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Multi-decadal scale variability in the eastern Baltic cod fishery 1550–1860—Evidence and causes

Brian R. MacKenzie [a,*], Maibritt Bager [b], Henn Ojaveer [c], Kenneth Awebro [d], Ulla Heino [e,1], Poul Holm [f], Aadu Must [g]

[a] *Technical University of Denmark, Danish Institute for Fisheries Research, Department of Marine Ecology and Aquaculture, Kavalergården 6, DK-2920 Charlottenlund, Denmark*
[b] *Centre for Maritime and Regional History, The University of Southern Denmark, Niels Bohrs Vej 9-10, DK-6710 Esbjerg, Denmark*
[c] *Estonian Marine Institute, University of Tartu, Vana-Sauga 28, 80031 Pärnu, Estonia*
[d] *Södertörn University College, 141 89 Huddinge, Sweden*
[e] *University of Turku, Turku, Finland*
[f] *Roskilde Universitetscenter, Hus 04.2, Universitetsvej 1, Postboks 260, DK-4000 Roskilde, Denmark*
[g] *Department of History, University of Tartu, Ülikooli 18, 50090 Tartu, Estonia*

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Abstract

Identification of periods of high and low cod production, and the reasons for these periods, can increase understanding of variability in populations and ecosystems. In this study we investigate the multi-decadal and multi-century scale variations in the cod population in the eastern Baltic Sea (ICES Subdivisions 25–32). Analytically derived estimates of biomass are available since 1966. These estimates show that biomass increased in the late 1970s–early 1980s, but decreased nearly 10-fold until the early 1990s and is still well below the long-term average. Prior to 1966 the biomass of cod is unknown, as is the relative role of fishing, climate variability/regimes, eutrophication and reduction of marine mammal predator populations. We have begun to investigate whether historical fisheries information (landings, effort, distribution) from before the 1880s is available in Baltic archives and museums, and to what extent this information can be used to interpret variations in this population. We have located fisheries data for different parts of the Baltic for different time periods since the 1550s and have interpreted the findings using current process knowledge of oceanographic mechanisms affecting cod reproduction and ecology in the Baltic Sea. The recovered data show that the Baltic ecosystem was able to support modest-large cod populations even though it was oligotrophic and contained large populations of cod predators (e.g., marine mammals). Current ecosystem management policy in the Baltic as developed and implemented by organisations such as the International Council for the Exploration of the Sea (ICES), the Baltic Marine Environment Protection Commission (HELCOM), the nine coastal countries and the European Union includes recovery of the cod population, a reduction in nutrient loading and measures to promote recovery of seal and harbour porpoise populations. If these policies are successful, the role of predatory fish in the future Baltic could again be substantial and comparable to that which we show existed 450 years ago. However, such a scenario will also require a major reduction in cod fishing mortality and suitable hydrographic conditions which promote successful cod reproduction. Historical ecology investigations in the Baltic can contribute to scientifically based fishery and ecosystem management and recovery plans.

Keywords: Baltic Sea; Cod; Historical ecology; Fisheries; Ecosystem; Management

1. Introduction

The Baltic Sea has experienced several major human impacts during the 20th Century. Three of these impacts are fishing, removal of most marine mammal predators (i.e., seals, harbour porpoises), and eutrophication/pollution (Hansson, 1985; Elmgren, 1989; MacKenzie et al., 2002a). In addition, inter- and multi-annual changes in climatic and hydrographic forcing (Schinke and Matthäus, 1998; Hagen and Feistel, 2005; MacKenzie and Schiedek, 2007) have influenced conditions for reproduction of three of the most abundant commercial fish species (cod, sprat and herring (Axenrot and Hansson, 2003; MacKenzie and Köster, 2004; Köster et al., 2005), and the intro-

* Corresponding author.
E-mail address: brm@difres.dk (B.R. MacKenzie).
[1] Present address: Ekmanink.6 B 68, Turku, Finland.

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duction of non-native species has altered some food webs and ecosystem functions especially in coastal areas (Schiedek, 1997; Ojaveer et al., 2002; Leppäkoski et al., 2002).

Some of these changes have occurred nearly simultaneously and over many decades during the 20th Century. The coinciding nature of these impacts complicates the interpretation of cause–effect relationships among forcing variables and responses, and as a result the causes of changes in population biomasses or ecosystem structure and functioning cannot yet be definitively identified (MacKenzie et al., 2002a). Because of these uncertainties, it is difficult to design appropriate remedial actions and recovery plans, as well as to forecast how populations and the ecosystem will react under future scenarios of fishing, eutrophication, climate change and marine mammal predation (MacKenzie et al., 2002a; MacKenzie and Köster, 2004). This situation has stimulated new modelling studies which are attempting to quantify the trophic and energy flows within the ecosystem (Harvey et al., 2003; ICES, 2005a; Hansson et al., 2007).

One of the fish species whose biomass has changed most during the 20th Century is cod, *Gadus morhua*. The population in the eastern part of the Baltic (ICES Subdivisions 25–32; Fig. 1) is now at its lowest level in the available time series of biomass estimates (1966–2005; ICES, 2006), after decreasing ca. 10-fold from maximum biomass in the early 1980s. The population declined when a period of high fishing mortality coincided with a long period of environmental conditions which inhibited cod reproduction and recruitment (Köster et al., 2005). Before 1966 when VPA biomass estimates begin, the biomass and stock dynamics are poorly known (Thurow, 1997; MacKenzie et al., 2002a; Eero et al., 2007). There is some indication (Thurow, 1997) that the biomass of all fish species in the early decades of the 1900s was very low due to high marine mammal predation and a lower overall level of productivity of the Baltic (i.e., pre-eutrophication conditions).

