection methods of parasites in fishery products

Fish can be examined for the presence of parasites by a variety of methods (EFSA 2010) including visual inspection, slicing, candling, pressing, digestion and recently by Polymerase Chain Reaction (PCR)(Lopez and Pardo, 2010; Mossali et al., 2009). Visual inspection of fillets will reveal worms near the surface, however those embedded in the flesh are not immediately obvious, but may be detected by candling. The pressing method is widely used for systematic detection of nematode larvae in the flesh of fish in specific surveys. However the digestion method which involves the use of a pepsin/hydrochloric acid solution at 37°C to free parasites from muscle or other tissues (Jackson et al., 1981; Smith and Wootten, 1975) which is then sieved and examined for larval nematodes recovers virtually all anisakid nematodes although it is time consuming and thus used for specific surveys rather than mass screening.

A. simplex (*s.s.*) has not been reported in herring and sprat caught in ICES regions 27-32, however there were limited observations and where these have been performed the majority were carried out by visual inspection. Because plain visual inspection is unlikely to unambiguously demonstrate the absence of parasites in fish products, adequate sampling using the most sensitive analytical techniques such as artificial digestion together with an understanding of the migratory patterns of the fish species is necessary to ensure the absence from specified fishing grounds.

7.2. *Anisakis simplex* (*sensu stricto*)

The anisakid parasite larvae present in tissues of numerous fish species, including flatfishes are of great economic importance in marine regions world-wide. *A. simplex* (*sensu stricto*) is the only sibling species of the *A. simplex* complex present in the Baltic Sea (Kijewska et al., 2000; Nascetti et al., 1986; Skov et al., 2009; Szostakowska et al., 2002).

It is probable that the completion of the life cycle of a population of the species *Anisakis simplex* (*sensu stricto*) in the Baltic Sea (Figure 6) cannot occur due to *i*) the absence, except in deep basins, of suitable intermediate/paratenic hosts, i.e. euphausiids (Fagerholm, 1982), which are among the principal food items of several fish species, including herring in the North Sea (Last, 1989), and *ii*) due to the low salinity of the water, which may be important in inhibiting the hatching of the eggs of this parasite species (Højgaard, 1998). This, however, does not exclude the possibility of *Anisakis*-infected fish species, especially herring, migrating from the southern to the northern part of Baltic Sea.

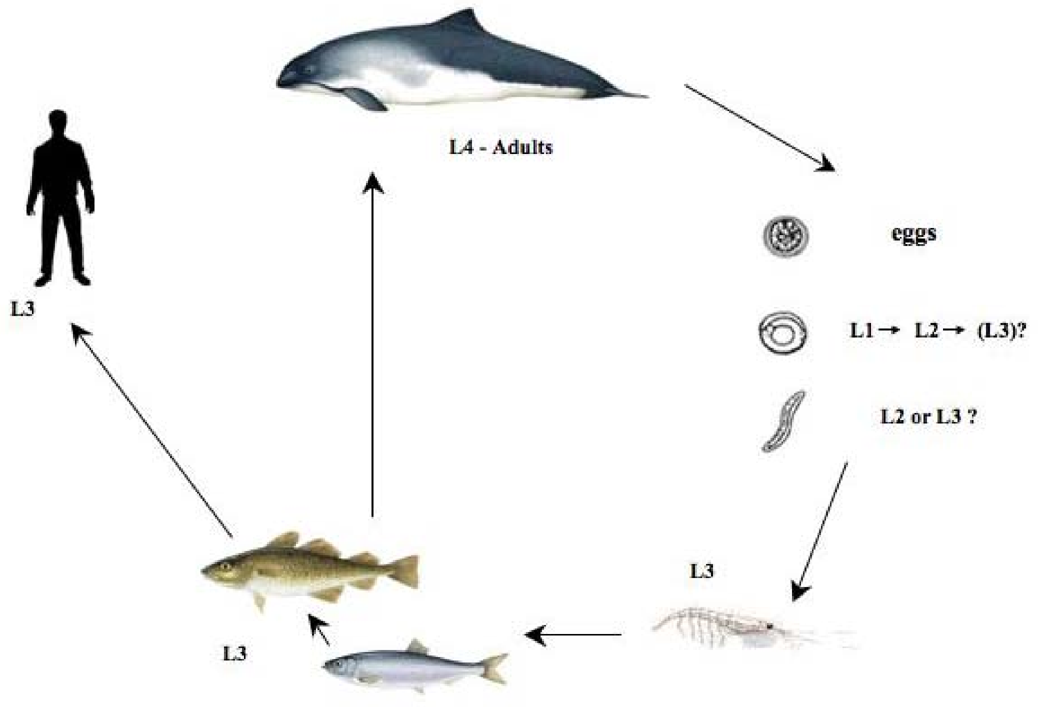

Figure 7: Hypothetical life cycle of *A. simplex* (*s.s.*) (Source: Mattiucci, S.).

In the Figure 7 the larval development of *A. simplex* (*s.s.*) is indicated to occur to the third stage inside the egg, as reported by Køie et al. (1995). Nevertheless other authors have recorded moulting 2nd stage larvae in krill (Hays et al., 1998), which thus makes it a true intermediate host, where larval moults occur. Since this is, however, still under debate (Klimpel et al., 2004), the *A. simplex* larval development is indicated as hypothetical.

A. simplex (*sensu stricto*) larvae were genetically identified based on allozyme markers, from *Clupea harengus* fished in the southern Baltic Sea and Gulf of Gdansk (Mattiucci et al., 1989). These authors concurred with Grabda's hypothesis (1974) that the spring-spawning herring found to be heavily infected with *Anisakis* larvae in the south-western Baltic Sea were those which spawned in these areas, after feeding migration to the North Sea. In contrast, herring which have spent all their life within the Baltic Sea were only occasionally infected (Grabda, 1974). Grabda (Grabda, 1974, 1976) showed that the occurrence of *A. simplex* (*s.s.*) larvae in the southern Baltic was associated with the periodic occurrence of migratory North Sea herring, and that the Baltic cod acquired the larvae by feeding on infected herring.

Infection data of *A. simplex* larvae in herring from the Polish EEZ covering parts of ICES subdivisions 24 – 26, have previously been reported by various authors. Lubieniecki (Lubieniecki, 1972) recorded 12% prevalence and 3.6 mean intensity, in the Gulf of Gdansk during winter and spring of 1969–1972, while Strzyzewska (Strzyzewska, 1979) found larvae in 64.5% in a single sample of large herring (22–32 cm) collected in March 1974 in the same area. Otolith examination suggested that the infected herring were immigrants and belonged to the Rugen coastal spring-spawner population (Strzyzewska, 1987). The local stocks were, at the beginning of 1970s, free of *A. simplex* (Grabda, 1974). These findings are in accordance with the results obtained over 15 years of sampling (ICES subdivision 22 and 24-26), indicating a strict seasonality in the occurrence of *Anisakis* larvae in herring, which seems to be consistent with the migratory behaviour of the actual herring stocks (Lang, 1990). Moreover both prevalence and intensity of the infection appeared to be related to both length and age of the fish. Pronounced differences in *Anisakis simplex* (*s.s.*) larval infections between herring caught in ICES subdivisions 22, 24, 25 and 26 were detected. Thus while in subdivisions 22 and 24 approximately 35% of the herring (size range 20-27 cm) were infected, only 0.6% *Anisakis* prevalence was found in fishes from subdivisions 25 and 26 (Lang, 1990).