If this biomass estimate is (eventually shown to be) reliable, then one must ask whether the period of low biomass was a temporary situation, or whether biomass was generally this low and therefore representative of the long-term carrying capacity of the Baltic Sea for cod production. Given that reproduction in eastern Baltic cod depends on hydrographic and climatic variables (Köster et al., 2005), one might hypothesize that cod biomasses and landings have fluctuated in the past. Alternatively if abundances were always low before the 1900s then this result would be consistent with the possibility that a future increase in marine mammal abundance and a reduction in nutrient concentrations could lead to, or sustain the present, low cod biomass regime in the Baltic Sea (Hansson et al., 2007). The roles of these different impacts (eutrophication, fishing, marine mammal predation) can start to be resolved by considering the historical ecology of cod in the Baltic.

We have begun to address these ideas by recovering from various national archives original historical material related to the Baltic cod fisheries during the last 500 years (MacKenzie et al., 2002b). The history of the Baltic region and the recovery and retrieval of historical documents is however complicated because the Baltic is bordered by nine countries having different administrations, and because of invasions, occupations and wars. Consequently the state of the archives varies greatly between countries and over time (see below) because the organisation of the administrative authorities was not uniform. The contents of the national archives are therefore influenced by the historical changes in jurisdictional authority over territories and the changes in central administration over time within countries. Moreover, the written records of the economies of some countries which were previously occupied are located in the former occupier's country and not the country in whose waters the fishing actually took place. For example, much of the southern Swedish fishery information during the early 1600s is located in Danish archives (Holm and Bager, 2001; MacKenzie et al., 2002b) because the southern province of Sweden (Scania) was at that time part of Denmark. Similarly, and as we will show below, some fishery information for German and Polish towns is located in Denmark and Sweden. Lastly, many of the archives in several Baltic countries (i.e., those in the former east-block) have been closed for investigation by both domestic and foreign colleagues for 4–5 decades, and have only since the early 1990s become accessible. Most of these archives have never been investigated for fishery purposes, and their potential contribution to fishery dynamics is only beginning to be identified (MacKenzie et al., 2002a; Lajus et al., 2007; Gaumiga et al., 2007).

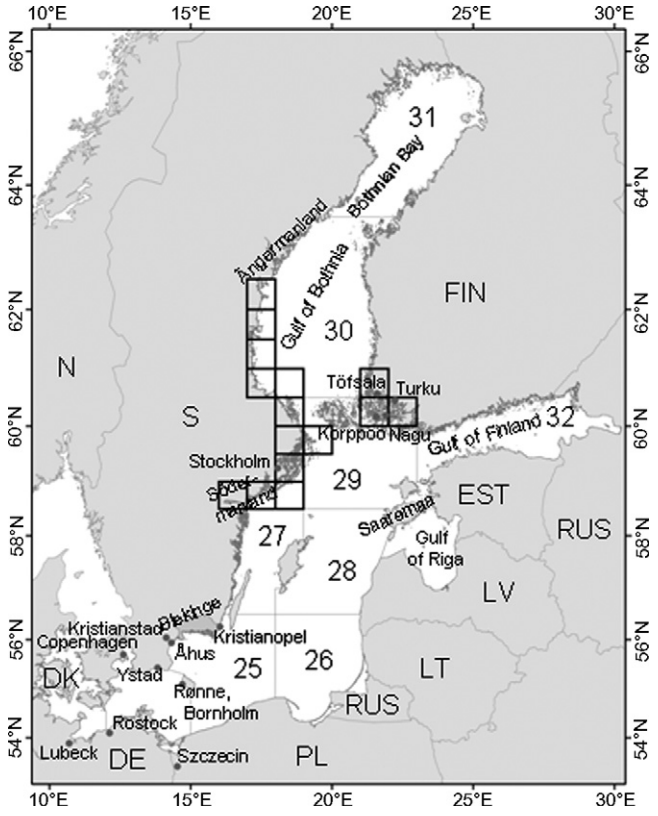

Fig. 1. The Baltic Sea with bordering countries, locations of some important towns for cod fishing and trade during 1550–1860 and ICES Subdivisions (numbers). The Baltic Proper is the area within Subdivisions 25–29. Also shown are positions of ICES statistical squares where historical (late 1500s–early 1600s) and contemporary (late 20th Century) Swedish and Finnish cod landings data are available (see text for details).

It is therefore necessary that this historical context is acknowledged when attempting to document the fisheries in an ecosystem exploited by many different countries. Our work therefore involves a close collaboration between maritime and fisheries historians and fisheries ecologists, and has three objectives. First we wanted to identify which type of records might contain historical fishery information, and where the relevant archives for individual countries were physically located. Second, having identified some likely sources for fishery information, we wanted to provide an overview of the type of information that these archives contained (e.g., qualitative statements regarding good or bad fishing periods and places; landings and effort data) which could stimulate new long-term studies of Baltic fisheries. Third, depending on the quantity and quality of information found in the archives, we wished to recover information and data (e.g., magnitude of landings, when and where the fisheries took place, levels of effort used in the fishery) that could be used to help quantify temporal and spatial variations in the Baltic cod fishery.