More recently, Horbowy and Podolska (Horbowy and Podolska, 2001) reported that herring sampled between 1992-1996 off the Polish coast (ICES subdivisions 24, 25 and 26 including the Vistula Lagoon) were infected with *A. simplex* at prevalence ranging from 6% in fish <19 cm in body length, to 100% in those ranging 29 - 34 cm in length. The authors also suggested that the herring acquired the infection during their feeding migration to the North Sea or Danish Straits when preying on infected euphausiids. In another work dealing with the *Anisakis* infection in spring spawning herring from the Polish EEZ, Podolska and Horbowy (Podolska and Horbowy, 2003) reported the highest prevalence of *A. simplex* larvae in the 1st and 2nd quarters each sampling year (1992-99) while almost no infection was observed in the 3rd quarter. Moreover, the prevalence increased with both length and condition factor (calculated by Fulton's formula; Fulton, 1911), while decreasing eastwards and being higher in coastal areas compared to offshore waters. The same authors also recorded a sharp increase in larval intensity in 1997 and 1999 (while the prevalence remained stable), the reason for this trend are not known (Podolska and Horbowy, 2003).

The tendency for a marked decline in *Anisakis* infection levels from the south-western to the Central Baltic Sea (subdivisions 22, 24, 29) was confirmed by Karl (Karl, 2008) who found 98% prevalence and 18.6 mean abundance in herring caught during winter of 1999 from the Lübeck Bight (ICES subdivision 22) while only 3% and 0.15 prevalence and mean abundance, respectively, were recorded in herring caught off eastern Bornholm (ICES subdivision 25) during September the same year. Thus, it seems to be well documented that the *Anisakis* infection pattern of Baltic herring reflects the migratory behaviour of the different stocks since the heaviest infected fish apparently belong to the south-western and central spring spawning coastal stocks whose members seem to acquire the parasites during feeding migrations to the Danish Straits, the Kattegat and the North Sea (Aro, 1989; Grabda, 1974; Podolska et al., 2006; Szostakowska and Sulgostowska, 2001). Thus, the eastern- and most northerly Baltic herring stocks, i.e. largely confined to subdivisions 27 – 32, appear not to be infected with *A. simplex* (*sensu stricto*) larvae (Grygiel, 1999; Sjöblom and Kuittinen, 1976).

Investigations on the prevalence of anisakid nematodes in three fish species from the southern Baltic Sea (ICES subdivisions 24-26), reported no such parasites in sprat (n = 3,401) (Szostakowska et al., 2005a). However, no information was provided regarding the parasite detection method(s) used. Thus, *A. simplex* seems to be absent in herring and sprat from ICES subdivisions 27-32. However, regular monitoring using sensitive analytical techniques is required in order to confirm the absence of the parasite in herring and sprat from these areas.

The occurrence of *A. simplex* (*sensu stricto*) infections in cod and flounder from the Baltic Sea seems to follow the same basic trend as seen in herring. Thus, *A. simplex* (*sensu stricto*) larvae have been found at generally low prevalence and abundances in both fish host species at western, southern and central Baltic localities (corresponding to subdivisions 24 - 26) (Grabda, 1976; Køie 1999; Möller, 1974; Myjak et al., 1994; Perdiguero-Alonso et al., 2008; Szostakowska et al., 2005a) while *A. simplex* larvae appear to be absent in both fish species from subdivisions 27-32 (Fagerholm, 1982; Køie 1999). However, due to the apparent lack of data on cod from subdivisions 27-32, the possibility exists that the fish could acquire *A. simplex* (*sensu stricto*) larvae through regular or occasional feeding of infected migratory fish species such as herring. Indeed, Fagerholm (1982) recorded *A. simplex* (*sensu stricto*) larvae in a single garfish from off the Åland archipelago (subdivision 29). Although the garfish is a migratory species not endemic to the area, this may act as a source of *A. simplex* (*sensu stricto*) infection in larger piscivorous cod.

Since migrating fish from areas where *A. simplex* (*sensu stricto*) occurs may carry the parasite and reach the northern Baltic, public health risks due to this species in all migratory fish (including salmon) cannot be excluded.

Additionally, *A. simplex* (*sensu stricto*) larvae have been found at high prevalence and intensity in the flesh of pikeperch (*Sander lucioperca*), a freshwater fish, from brackish water localities around the Greifswalder Bodden (ICES subdivision 24) (Karl et al., 2002). However, no reports exist regarding the occurrence of *Anisakis* larvae in fish from other brackish water localities of the Baltic Sea including the Bay of Bothnia (EFSA, 2010).

The presence of *A. simplex* (*sensu stricto*) larvae in migratory fish in the northern Baltic, as shown by Fagerholm (Fagerholm, 1982), does not exclude the possibility that suitable definitive hosts may occasionally consume infective larvae of this parasite. Cetaceans, the main definitive hosts for the species of the genus *Anisakis*, are not regularly found in the Baltic, except for the harbour porpoise, *Phocaena phocaena*, which represents one of the major hosts for *A. simplex* (*sensu stricto*) in North Sea waters (Mattiucci and Nascetti, 2008). In the Baltic Sea, the population size of harbour porpoise has decreased by more than 90% during the 20th century, and the species is currently classified as ‘‘vulnerable’’ (HELCOM, 2009). Much of the decline is presumably due to historically high levels of direct exploitation. For example, hundreds of harbour porpoises were captured annually by targeted hunting in the Little Belt, Denmark during migrations to and from the Baltic Sea (MacKenzie et al., 2002). Environmental contaminants are also likely to affect the long-term viability of Baltic Sea harbour porpoise stocks and this factor might have been a major cause for the decline of these populations between the 1940s and the 1970s. Since then concentrations of PCBs and other organochlorine contaminants have recently declined, the current most important threat to Baltic Sea harbour porpoises is by-catch (Koschinski, 2002). So far, seals have not been reported as parasitized by *Anisakis* in the Baltic Sea (Mattiucci and Nascetti, 2008). In Table 5 the observations of harbour porpoises (*Phocaena phocaena*) in Finland are shown.

Table 5: Observations of harbour porpoises (*Phocaena phocaena*) in Finland in 2001-2009.

Year	Nr. of observations	Total no. of animals	ICES subdivisions
2001	6	10	30-31-32
2002	3	7	32
2003	6	5-8	29, 32
2004	3	5-7	29, 30, 32
2005	1	1	29
2006	1	1	29, 32
2007	3	8	29, 32
2008	2	6	32
2009	3	5	29, 30

Data source: Finland environmental administration (www.ymparisto.fi).

At examination for helminth parasites of 17 young harbour porpoises, stranded or caught in fish nets in the southern Baltic Sea during 1989-1995, Rokicki et al. (1997) found no nematodes in these animals' digestive tracts. They especially noted the absence of *A. simplex* (*sensu stricto)* in their material studied.

In Table 6 data on the distribution of *A. simplex* (*sensu stricto*) in different fish species in the Baltic Sea are reported.

Table 6: Distribution of *A. simplex* (*s.s.)* in different fish species in the Baltic Sea.

Fish Species	No. fish	Prevalence %	Abundance	Intensity (range and Im: mean)	Catching area (ICES)	Reference
Garfish	5	20	n.a.	5.0	29	Fagerholm 1982
Salmon	1	n.a	n.a.	1.0	31	(Hirvela Koski, 2010)
Cod	300	0.0	n.a.	n.a	29-31	Fagerholm, 1990
Pikeperch	n.a.	n.a.	n.a.	n.a	24	(Feiler and Winkler, 1981)
Pikeperch	n.a.	n.a.	n.a.	n.a	24	(Walter, 1988)
Herring	206	94.6	n.a.	n.a	24	(Campbell et al., 2007)
Herring, cod and flatfish*	31,091 herring	86.0	n.a	1-157 Im= 8		(Szostakowska et al., 2005a) *
	3,036 cod	0.92	n.a.	n.a	24-26	
	1,598 flounder	25.0	n.a	1-6		
	3,401 sprat	0	n.a.	n.a.		
Flounder	25	4			24-25	(Køie 1999)
Herring	4727	0.4	n.a.	1-6	26	(Grygiel, 1999)
Cod	97	11.3		3.7	25	Buchmann 1983 unpub.
Flounder	60	10.0		1.5	25	Buchmann 1989 unpub.
Herring	76	1.3		5.0	25	Buchmann 1983 unpub.
Herring	n.a.	n.a.		75.0		(Szostakowska et al., 2002)
Cod	n.a.	n.a.		11.0	26	
Flounder	n.a.	n.a.		13.0		

*brought to the Baltic by infected herring migrating from the North Sea for spawning in coastal waters of the southern Baltic.
n.a.: not available or not estimated.

7.2.1. Zoonotic potential

Anisakis simplex (*sensu stricto*) is well recognized as having a zoonotic role to cause gastric and intestinal infection to humans (EFSA, 2010; Umehara et al., 2007).

Cases of anisakiasis in the Baltic area have been reported: Knöfler and Lorenz described five cases of anisakiasis from Germany between 1975-1981. Some of these infections were identified as resulting from eating under-cooked herring caught in the Baltic Sea (Knöfler and Lorenz, 1982).

7.3. *Contracaecum osculatum* (*sensu stricto*)

Contracaecum osculatum (*sensu stricto)* is an anisakid parasite of possible public health importance. The only species of the genus *Contracaecum* maturing in seals present in the Baltic Sea is *C. osculatum* (*sensu stricto*) which is a sibling species of the *C. osculatum* complex and is genetically distinct from *C. osculatum* A and *C. osculatum* B, occurring in the North Atlantic Ocean (Nascetti et al., 1993).

In the Baltic Sea, *C. osculatum* (*sensu stricto*) is a parasite, at the adult stage, of the grey seal, *Halichoerus grypus*. High infection levels by adults of *C. osculatum* (*sensu stricto*), has been documented in this seal host from the Bothnian Bay (Nascetti et al., 1993). The life cycle of *C. osculatum (s.s.)*, likely to occur in the Baltic Sea, is shown in Figure 8, where, as for *A. simplex*, the larval development is indicated to occur to the third stage inside the egg. Since this is, however, still under debate, the larval development is indicated as hypothetical. According to experimental infections trials (Køie and Fagerholm, 1995), copepods act as paratenic hosts in the life-cycle of *C. osculatum* (*s.s.*), while smaller fish species (such as *Gasterosteus* spp.) represent first intermediate hosts.

Species of the genus *Contracaecum* also occur in fish-eating birds, and e.g. both adult and larval stages of *C. rudolphii* have been documented in cormorants (Szostakowska and Fagerholm, 2007).

The Baltic Sea is inhabited by three species of seals: the ringed seal (*Phoca hispida*) is an Arctic species and is therefore directly dependent on quality of ice by colonizing mainly the large gulfs in the north-eastern Baltic Sea (Gulf of Bothnia, Gulf of Finland, and Gulf of Riga) where ice is annually formed. The main concentrations of grey seal (*Halichoerus grypus*) are found in the northern part of the Baltic Proper. The harbour seal, *Phoca vitulina* is present only in the southern Baltic (Ojaveer et al., 2010). In the ringed seal, Fagerholm (Fagerholm, 1990) reported a very low infection level by *C. osculatum (sensu lato*), despite the high number of seals parasitologically examined; whereas, the grey seal was found heavily infected by *C. osculatum* (*sensu stricto*). In addition to adult worms, fourth stage larvae, and several third stage larvae were commonly found in the infected grey seals thus suggesting that the seals have acquired the infection by preying upon infected fish from the same region (Fagerholm, 1990).

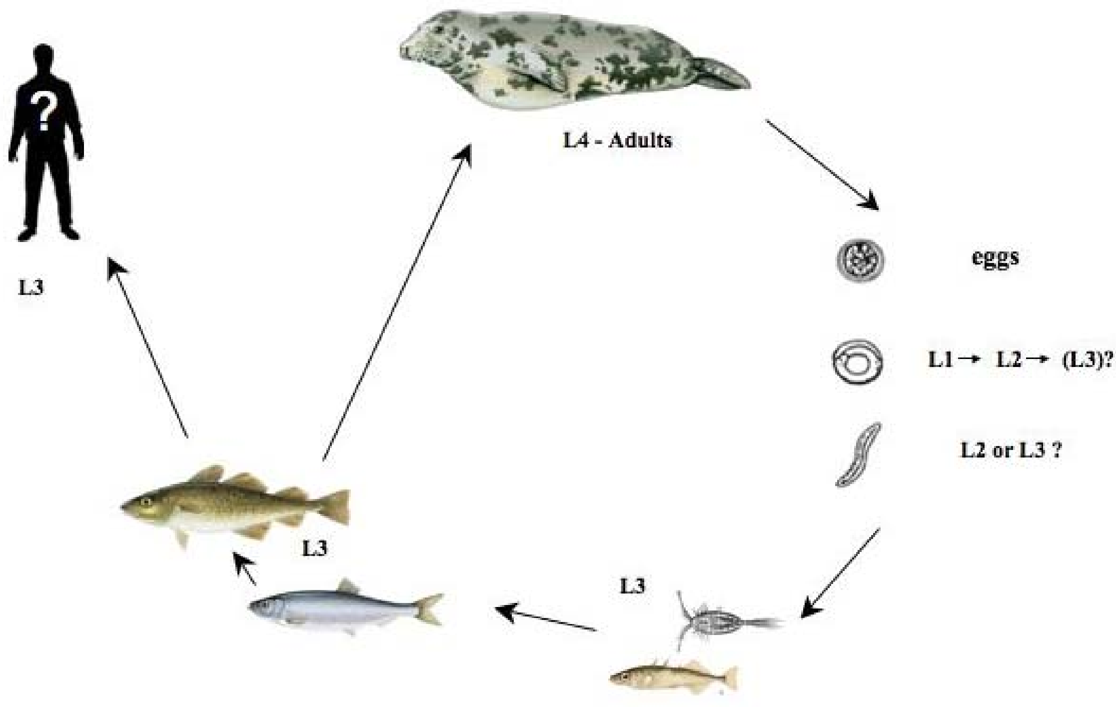

Figure 8: Hypothetical life cycle of *Contracaecum osculatum* (*s.s.*) in the Baltic Sea (Source: Mattiucci, S.).

The larval stages of this parasite species can not be identified to the species level by means of morphological features, but only by genetic/molecular methodologies (Mattiucci and Nascetti, 2008). Indeed, the 3rd-stage larvae of the genus *Contracaecum*, maturing in seals and occurring in fish, are commonly indicated as *Contracaecum/Phocascaris* larvae because they cannot be morphologically distinguished from those belonging to the genus *Phocascaris* (Mattiucci and Nascetti, 2008).

Contracaecum/Phocascaris larvae occur in a wide range of fish species throughout the Baltic, including herring, cod, flounder and Atlantic salmon which are all commercially important (Fagerholm, 1990; Grabda, 1976; Myjak et al., 1994; Myjak and Szostakowska B, 1996; Perdiguero-Alonso et al., 2008; Szostakowska et al., 2005a).

Contracaecum/Phocascaris larvae can also be found in the fish flesh from Baltic waters: *Phocascaris* spp. was reported in Baltic herring caught in coastal Finnish areas in 1976 and 1978 (Sjöblom and

Kuittinen, 1976). In other investigations (Engelbrecht, 1958; Grabda, 1976; Petrushevski and Shulman, 1955; Rokicki, 1972; Shulman, 1948; Studnicka, 1965) nematode larvae, mainly from the liver of Baltic cod and Baltic herring and some other fish species, have been reported as *Hysterothylacium aduncum*. Those nematodes were likely the third-stage larvae of *C. osculatum* as indicated by Fagerholm (Fagerholm, 1979).

Valtonen (Valtonen et al., 1988) investigated the occurrence of *C. osculatum* in fish and seals from the Bothnian Bay, and found 7 of 30 fish species studied to be infected with 3rd stage larvae of the parasite. The highest prevalence was recorded in Atlantic salmon, sculpin (*Myoxocephalus scorpius*), burbot (*Lota lota*) and cod. Although the average intensity of infection was low and not markedly aggregated, a slight accumulation of larvae with fish length was observed.