2. Methods

We investigated archives of several of the nine countries surrounding the Baltic Sea (i.e., Denmark, Estonia, Finland, Latvia, Russia and Sweden). In addition, literature information has been used from all countries around the Baltic. The choice of countries which have been investigated depended primarily on accessibility and availability of likely archival material for the time period considered. The team of researchers have special competencies in the history of the Nordic and Baltic countries, and much remains still to be discovered, especially in the archives of Germany and Poland. As a starting point for entry to the archival sources, we (1) used historical accounts of the Baltic fisheries (e.g., Otterlind, 1984; Bagge et al., 1994; Holm and Bager, 2001) published in journals and monographies; and (2) established a dialogue and collaboration between natural scientists and fisheries/maritime historians on the topic of our study. Both actions succeeded in identifying and interpreting older source literature (Fig. 2; see Appendix A and Section 3). Since the fishery was an economic activity contributing to a nation's wealth, we narrowed our investigation of archival material to the examination of national economic records for different periods of interest. The economic records included customs and tax accounts, as well as export and import records. Our investigation therefore is primarily based on official sources recorded by governmental authorities and therefore does not include other potential data sources such as personal journals of individual fishermen or aristocrats or church (e.g., monastery) records.

The data recovered from archival sources depends partly on the regulatory and administrative structures in place. Because these structures differ between countries and change over time, they can influence the data available for interpreting fluctuations in the cod fishery. We briefly describe in Appendix A the various archives and administrative structures investigated in different countries. We emphasize that we have not been able to examine all archives in all countries nor even all archives within individual countries; where possible we identify where additional fishery information can likely be found in new investigations. All data sources which have been investigated are described below in Results according to the different countries.

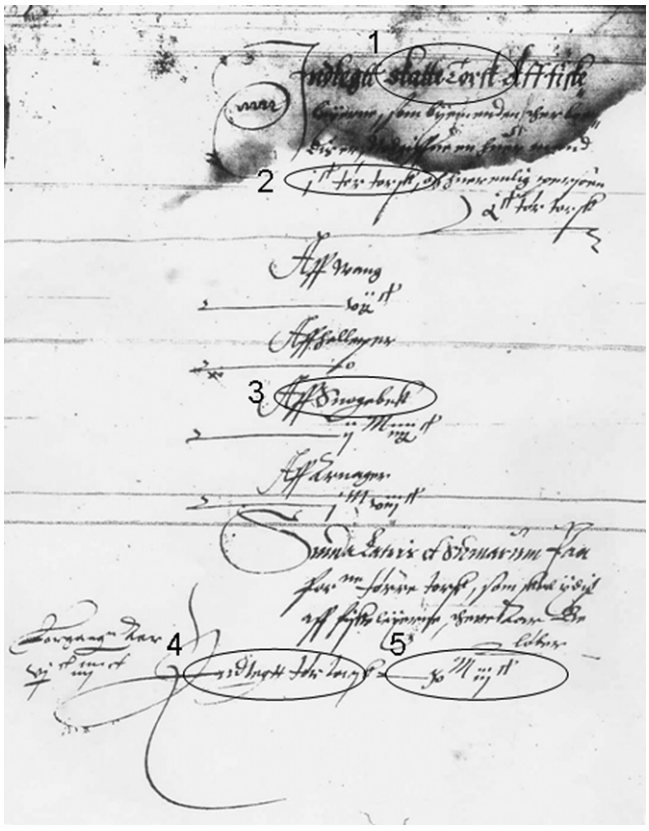

Fig. 2. An example of a tax account record from 1602 from the Danish county of Hammershus on the island of Bornholm (Fig. 1). Examples of parts of the text translated from Danish are given by the circled and numbered texts—1: identifies that the record refers to tax cod (Danish: skatte-torsk); 2: states that the taxation rate was 100 dried cod per household; 3: the village name, Snogebeck; 4: total dried cod; 5: four 1/2 M 300 dried cod = 4.5 × 1000 + 300 = 4800 dried cod paid in tax in the year of the account (1602).

3. Results and discussion

3.1. Identification of archival sources

Appendix A contains a description of the archives which have been investigated; this description provides the administrative context for the development of fisheries reporting in different Baltic countries.

The history of the Baltic region is complicated because of wars, invasions, occupations and other disasters (e.g., major fires). This means that the written records of the economies of some countries have been destroyed, and can be located in the former occupier's country rather than the (present) country of origin of the fishing activity. The state of the archives also varied greatly by country, because the organisation of the administrative authorities was not uniform within the region. The contents of the national archives reflect the historical process of changes in jurisdictional authority over territories and the changes in central administration over time in each country. In this study,

Table 1
Different units of fish catch records used in the Baltic countries during the 16–20th Century, as found in archival research in different countries

Unit	Conversion	Time period	Country	Species
Volumetric units				
Barrel		1681–1687	Estonia	Herring
Barrel	108.2 l	1663–1843	Denmark	Cod, herring, salmon
Barrel	126.6 l	1754–1888	Sweden	Herring, mackerel
Barrel	120 l	1889–1913	Sweden	Herring
Barrel		1862	Latvia	Herring
Cubic feet	0.125 barrel	1874–1878	Sweden	Herring, sprat
Fjärdingar	0.25 barrel	1755–1770	Sweden	Herring
Hectolitre	100 l	1873–1912	Sweden	Herring
Kulmit	14.1 l	1838–1851	Estonia	Herring
Loof	42.3 l	1840–1851	Estonia	Herring
Val(ar)	0.04 barrel	1874–1910	Sweden	herring
Zuber	0.2 barrel	1846–1851	Estonia	Herring
Åm/fat	157 l	1801–1810	Sweden	Herring
Laest	12 barrels or 1520 l	1550s	Sweden	Cod
Laest	1905 kg (for dried fish); 12 barrels or 1298 l for salted herring)	1672–1825	Denmark	Cod, herring
Laest	150 ft^3	1830–1867	Denmark	Cod, herring
Laest	1.95 registertons	1825–1867	Denmark	Cod, herring
Registerton	1000 ft^3 or 2830 l	1867–20th Century	Denmark	Cod, herring
Weight units				
Lispund	8 kg	1663–1843	Denmark	Cod, salmon
Lispund	8.5 kg	1868–1885	Sweden	Herring
Lispund	8.5 kg	1868–1885	Sweden	Cod, plaice
Lispund	8.5 kg	1879–1883	Sweden	Eel
Lispund	8.5 kg	1874–1885	Sweden	Salmon, sea trout
Lispund	8.5 kg	1886–1887	Sweden	Whitefish
Pound	0.5 kg	1663–1838	Denmark	All species
Pood	16.4 kg	1911	Latvia	Several species
Pound	0.500 kg	1839–2002	Denmark	All species
Tonnes (barrel)	10 lispund			
(85 kg)	1796–1851	Estonia	Herring, ide, roach, perch	
Tonnes	1000 kg	1881–1910	Sweden	Herring
Tonnes	1000 kg	1892–1901	Latvia	Salmon
Val	2.25 kg	1914	Sweden	Herring
Counting units				
Ol	80 pieces	1500–1920	Denmark	Herring
Score	20 pieces	1861–1865	Sweden	Plaice, sprat
Score	20 pieces	1663–1901	Denmark	All species
Score	20 pieces	1884–1895	Sweden	Flounder
Val	80 pieces	1878–1883	Sweden	Herring

Table 2
Cod exports and taxes for towns in Södermanland county and near Stockholm archipelago (Fig. 1), as recovered from a preliminary investigation of Swedish archives for the years 1556–1559

Year	Town/area	Laests	Barrels	Total kg
1556	Nyköping, Enskær, Hamnskær		15	1424
1557	Different miscellaneous taxes	10	6.75	12,035
1557	Frösåker		1	95
1557	King's own fishery	1	7.5	1,852
1557	Södermanland		1	95
1557	Strångehamn (Döderhult parish)		3	285
1558	Frösåker: customs from fishing boats from Ängermanland and Finland		1	95
1558	Outer Stockholm archipelago	2	0.5	2,326
1558	Stockholm		22.5	2,136
1558	Svenska Högarna		27	2,564
1559	Stockholm	15	8	17,851

One Swedish laest = 12 barrels or 1520 l. The data shown above illustrate the potential for further data recovery and interpretation.

we have focussed only on cod, although similar information is available for several other commercially important species such as herring, eel, salmon (MacKenzie et al., 2002b; Gaumiga et al., 2007; Lajus et al., 2007; Ojaveer et al., 2007).

During various time periods, different units (i.e., volumetric, weight and counting) have been applied for recording fish catches in different countries around the Baltic. The units found in historical archival documents within the current study are displayed with some additional explanatory information in Tables 1 and 2.

3.2. Quantifying the magnitude of the Baltic cod fishery 1550–1860

The cod fishery in the Baltic Sea has an ancient history and archaeological studies have found cod bones on Bornholm and in other coastal areas along the Baltic. These finds are from the Stone Age period 7000–3900 B.C. (Enghoff et al., 2007), and the 6–7th and 11th Centuries A.D. (Enghoff, 1999). Early societies were therefore capable of capturing cod at subsistence levels of consumption since millennia, although quantities captured are not known.

We have now found substantial new written quantitative evidence of cod fishing during the past 4–5 Centuries. The archipelago of Gillöga (WSW Svenska Högarna; north of the Stockholm archipelago) was one of the places where inhabitants paid a "cod duty" to the King Gustav Vasa in 1558 (Otterlind, 1984). We therefore conducted a preliminary examination of some of the Swedish archives (Strödda kamerala handlingar) and focussed our initial exploratory investigation on the 1550s. The objective was to evaluate whether quantitative information about landings, exports, number of participants, and fishing effort exists and whether a more extensive investigation and recovery would be fruitful.

Our initial exploration showed that records of landings and exports exist for named individual fishermen, as well as the King's fishery, during the 1550s. These fisheries were conducted in the area near Stockholm and further to the south (e.g., Småland; Table 2). We have also found evidence of cod landings north of Stockholm and of cod imports to Stockholm from neighboring towns along the Swedish coast. The amounts of cod exported to Stockholm were several barrels (1 barrel = 126.6 l) per fisherman per year, and when accumulated on an annual basis, reach 5–15 tonnes/year (Table 2; Fig. 3), assuming that 1 l of cod weighs 1 kg.

This fishery took place in the northern part of the central Baltic Sea in shallow coastal waters (northern part of ICES subdivisions 27 and 29; Fig. 1). The duration and multi-annual variability of this fishery has not yet been documented. Nevertheless these findings document the existence of a cod fishery in the 1550s whose economic importance was sufficient to justify taxation by local authorities. The archival information also showed that cod landings in those years often ranked third in value after salmon and herring.

Additional archival records from approximately the same time period and for some decades shortly afterwards from southwest Finland (ICES SD 29) show that an economically

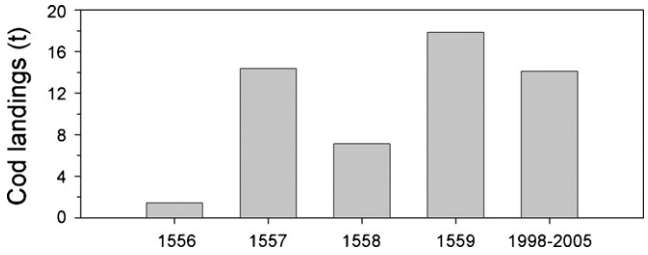

Fig. 3. Landings of cod in fishing villages near Södermanland and the Stockholm archipelago as recovered from Swedish National Archives (Strödda kamerala handlingar) for the years 1556–1559. These landings are most likely underestimates of the total landings (see text for explanation). Nevertheless they were comparable to the Swedish cod landings for the years 1998–2005 for ICES squares in Swedish coastal waters for an area similar to that where cod fishing occurred during 1556–1559 (46G6, 46G7, 46G8, 47G8, 48G8, 48G9, 49G8, 50G7, 50G8, 51G7, 52G7, 53G7). Swedish data for 1998–2005 kindly provided by Anne-Sofie Gren, Swedish National Board of Fisheries.

important cod fishery also occurred in this area from at least the mid-1550s to the 1630s (Fig. 4). The Finnish fishery, based on recovered export data, was most active during 1561–1578 when ca. 10 tonnes/year were exported from Finland to Sweden. Exports apparently decreased in later years. After 1635, the export records are no longer available.