In brackish Baltic Sea localities, the *C. osculatum* (*s.s.*) frequently occurs in various fish species including herring and cod, from the south-western and southern fishing grounds (Szostakowska et al., 2005b). In the Bay of Bothnia, *C. osculatum* reaches prevalence of 20% and 15% in Atlantic salmon and cod, respectively. Fish caught in Finnish water can be infected with *C. osculatum.*

An ongoing investigation carried out by means of molecular/genetic methodologies for the identification of anisakids of capelin (*Mallotus villosus*) from the south-eastern Barents Sea, has so far revealed that *Contracaecum osculatum* B larvae appear to be the most prevalent and abundant anisakid in the musculature of the fish species. The larvae were situated in the belly flaps, in close proximity to the peritoneum (Figure 9). In 2009 (n fish = 127) and 2010 (n fish = 193), the prevalence of the larvae in the belly flaps ranged from 17 – 28 % while the mean intensity was 1.4 (intensity range 1-8) in both sampling years (Levsen and Mattiucci, 2011). Although the possibility exists that at least some of the larvae migrated into the belly flaps *post mortem*, possibly facilitated by the small size of the fish (weight range 10 – 52 g) and hence a short migratory distance, the findings show that *C. osculatum* may occur in the flesh of fish intended for human consumption, thus underlining its zoonotic potential.

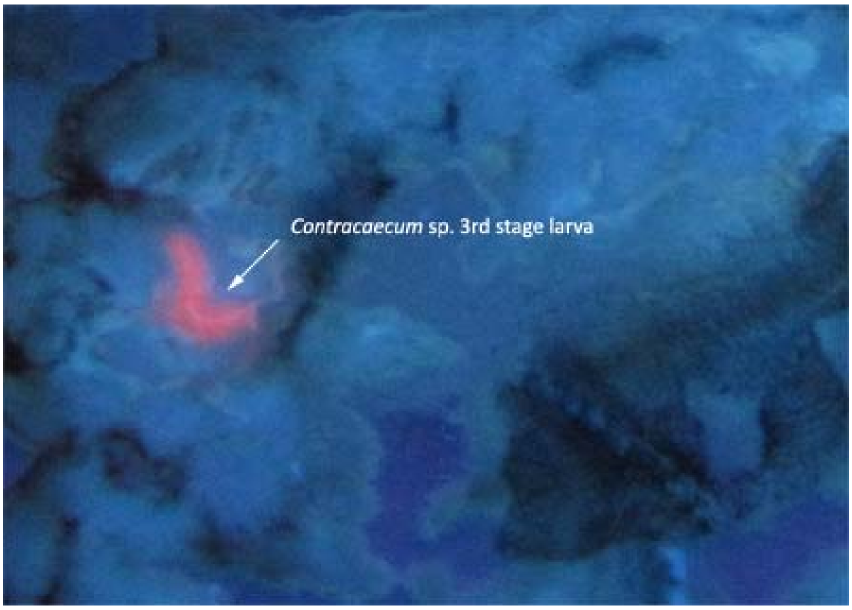

Figure 9: *C. osculatum* B third stage larvae in the flesh (belly flaps) of capelin from the Barents Sea (seen under a 366 nm UV-light source) (Source: A. Levsen).

In Table 7 data on the distribution of *C. osculatum* in different fish species in the Baltic Sea are reported.

Table 7: Distribution of *C. osculatum sensu stricto* in different fish species in the Baltic Sea

Fish Species	No. hosts	Prevalence %	abundance	intensity	Catching area (ICES)	Reference
Cod	97	22.7		4.3	25	Buchmann 1983 unpub.
Herring	76	3.9		1.0	25	Buchmann 1983 unpub.
Salmon, bull trout, burbot and cod, grey seal	7400	20.0, 20.0, 16.0 and 15.0,	n.a.	n.a.	31	(Valtonen et al., 1988)
Cod	300	Frequently found	n.a.	n.a	29	Fagerholm 1990
Flounder	200	8-24	n.a.	1-2	25,28,29,32	(Køie 1999)
Grey seal	n.a.	n.a.	n.a.	43	25-26	(Szostakowska et al., 2002)
Herring	n.a.	n.a.	n.a.	2	25-26	(Szostakowska et al., 2002)
Cod Flounder	3036 1598	2.5 0.12	n.a. n.a.	n.a. 1	25-26 26	(Szostakowska et al., 2002, 2005)
Crucian carp, Caspian round goby *	n.a.					(Szostakowska and Fagerholm, 2007)*

* *C. rudolphii* B, can develop both in fresh and brackish water
n.a.: not available or not estimated.

7.3.1. Zoonotic potential

Fagerholm (1988) showed that following infective third-stage larvae of the genus *Contracaecum* from fish cultured in vitro and being fed to rats, fourth-stage larvae can develop in rat's stomach at 2-5 days post-infection (p.i.), but no adult worms developed. Larvae introduced surgically into the body cavity of laboratory rats yielded some adult worms from day 42 onwards. Adult males were identified as *Contracaecum osculatum* (Fagerholm, 1988). In this experimental infection, some larvae were found deeply embedded in the gastric submucosa and in the peritoneal cavity of the experimental infected rats. Elarifi (Elarifi, 1981) administered ten *Contracaecum osculatum* larvae from North Sea whiting to each of 24 rats and recovered 33 larvae from 4 hours to 10 days post-infection. After 4 hours post-infection the majority of larvae were firmly embedded in the stomach wall. A strong inflammatory reaction with necrosis and ulceration was associated with the attached larvae. Pathology was seen in rats up to 18 days post-infection even though larvae were not recovered.

A single human case of nematode infection has been reported due to the larval stages of *C. osculatum* following consumption of fish caught from the Baltic Sea in Germany (Schaum and Müller, 1967). The possibility of under-diagnosis cannot be excluded in patients with gastro-intestinal illness. *Contracaecum osculatum* in fish occurs throughout all areas of the Baltic Sea, however, it is not possible to assess the public health importance of viable *C. osculatum* larvae in fishery products from any fishing grounds of the Baltic Sea.

7.4. *Pseudoterranova decipiens* (*sensu stricto*)

The larval stages *Pseudoterranova* sp. from Baltic fish have, so far, been rarely detected and has not been detected in subdivisions 28 – 32. *Pseudoterravova* sp. larvae were found very rarely infecting cod from the southern Baltic Sea (Szostakowska, 2005). Infection by *Pseudoterranova* sp. larvae was reported in angler fish by Skov (2009) in Danish waters.

Myjak et al. (1994) found two *P. decipiens* larvae in a single cod caught off the Polish coast out of 3036 cod sampled in the southern Baltic (subdivisions 24 – 26), while Perdiguero-Alonso et al. (2008) recorded 3.9% and 0.07 ± 0.39 prevalence and mean abundance (± SD), respectively, in cod (n = 180) from off the south-eastern coast of Sweden, corresponding roughly to ICES subdivisions 25 and 27.

An investigation of anisakid nematodes in the harbour seal (*Phoca vitulina*) from the Skagerrak, Kattegat and the Baltic revealed that *P. decipiens* was the most prevalent nematode species. The abundance of the species was highest in the northernmost Skagerrak and Kattegat (16.8-22.9 parasites per animal) while only low intensities of *P. decipiens* (< 5 in both immature and adult seals) was recorded in harbour seals (n = 12) from the southern coast of Sweden (Lunneryd, 1991). In the latter seals the mean intensity of both larval stages and adults of *C. osculatum* was 3, while *A. simplex* appeared to be absent. These data are coherent, and explain the low abundance of *P. decipiens* larvae in fish from neighbouring areas such as subdivisions 25 and 27 (Perdiguero-Alonso et al., 2008).

In Figure 10 the hypothetical life cycle of *Pseudoterranova decipiens sensu stricto* in the Baltic Sea is shown. As for *A. simplex* and *C. osculatum*, the larval development is indicated to occur to the third stage inside the egg. Since this is, however, still under debate (Measures and Hong, 1995), the larval development is indicated as hypothetical.

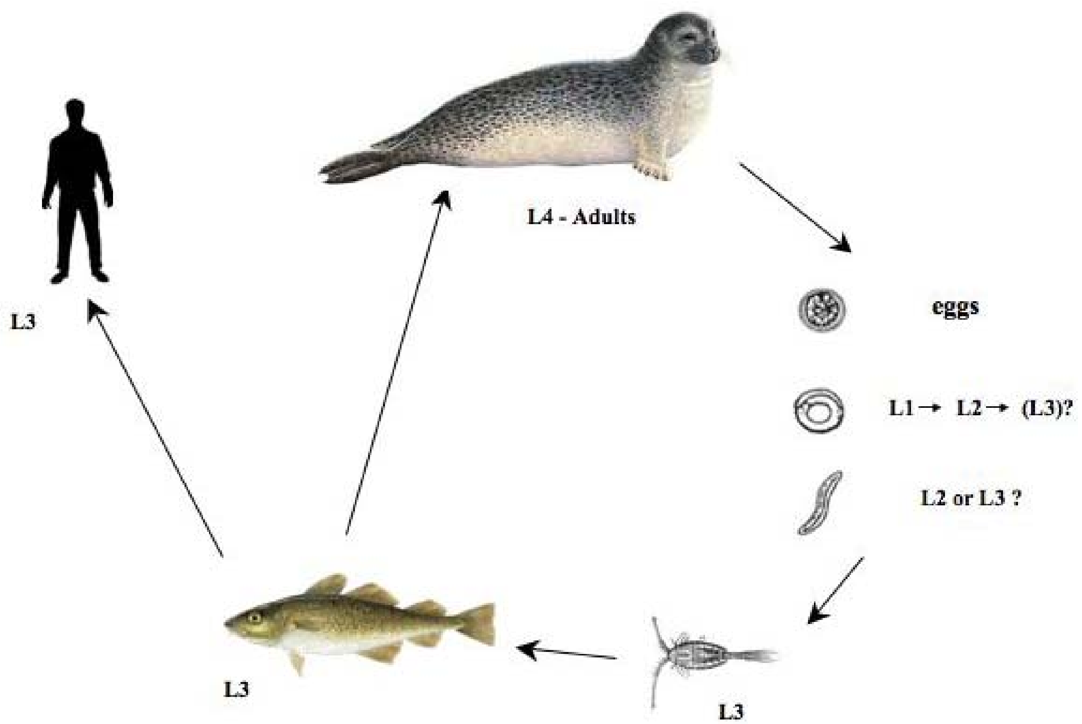

Figure 10: Hypothetical life cycle of *Pseudoterranova decipiens (s.s.)* in the Baltic Sea (Source: Mattiucci, S.).

By means of genetic methodologies, it has been demonstrated that *Pseudoterranova decipiens (sensu lato*) from the North Atlantic Ocean and Norwegian and Barents seas comprises three sibling species. These species have different host preference with respect to different species of seals as definitive hosts, and different geographical distributions (Paggi et al., 1991). The common seal, *Phoca vitulina* from the Baltic Sea (Tjarno, Sweden) have been found to be infected with few adult specimens of the sibling species *Pseudoterranova decipiens* (*sensu stricto*) (Paggi et al., 1991). This species is genetically distinct from the other sibling species of the *P. decipiens* complex, i.e. *P. krabbei*, *P. bulbosa* occurring in the North Atlantic (both Eastern and Western) as well as from *P. azarasi* from the North Pacific waters (Mattiucci et al., 1998) which predominantly parasitizes the grey seal, the bearded seal and the Steller sea lion, respectively (Mattiucci and Nascetti, 2008).

In Table 8 data on the distribution of *P. decipiens* (*sensu stricto*) in different fish species in the Baltic Sea are reported.

Table 8: Distribution of *P. decipiens* (*sensu stricto*) in different fish species in the Baltic Sea (.

Host species	No. samples	Prevalence	abundance	intensity	Catching area (ICES)	Reference
Cod	180	3.9	0.07 ± 0.39	n.a.	ICES 25-27	(Perdiguero-Alonso et al., 2008)
Cod	3036	1 cod infected	n.a.	2	ICES 25-26	(Myjak et al., 1994)
Harbour seal	12	n.a.	n.a.	4.0	25,27	(Lunneryd, 1991)
Cod	3036	1 infected fish	1	4.0	25-26	(Szostakowska et al., 2005a)
Monkfish	10	20.0	0.2	n.a.	22-23	(Skov et al., 2009)

- n.a.: not available or not estimated.

One important question is why *Pseudoterranova decipiens* (*sensu lato*) has not established itself as a parasite of seals in the Baltic Sea and thus becoming a threat to Baltic fishery. In contrast to *Anisakis simplex,* the eggs of *P. decipiens* can develop in low salinity conditions, even in freshwater (Burt et al., 1990), and under these conditions, the unsheathed larvae coming out of the eggs thrive. Suitable paratenic and intermediate hosts for *P. decipiens* larvae (different crustaceans and small sized fish species, McClelland, 1990) abound in the Baltic Sea, as well as suitable final hosts (seals).

7.4.1. Zoonotic potential

Historically, the "codworm" or "sealworm" *Pseudoterranova decipiens sensu lato (= Phocanema decipiens),* has been identified to cause anisakiasis: first reports of human *Pseudoterranova decipiens sensu lato* infections were from North America, Alaska and California (Myers, 1979; Kliks, 1983; Margolis and Beverley-Burton, 1977; Smith and Wootten, 1978). Although now reported worldwide (Lee 1998, Koh et al 1999; Yu et al., 2001; Arizono et al., 2011; Mattiucci et al., 2011; Torres et al., 2007) far fewer cases of nematode infection ascribed to *Pseudoterranova* spp. are reported in the literature compared with those attributed to *Anisakis* spp. larvae.
Since *P. decipiens* has been found in fishery products in the southern Baltic Sea (ICES 22, 23, 24, 25, 26 and brackish water lagoon), public health risks due to this parasite in all fishery products caught from these areas cannot be excluded.

7.5. *Diphyllobothrium* spp.

The life cycle of *Diphyllobothrium* spp. is shown in Figure 11.