The Finnish export data presented here originate from the coastal parishes (i.e., not from the towns) of Proper Finland from Turku to Vehmaa (northern Finland). The Finnish parishes which exported most cod to Stockholm were Korppoo and Töfsala (Fig. 5). These parishes are located in the archipelago of southwest Finland (approximately ICES squares 49H1 and 49H2 of Subdivision 29). Although other fish species (e.g., herring, perch, salmon) were exported from other parishes (see Fig. 5 for parish names) to Sweden, no cod was exported from these parishes. We assume therefore that the Finnish cod fishery at this time was mainly concentrated in the Korppoo and Töfsala regions.

It is useful to compare the size of these historical Swedish and Finnish fisheries (ca. 10 tonnes/year) with landings data from the late 20th Century. For example, the annual Swedish landings in the late 1550s, even though they are likely underestimated for reasons stated above, were similar to the officially reported Swedish landings (average = 14 tonnes; Swedish National Fisheries Board) in the same area during 1998–2005 (i.e., those ICES squares immediately adjacent to the coast north of 58.5°N: 46G6, 46G7, 46G8, 47G8, 48G8, 48G9, 49G8, 50G7, 50G8,

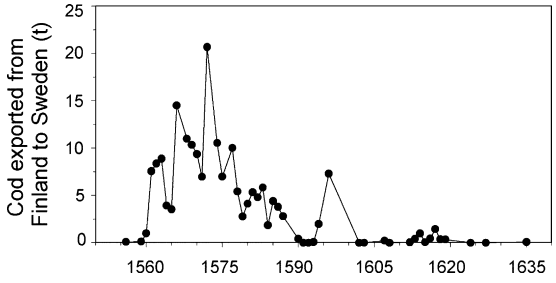

Fig. 4. Exports of processed cod from southwest Finland to Stockholm, Sweden during 1556–1635. Note that the landings of whole, fresh cod would have been higher if the exported cod were gutted and/or salted.

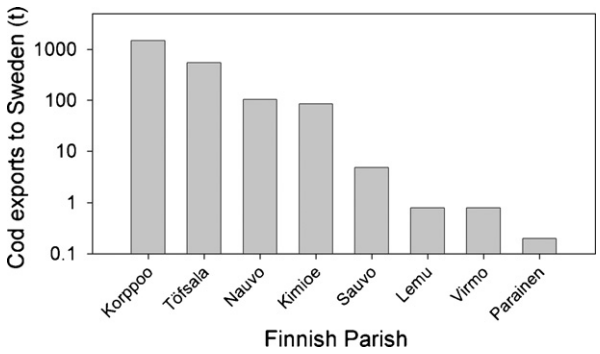

Fig. 5. The cumulative amount of cod exported to Stockholm, Sweden from different Finnish (formerly Swedish) parishes during the entire period 1556–1635 (names given in panel are Finnish). Note that the parish of Virmo is in the present area of Mynämäki. Archival records from several other parishes (Halikko, Rymättylä, Letala, Reso, Vehmaa, Nykyrka, Lappo, Masku, St. Karin) were examined, but no cod was exported from these locations.

51G7, 52G7, 53G7; Fig. 3). Similarly, landings by the Finnish fishery in the same three ICES squares where cod fishing took place in the late 16th Century were only 1–2 tonnes/year during the mid-late 1970s (Fig. 6), and annual reported Finnish landings in the entire subdivision 29 (Fig. 1) have not exceeded 3 tonnes since 1996 (ICES, 2006).

We also found new Danish and Swedish evidence of cod fishing in the southern Baltic Sea (ICES Subdivision 25). Cod taxes to the Danish king were paid from Hammershus county (Bornholm) and Kristianopel county (southern Sweden) during 1598–1654 (Fig. 7). The cod tax data from Hammershus county (Bornholm) until 1609 suggests that the number of fishermen who participated in cod fishing was relatively stable, although the exact number of fishermen cannot be determined from these data. The land rental taxes paid at Kristianopel also document a cod fishery, and that its tax revenue was considerably larger than the cod tax revenue from Hammershus (Fig. 7).

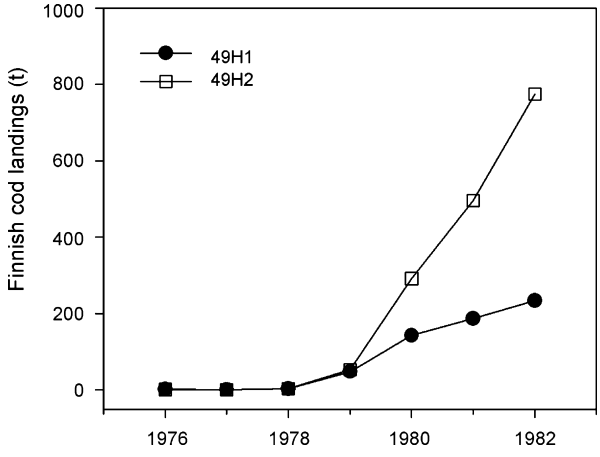

Fig. 6. Finnish commercial cod landings in two coastal areas of southwest Finland (ICES squares 49H1 and 49H2, Subdivision 29; Aro and Sjöblom, 1984), corresponding to the area where cod fishing occurred during 1556–1635 (see also Figs. 1 and 5). Note that landings in the late 1500s–early 1600s (ca. 10 tonnes/year; Fig. 3) were higher than during 1976–1978.

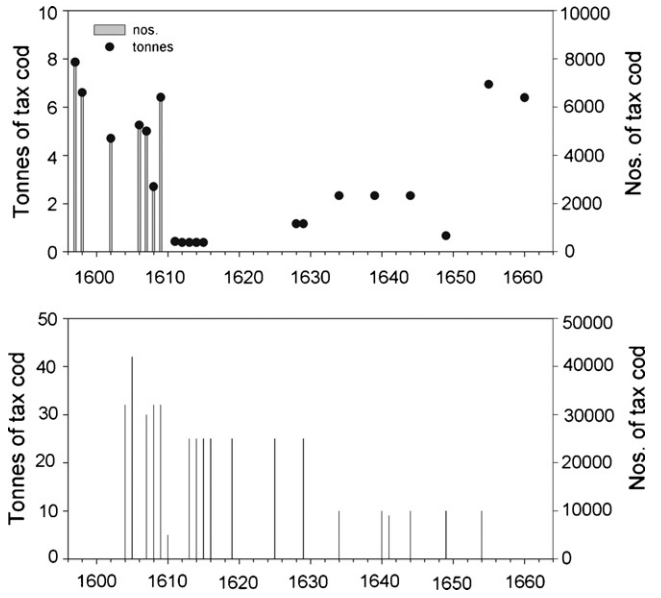

Fig. 7. Quantities of cod paid as tax by fishermen to the Danish king. Top panel: cod tax paid in Hammershus County, Bornholm, Denmark during 1598–1660. Bottom panel: cod tax paid in Kristianopel County (now part of southern Sweden) during 1604–1654 (Holm and Bager, 2001). It is assumed that 1 tax cod weighed 1 kg (whole fresh weight).

The cod revenue from the Kristianopel cod fishery declined after 1613. The reasons for the decline are unclear and could be due to changes in fishing effort (i.e., number of households and individual fishermen involved in the fishery) because the taxation basis remained stable during this period (Holm and Bager, 2001). Nevertheless, the fact that cod was paid as a tax confirms that cod fishing took place in these years, and that the species was present in exploitable quantities. The amounts paid in taxes from each of these counties, assuming each cod weighed 1 kg, were similar to the amount of cod exported from Finland to Stockholm in these same years. It was not possible to recover the landings data (on which the tax was paid) for Kristianopel or Hammershus because these records could not be found and probably have been destroyed.

The cod landed in southeastern Sweden or Bornholm was not always used for local consumption in the immediate village or town. An unknown proportion of it was exported to neighbouring towns of the Baltic; for example, some of the cod exported from one of the Swedish towns (Rönneby) in the 1630s was transported to several former Hanseatic towns along the southern Baltic coast. We estimated the amount of cod exported in kg (Fig. 8) by applying Danish barrel volumes used at the time (Table 1; Thestrup, 1991) and by assuming that the amount of salt added to barrels for cod preservation in southern Sweden was the same as that used on Bornholm (26 l salt per barrel or 24% of the barrel volume (Oeder, 1771; Olavius, 1787). Exports from this single town were thus 5–10 tonnes/year (Fig. 8), and other towns also exported cod. The trade in cod was active throughout the 17th Century but available data suggests that it was highest in the early decades of the 17th Century and decreased from ca. 1620 to 1650 (Fig. 9).

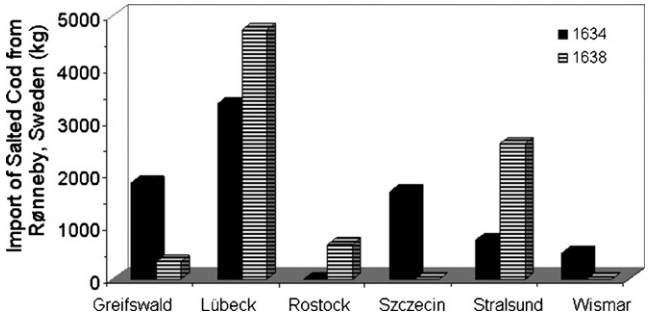

Fig. 8. Import of salted cod from Rönneby, Sweden by Hansa towns along the southern coast of the Baltic Sea during 1634 and 1638. The data were recovered from the Rönneby custom account where they were labelled as small custom duty (dansk: *små told*).

It is not known why the cod exports from Bornholm or southeast Sweden decreased during these decades or even whether the decrease is an artifact (e.g., due to changes in reporting systems, loss of records). However, regardless of the cause or the extent of the variations, the existence of the cod tax and exports demonstrates that the local cod population was sufficiently large and accessible to encourage participation in the fishery and to stimulate local authorities to impose a tax and tax collection mechanism. The findings suggest that the Hanseatic towns and villages may have been an important consumer of cod from the Baltic. If this is true, then cod import information could be available in German and Polish archives for the relevant importing towns identified here (e.g., Lubeck, Rostock, Gdansk). New studies of those archives, if still available, could be fruitful.