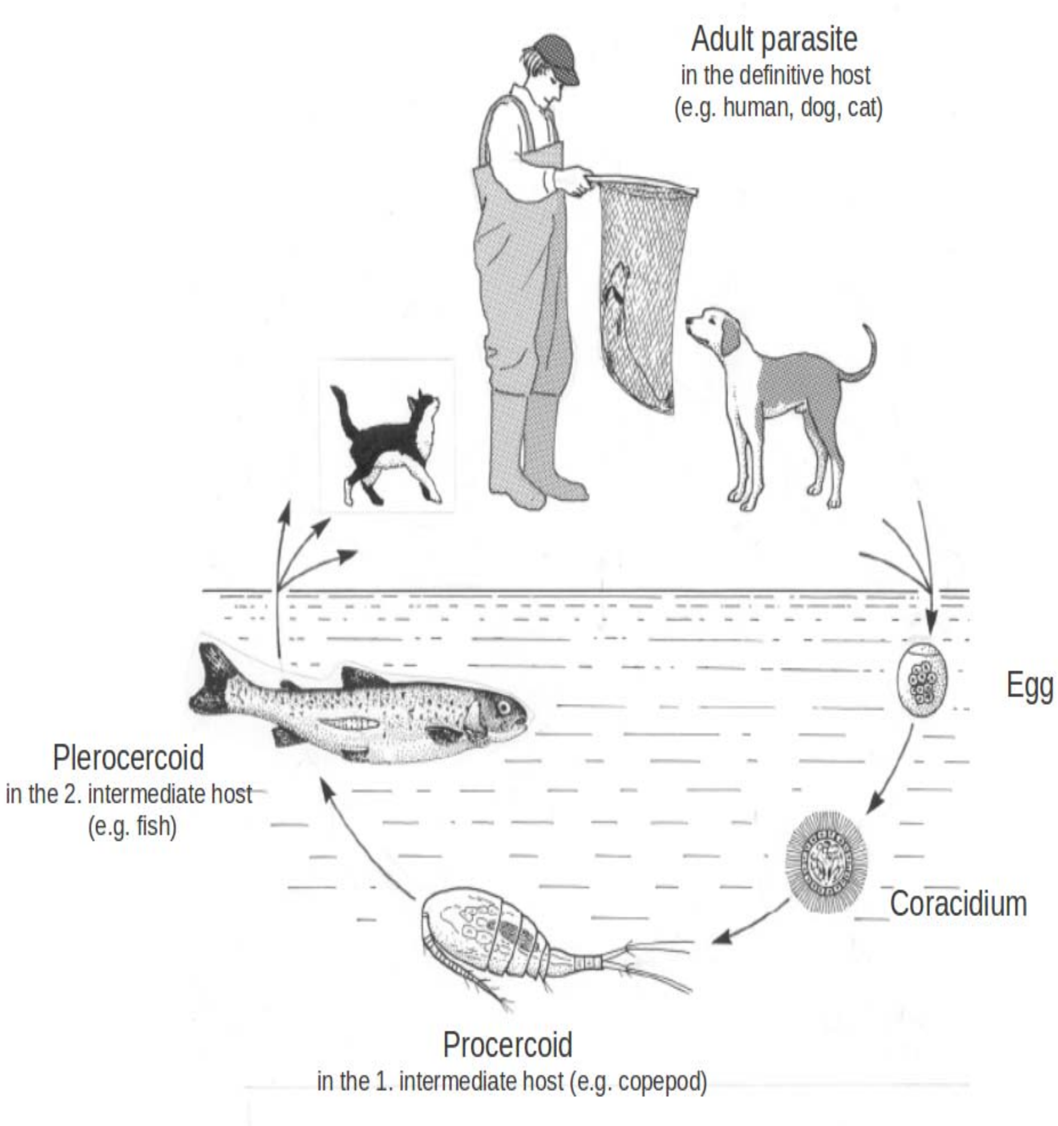

Figure 11: Life cycle of *Diphyllobothrium* spp. (Buchmann, 2009).

There is limited reliable data on the occurrence of plerocercoids of *Diphyllobothrium* in strictly marine fish (Andersen, 1977). Plerocercoids of *Diphyllobothrium* cestodes from salmonids have frequently been identified as being *D. latum*. However, whitefish (subfamily: Coreginae) do not harbour plerocercoids of *D. latum*, but are frequently infected with larvae of other *Diphyllobothrium* species, especially *D. dendriticum* and *D. ditremum* (Andersen, 1977*).*

Fagerholm and Valtonen (1980) found plerocercoids of *D. dendriticum* on the oesophagus and stomach of migratory whitefish (*Coregonus lavaretus* L.) from the brackish water of the northern Bothnian Bay (salinity ≤ 3.5‰) while whitefish from the slightly more saline waters around the Åland area (salinity 5.5 – 6.0‰) were apparently not infected with the parasite. Andersen and Valtonen (Andersen and Valtonen, 1992) recorded the larvae of three *Diphyllobothrium* species, i.e. *D. latum*, *D. dendriticum* and *D. ditremum*, in 13 out of 31 fish species from the Bothnian Sea. According to Andersen and Valtonen (1992), plerocercoids of *D. latum* occur at low to moderate infection level in pike, burbot, perch and ruff, with the highest prevalence (~39%) and mean intensity (3.3) in burbot.

In Table 9 data on the distribution of *Diphyllobothrium* spp. in different fish species in the Baltic Sea are reported.

Table 9: Distribution of *Diphyllobothrium latum* in different fish species in the Baltic Sea.

Fish Species	No. fish	Prevalence %	Catching area (ICES)	Reference
Whitefish	146	1.4	31	Fagerholm and Valtonen, 1980
Stickleback*	31 fish species	42% of fish species	31	(Andersen and Valtonen, 1992)
Pike	n.a.	Up to 84	Finnish inland waters into 32	(Von Bonsdorf, 1977)
Burbot	n.a.	Up to 86	"	(Von Bonsdorf, 1977)
Ruff	n.a.	Up to 9	"	(Von Bonsdorf, 1977)
Perch	n.a.	Up to 39	"	(Von Bonsdorf, 1977)
Pike	n.a.	100.0 %	Lake Peipus (Estonia) flowing into ICES 32	(Kondrateva, 1961)
Burbot	n.a.	93.4 %	"	"
Perch	n.a.	26.2%	"	"
Ruffe	n.a.	6.6%	"	"

*Infections with *D. ditremum* and *D. dendriticum* plerocercoids were also reported.
n.a.: not available or not estimated.

7.5.1. Zoonotic potential

A comprehensive review of diphyllobothriosis was recently completed by Scholz (Scholz et al., 2009) who described human diphyllobothriosis as still being present in western Europe, but at markedly decreased prevalence in the historically endemic areas of the brackish waters of the Baltic Sea, e.g. Estonia, Latvia, and Lithuania, as well as in Poland, Sweden, and Norway. In Finland, where human cases were commonly recognised, infections with *Diphyllobothrium latum* showed a decrease to the 1980s (Raisanen and Puska, 1984), and currently about 20 cases/year are reported (Scholz et al., 2009). In this country whitefish[6], trout, pike, ruff, burbot, perch have been traditionally the most common host that transmit diphyllobothriosis (Von Bonsdorf, 1977).

The zoonotic potential of *Diphyllobothrium* is associated with food and the environmental contamination from reservoirs of the parasite. Diphyllobothriosis is associated with eating raw or poorly cooked fish. This includes the consumption of raw, salted or marinated and lightly processed fish, e.g. "gravad fisk", which is a common dish in parts of Sweden and Finland and other Baltic or Scandinavian countries including areas surrounding the Bothnian Sea (Scholz et al., 2009).

The risk of water contamination with these tapeworms' eggs is increased by the ability of most *Diphyllobothrium* species to mature in nonhuman hosts. Because of their generally broad host specificity, their life cycles are maintained in nature independently from humans. Therefore, antihelminthic treatment of the human population does not necessarily eliminate the parasite from affected areas. Sylvatic cycles involving bears, foxes, seals, gulls, and other fish-eating birds and mammals probably play a crucial role in water contamination. The close contact between dogs, cats, and humans may represent a risk of transmitting this zoonotic agent, but some surveys revealed a low infection rate of these hosts. For example, coprological examinations of 505 and 296 dogs from Switzerland and Finland, respectively, revealed the presence of *D. latum* in only 0.4% of dogs examined (Pullola et al., 2006). The wide host range of animals serving as a reservoir of *D. latum* may result in the dissemination of parasites to new geographical areas similarly to the import of fish intermediate hosts such as Pacific salmons, rainbow trout, or whitefish (Scholz et al., 2009). Among these cestodes, *D. latum* is considered the species with greatest zoonotic potential, although there is some evidence that also other species are able to infect humans, such as *D. dendriticum* (Halvorsen, 1970; Williams and Jones, 1994).

[6] Fish belonging to the subfamily Coregoninae

Diphyllobothrium occurs in fish species in brackish waters of Baltic Sea. Hence all freshwater fish as well as migrating fish including sea trout and whitefish are of public health importance since they may carry viable parasites.