We have also found written evidence of a fishery for cod and other species in the northern part of ICES Subdivision 27 (near Södermanland) in the 1740s–1750s (Awebro, 2007a,b). The typical quantities caught were ca. 100 barrels/year (Awebro, 2007a). The cod were used for private consumption, sold to local farmers and transported to nearby towns (Stockholm, Nyköping) for sale (Awebro, 2007a). Given these findings, it is likely that a more detailed and comprehensive investigation of the Swedish archives would recover more data. A full description of the cod fishery (e.g., annual landings, effort) and its ecological and economic context is however still lacking. For example, Sweden annually imported 1–3 tonnes of cod from Russia during several years between 1745 and 1753 (Awebro, 2007a). This cod trade

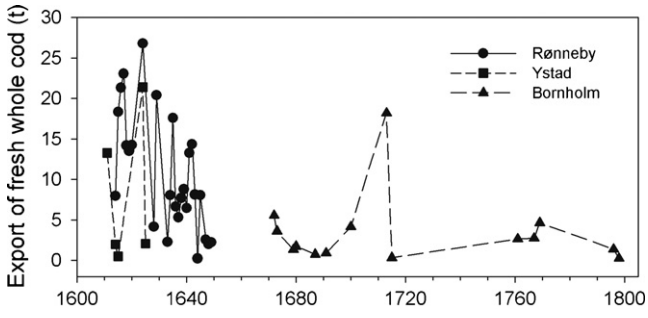

Fig. 9. Exports of fresh whole cod from Bornholm and southern Sweden during the 1600–1800s. The data have been reported as barrels of salted cod exports in the customs accounts of the three locations, as held in the Danish National Archives; see text and Table 1 for conversion factors.

suggests that Russian fishermen were exploiting cod in this time period although the location of the Russian fishery which supplied the cod has not yet been investigated. Some decades later (at the turn of the 18th Century), 10–11 tonnes of cod were on average caught annually in Courland (open sea coast of Latvia and west coast of the Gulf of Riga (Derschau and Keyserling, 1805).

During the mid-late 1700s, a new development occurred in the Danish Baltic cod fishery. Fishermen started to transport live cod from Bornholm to the Copenhagen fish market for sale in the Danish capital (Fig. 10). This fishery relied on specially designed boats called smacks (kvaser in Danish) and the deployment of these boats is recorded in the Dan-

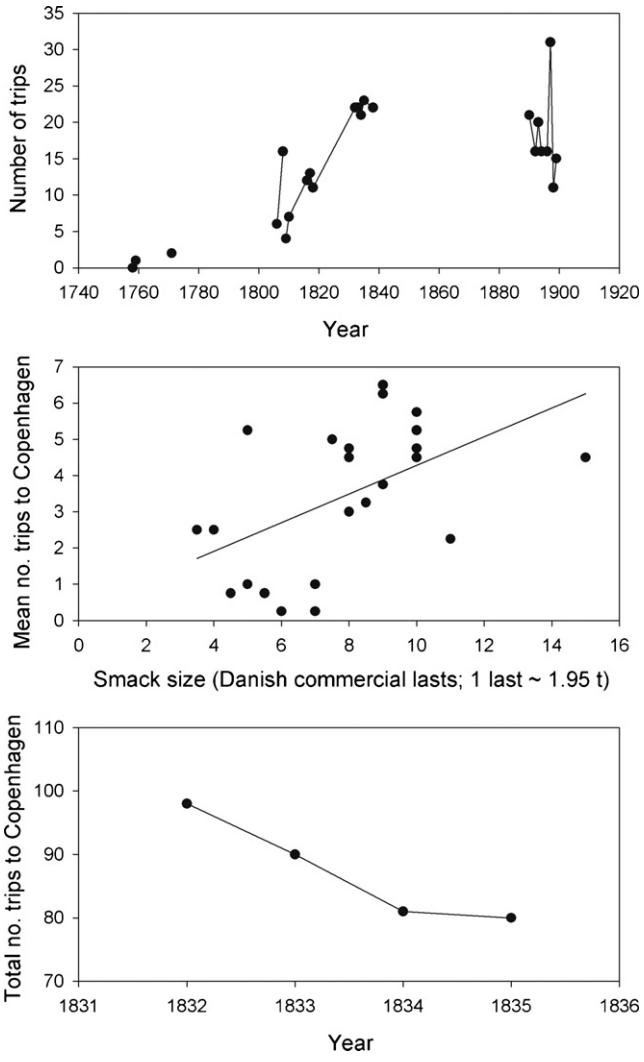

Fig. 10. Top panel: Increase in the number of fishing smacks participating in the export of live cod from Bornholm. Smacks were boats capable of transporting live cod to primarily Copenhagen. Middle panel: Relationship between number of smack trips per year to Copenhagen carrying live cod and smack size during 1832–1835. The regression line is described by the equation $y = 0.39x + 0.33$ and is statistically significant ($R^2_{adj.} = 0.25$; $P = 0.0065$). The dimensions for the measurement for boat size, commercial lasts, differ depending on the commodity which being transported; for our calculations we assume that 1 commercial last was equivalent to 1905 kg, which is the conversion factor given for dried fish (Thestrup, 1991). Lower panel: Number of trips made to Copenhagen per year by smacks carrying live cod from Bornholm.

ish fishery archives (Denmarks National Archives: Rigsarkivet, Søetaten XVII, Søindrulleringen, Journal over udgående skibe fra København 1780–1820). The live export trade increased throughout the early 1800s and appeared to reach its maximum (ca. 20 smacks) in the 1830s and remained at a similar level throughout the rest of the century (Fig. 10). Each smack typically made 3–4 trips to Copenhagen per year, although the bigger smacks made significantly more trips than the smaller ones (Fig. 10). The total number of trips by all smacks was 70–80 per year (Fig. 10).