CONCLUSIONS

- Parasites in fishery products of possible public health risk in Baltic Sea include *Anisakis simplex* (*sensu stricto*), *Contracaecum osculatum* (*sensu stricto*), *Pseudoterranova decipiens* (*sensu stricto*) and *Diphyllobothrium* spp.

- *A. simplex* (*sensu stricto*) has not been detected in herring and sprat caught in ICES regions 27-32, however there are limited observations and where these have been performed, the majority were carried out by visual inspection.

- Because plain visual inspection is unlikely to confirm the absence of parasites in fish products, adequate testing using sensitive analytical techniques such as artificial digestion together with an understanding of the migratory patterns of the fish species is necessary to determine the absence from fishery products, including herring and sprat, from specified fishing grounds (ICES regions 27-32) in the Baltic Sea.

- Since *A. simplex* and *P. decipiens* have been found in fishery products in ICES subdivisions 22, 23, 24, 25, 26, public health risks due to the presence of these parasites cannot be excluded in any fishery products caught from these areas.

- Migrating fish from areas where *A. simplex*, and to a lesser degree *P. decipiens*, occur may carry these parasites and reach the northern Baltic. Therefore public health risks due to parasites in all migrating fish (including salmon) cannot be excluded.

- *C. osculatum* occurs in fish throughout all areas of the Baltic Sea. However, at present it is not possible to assess the public health importance of viable *C. osculatum* larvae in fishery products from the Baltic Sea.

- *Diphyllobothrium* spp. occurs in fish species in brackish waters of the Baltic Sea. Hence all freshwater fish as well as migrating fish including sea trout and whitefish may carry viable parasites of public health importance.

RECOMMENDATIONS

- In order to be able to attribute anisakids from fish from the Baltic Sea to human infections, genetic/molecular methods should be more widely applied to marine hosts from the Baltic Sea.

- Surveillance of anisakiasis and other parasitic infections in the human population in Baltic Sea countries should be improved.

- To elucidate the importance of *C. osculatum* from fish as a source of human infection, more research is needed including the pathogenicity of this parasite to humans and the anatomical distribution of the parasites in edible parts of the fish.

DOCUMENTATION PROVIDED TO EFSA

- Letter from Ministry of Agriculture and Forestry, Finland dated 1.9.2010 (ref. 479/312/2007).

- Letter from the Estonian Food and Veterinary Board dated 10/11/2010 (ref. 10.11.2010 No 4-8/3673).

- Annex 1: The report by Evira (Finnish Food Safety Authority) on investigations of fish for parasites on 21 June 2010. This includes also the opinion of Dr. Hans-Peter Fagerholm, Abo Akademi University. Department of Biology, Laboratory of Aquatic Pathobiology.

- Annex 2: The opinion of Dr. Seppo Meri, University of Helsinki, Haartman Institute, Department of Bacteriology & Immunology and Helsinki University Central Hospital Laboratory, Parasitology Unit, concerning the human data in Finland on 31 August 2010 (the update of the earlier report, see Annex 4).

- Annex 3: The opinion of Dr. B. Goran Bylund, Abo Akademi University, Laboratory of Aquatic Pathobiology on parasites transmittable from fish to humans in Finnish fish products on 10 March 2008 (the update of his earlier opinion, see Annex 4).

- Annex 4: The letter of Director General Jaana-Husu Kallio, the Ministry of Agriculture and Forestry, Veterinary and Food Department, to the European Commission on conditions concerning parasites in fish on 17 November 1998. This includes also the report of Dr. Sakari Jokiranta and Dr. Seppo Meri of Helsinki University, Haartman Institute, Department of Bacteriology and Immunology, Parasite Research Unit, on fish derived human parasitic infections in Finland on 30 January 1997, as well as the opinion of Dr. B. Goran Bylund, Abo Akademi University, Institute of Parasitology, on parasites transmittable from fish to humans in Finnish fish products on 2 April 1997.

- Annex 5: The description of the Finnish Fish Farming Association concerning the trout and whitefish production in Finland on 16 August 2010. The official statistics of Aquaculture 2009 in Finland, produced by Finnish Game and Fisheries Institute, also in English: http://www.rktl.fi/www/uploads/pdf/uudet%20julkaisut/tilastoja_5_2010.pdf.

- Annex 6: The letter of Deputy Director General Pentti Munne, the Ministry of Agriculture and Forestry, Department of Fisheries and Game, to the European Commission, DG MARE, on Council Regulation (EC) N:o 81212004 concerning incidental catches of cetaceans in fisheries in the Baltic Sea, second and final national report of Finland, on 24 April 2008. (The report shows that no whales or harbour porpoises were caught incidentally in Finland in 2006 and in 2007.).

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APPENDIX

A. NOTIFICATIONS FROM THE RAPID ALERT SYSTEM FOR FOOD AND FEED (RASFF)

In the Table 10 notifications from the Rapid Alert System for Food and Feed (RASFF) system are reported, extracted on the following criteria:

- *Period*: 2004-Feb 2011
- *Countries of origin*: Denmark, Latvia, Lithuania, Poland, Russia, Sweden, Finland, Germany, Estonia (for the last three nothing was found)
- *Product category*: Fish and fish products
- *Hazard category*: parasitic infestation

Table 10: Notifications of parasitic infestations in fishery product from the RASFF system

Country of notification	Country of origin	Year	Fish species	Conservation	Body parts	Parasites species	Localisation of larva
IT	DK	2004	mackerel	fresh		*Anisakis* spp.	muscle, peritoneal cavity
IT	DK	2004	mackerel	fresh		*Anisakis* spp.	peritoneal cavity
IT	DK	2004	mackerel	fresh		*Anisakis* spp.	
IT	DK	2004	mackerel	fresh		*Anisakis* spp.	
IT	DK	2004	mackerel	fresh		*Anisakis* spp.	
IT	DK	2004	mackerel	fresh		*Anisakis* spp.	
IT	DK	2004	mackerel	fresh		*Anisakis* spp.	
IT	DK	2004	mackerel	fresh		*Anisakis* spp.	
IT	DK	2005	monkfish		tails	*Anisakis* spp.	
IT	DK	2005	monkfish		tails	*Anisakis* spp.	
IT	DK	2005	monkfish	chilled	tails	*Anisakis* spp.	
IT	DK	2005	monkfish	fresh	tails	*Anisakis* spp.	
IT	DK	2005	monkfish		tails	*Anisakis* spp.	
IT	DK	2006	Mackerel			*Anisakis* spp.	
A	SE	2007	cod	fresh	fillets	*Anisakis* spp.	
IT	DK	2007	cod	fresh	loins	*Anisakis* spp.	
IT	DK	2008	cod	fresh	fillets	*Anisakis* spp.	
IT	DK	2008	cod	fresh	fillets	*Anisakis* spp.	
BG	DK	2008	roe spread			nematodes	
F	DK	2009	cod			*Anisakis* spp.	

Country of notification	**Country of origin**	**Year**	**Fish species**	**Conservation**	**Body parts**	**Parasites species**	**Localisation of larva**
IT	DK	2009	cod	fresh chilled	fillets, whole fish	*Anisakis* spp.	muscle
IT	DK	2008	monkfish			*Anisakis* spp.	
LIT	E	2010	cod	frozen	fillets	*Anisakis* spp.	peritoneal
LIT	E	2010	cod	frozen	fillets	*Anisakis* spp.	peritoneal
LV	LIT	2010	carp	live		*Piscicola geometra, Dactylogyrus* sp., *Tetraonchus* sp., *Valipora* sp., *Carryophyllaeus*	
LV	LIT	2010	carp	live		*Piscicola geometra, dactylogyrus* sp., *Tetraonchus* sp., *Valipora* sp., *Carryophyllaeus*	
LIT	Russia	2010	pike	frozen	fillets	nematodes	
LV	PL	2006	fish liver	canned		nematodes	
SK	PL	2008	cod liver	canned		*Anisakis* spp.	
SK	PL	2008	cod liver	canned		*Anisakis* spp.	
SK	PL	2008	cod liver	canned		*Anisakis* spp.	
LIT	Russia	2008	pike	frozen		Philometra, trematode	
LIT	Russia	2008	pike	frozen		Philometra, trematode	
LIT	Russia	2008	pikeperch	frozen	fillets	trematode	
LIT	Russia	2009	pikeperch	frozen	fillets	nematodes	
LIT	Russia	2009	rudd	frozen		nematode, trematode	
LIT	Russia	2009	pikeperch	frozen	fillets	parasite	
LIT	Russia	2009	rudd	frozen		nematode, trematode	
LIT	Russia	2009	pike	frozen	fillets	*Philometra*, trematode	
LIT	Russia	2009	pikeperch	frozen	fillets	nematodes	
LIT	Russia	2009	pink salmon	canned		*Anisakis* spp.	
LIT	Russia	2009	pikeperch	frozen	fillets	nematodes	
LIT	Russia	2010	pike	frozen	fillets	nematodes	
LIT	Russia	2010	pike	frozen	fillets	nematodes	
AU	Sweden	2007	cod	fresh	fillets	nematodes	

B. FISH SPECIES NAME AND COMMON NAME OF THE MAIN FISH SPECIES IN THE BALTIC SEA MENTIONED IN THE PRESENT OPINION

Latin names	English	German	Italian	Spanish
Alburnus alburnus	Bleak	Ukelei, Laube, Zwiebelfisch	Scardola	Alburno
Anguilla anguilla	European eel	Aal	Anguilla	Anguila
Belone belone	Garfish	Hornhecht	Aguglia	Aguja
Blicca bjoerkna	Whitebream	Güster, Blicke	Scardola d'argento	Brema balnca
Carassius carassius	Crucian carp	Karausche	Carassio	Carpin
Chelon labrosus	Thicklip mullet	Dicklippige Meeräsche	Cefalo bosega	Muble, lisa
Clupea harengus	Herring	Hering	Aringa	Arenque
Coregonus lavaretus	Whitefish	Lavaret	Lavarello	Farra o lavareto
Engraulis encrasicolus	Anchovy	Sardelle	Alice	Anchoa, boqueron
Esox lucius	Pike	Hecht	Luccio	Lucio europeo
Gadus morhua	Atlantic cod	Kabeljau, Dorsch	Merluzzo bianco	Bacalao
Gasterosteus aculeatus	Stickleback	Dreistachlige Stichling	Spinarello	Espinoso
Gymnocephalus cernuus	Ruffe	Kaulbarsch	Acerina	Acerina
Leuciscus idus	Ide	Aland, Orfe, Nerfling	Cavedano	Cacho, cachuelo
Liza ramada	Grey mullet	Dünnlippige Meeräsche	Cefalo botolo	Morragute
Lophius piscatorius	Monkfish	Seeteufel	Rana pescatrice	Rape
Lota lota	Burbot	Aalraupe, Aalrutte, Trische	Bottatrice	Mustela de rio
Mallotus villosus	Capelin	Lodde, Kapelan	Capelano	Capelan
Merlangius merlangus	Whiting	Wittling, Merlan	Molo, merlano,	Merlan, plegonero
Neogobius melanostomus	Caspian round goby	Schwarzmund-Grundel	Ghiozzo krugljak	Gobio de boca negra
Oncorhynchus mykiss	Rainbow trout	Regenbogenforelle	Trota iridea	Trucha arco iris
Osmerus eperlanus	Smelt	Stint	Sperlano	Esperlano
Perca fluviatilis	Perch	Fluβbarsch	Pesce persico	Perca
Platichthys flesus	Flounder	Flunder, Butt	Passera nera	Platija
Salmo salar	Atlantic salmon	Lachs	Salmone	Salmón
Salmo trutta	Trout	Forelle	Trota fario	Trucha
Salvelinus confluentus	Bull trout	Stierforelle	Trota toro	Trucha toro
Sander lucioperca	Pikeperch	Zander	Lucioperca	Lucioperca
Scomber scombrus	Mackerel	Makrele	Sgombro	Caballa
Scophthalmus maximus	Turbot	Steinbutt	Rombo chiodato	Rodaballo
Sprattus sprattus	Sprat	Sprotte	Spratto	Espadin
Vimba vimba	Vimba bream	Zährte, Rußnase	Abramide russo	Vimba

GLOSSARY

- **Abundance**: is the number of individuals of a particular parasite species in a single host, regardless of whether the host is infected or not. **Mean abundance** is the arithmetic mean of the number of individuals of a particular parasite species per host examined (including both infected and uninfected).

- **Accidental hosts:** are those that are not part of the natural chain of infection and do not normally lead to infection of the definitive hosts, but are accidentally infected, ending to a dead end of the life cycle of the parasite.

- **Anadromous:** fish that live mostly in the ocean, and breed in fresh water (Greek: 'Ana' is up;

- The noun is "anadromy").

- **Anisakiasis:** human disease caused by an infection with a live *Anisakis* larva.

- **Cartilaginous fish:** jawed fish with paired fins, paired nares, scales, two-chambered hearts, and skeletons made of cartilage rather than bone. They are divided into two subclasses: Elasmobranchii (sharks, rays and skates) and Holocephali (chimaera, sometimes called ghost sharks), which are sometimes separated into their own class.

- **Catadromous:** fish that live in fresh water, and breed in the ocean.

- **Copepods:** a group of small crustaceans found in the sea and nearly every freshwater habitat. Many species are **planktonic** (drifting in sea waters), but more are **benthic** (living on the ocean floor). Copepods are sometimes used as bio-indicators and they are usually the dominant members of the zooplankton, and are major food organisms for small fish, whales, seabirds and other crustaceans such as krill in the ocean and in fresh water. They represent the intermediate/paratenic host for many fish parasites of public health importance (e.g. *Anisakis* spp., *Diphyllobothrium* spp.).

- **Coracidium:** the larval stage after egg hatching of pseudophyllidian cestodes such as *Diphyllobothrium* and *Spirometra* spp. This ciliated free-swimming larval stage contains six hooks like those in the oncospheres of other tapeworms.

- **Definitive hosts:** those in which the reproduction of adult form of the parasite occurs and from which the offspring is shed.

- **Fishery products:** all seawater or freshwater animals [except for live bivalve molluscs, live echinoderms, live tunicates and live marine gastropods, and all mammals, reptiles and frogs] whether wild or farmed and including all edible forms, parts and products of such animals

- **Intensity** (of infection): the number of individuals of a particular parasite species per infected host in a sample. It is commonly reported as a range, when used descriptively. **Mean intensity** is the arithmetic mean of the number of individuals of a particular parasite species per infected host species.

- **Intermediate hosts:** those that harbour juvenile stages of the parasite (their larvae), and allow the parasite to moult one or more times.

- **Paratenic host (or transport host):** a host of a parasite where survival but no larval development occurs. This stage may be crucial for successful transfer of the parasite to the next host level, e.g. another transport host upwards the food chain, or the definitive host

- **Pelagic fish**: fish which spend all or most of their adult life in the water column of coastal, oceanic or lake waters. Typically, many pelagic fish species show extensive shoaling behavior: e.g. herring, mackerel, blue whiting.

- **Plerocercoid:** the second larval stage of pseudophyllidian cestodes which infects a wide range of vertebrate hosts including fish, amphibia, reptiles, mammals, and birds (second intermediate hosts – the first one is a crustacean copepod). The definitive host becomes infected by eating the tissues of the second intermediate host.

- **Prevalence**: is the number of hosts infected with 1 o more individuals of a particular parasite species, divided by the number of the hosts examined for that parasite species. It is commonly expressed as a percentage when used descriptively.

- **Procercoid:** the first larval stage of pseudophyllidean tapeworms that develops after ingestion by the first intermediate host (e.g. copepod).