An indication of the amount of live cod transported to Copenhagen by these boats is possible for 1836. During that year, the total number of cod transported by each smack operating from Bornholm was recorded (Krøyer, 1866). If the mean weight of a live cod is 1 kg (typical value based on current fish weights in commercial catches; ICES, 2006), then the smacks would have transported 105 tonnes of cod to Copenhagen. A similar calculation for other years is not possible because the number of cod transported per trip is not known. However, it is likely to have been well over 300 kg per smack per trip (Ole Bagge, retired state fishery biologist, Danish Institute for Fisheries Research; personal communication, 2002). Assuming a minimum export weight of 300 kg of cod per trip, then the smacks would have transported at least 24–30 tonnes/year during the early 1830s, given the observed trip frequencies and smack numbers as compiled by Krøyer (1866).

In summary our archival investigations have successfully recovered important new quantitative information regarding the timing, magnitude and location of Baltic cod fisheries in previous centuries. Most of the recovered information is from Denmark, Sweden and Finland, and there still remains much material to be recovered and interpreted. Despite our search of Estonian, Latvian and Russian archives (see Appendix A), only a small amount of cod landings have so far been located, although landings data for other species (e.g., herring, salmon) have been found (Gaumiga et al., 2007; Lajus et al., 2007). The low recovery of cod data from those countries could be a consequence of loss and destruction of cod-related fishery records and archives, archives being located in foreign (occupying) countries, absence of cod from the coastal waters of these countries, or a lack of fishing interest in this species.

3.3. Ecological context of Baltic cod fisheries 1550–1860

The recovered archival material identifies several new important features regarding the multi-century scale development of the Baltic cod fishery. First, we have shown that several countries participated in a cod fishery and that this fishery was large enough to justify taxation and transport infrastructures. The mere presence of a cod fishery and trade demonstrates that the Baltic Sea ecosystem was capable of supporting a moderately large cod population during most of 1550–1860. Perhaps counter intuitively, the Baltic Sea prior to 1900 was probably less favourable for cod production and survival: the ecosystem was still oligotrophic and therefore less productive than present (Elmgren, 1989; Wulff et al., 2001). Moreover, the abundance of potential predators of cod (especially seals and harbour porpoise) was much larger (Elmgren, 1989; Harding and Härkönen, 1999) because these species had not yet been decimated. Both factors would have inhibited the production and survival of cod. Nevertheless the cod population was reasonably large. How could this be so?

We believe that the main reason is much lower level of fishing mortality. Although we have not been able to quantify fishing effort in this study, there is clear evidence that the fishing technology and practices underwent major changes after, ca. 1880 (Bagge et al., 1994; Thurow, 1997; Holm and Bager, 2001; Bager et al., 2007; Eero et al., 2007). For example, boats became motorized, hydraulic winches were implemented, offshore fishing grounds started to be used and nets and boats became larger during this time period. As a result, the potentially lower productivity of the Baltic and the higher level of predation due to marine mammals and cannibalism was probably substantially offset by much lower levels of fishing mortality.

A second notable finding of our study is the presence of an important cod fishery in the coastal areas of the northern Baltic Proper (southwest Finnish coastal waters and Stockholm archipelago area) during ca. 1550–1610 (Figs. 3–5). Cod only become abundant in Finnish and Stockholm archipelagos when the population becomes very large or when salinities in this region increase so that cod are less stressed physiologically by low salinity (Hessle, 1947; Aro and Sjöblom, 1982, 1984). The two mechanisms are inter-related in the Baltic Sea because an increase in salinity in Finnish waters will be accompanied by an increase in salinity in cod spawning areas in the southern Baltic (Plikshs et al., 1993; Hänninen et al., 2000). This in turn promotes cod reproduction and can allow biomass to increase (Plikshs et al., 1993; Köster et al., 2005).

The expansion of cod spatial distributions to northern Baltic waters therefore keeps abundances relatively low in the southern areas, and also helps to reduce cannibalism and inter-specific competition for food and shelter (Aro and Sjöblom, 1984; Bagge et al., 1994; ICES, 2005b). As a consequence, the presence of cod in waters near Stockholm, Finland and elsewhere in the northern Baltic Sea is a proxy indicator of situations when cod abundance and/or salinity is high. The salinity of the Baltic during 1550–1860 is not precisely known but has been estimated using paleo-oceanographic techniques, including chemical and taxonomic information (Emeis et al., 2003; Bock et al., 2005). These studies suggest that the Baltic, particularly in the 1500s–1600s, may have been fresher than at present. Hence the wide spatial distribution of cod in the Baltic in the late 1550s–early 1600s is not likely due to the effects of higher salinity on reproductive success or habitat availability, and is more likely a consequence of higher survival rates due to lower exploitation.

Ice-reconstruction and paleo-climatic data indicate that temperatures were relatively cold during the late 1500s–early 1600s. Periods of heaviest ice coverage in the western Baltic, which are indicative of very cold winters, occurred during 1554–1576 and 1593–1630 (Koslowski and Glaser, 1999). Multi-decadal European winter air temperatures were coldest during the late 1500s (Luterbacher et al., 2004), and European mean annual air

temperatures were also relatively cold in ca. 1600 (Luterbacher et al., 2004). These cold periods coincide with the presence of important cod fisheries in both the northern and southern Baltic. However, there was also a cod fishery in the Stockholm area and near Södermanland during 1745–1753 (Awebro, 2007a), when winters were much milder (Koslowski and Glaser, 1999); during another cold period (1675–1696, which was part of the Maunder minimum; Koslowski and Glaser, 1999) there were commercial fisheries for several species *but not cod* in the Gulf of Riga (Gaumiga et al., 2007). Laboratory studies show that temperatures lower than 4 °C inhibit development of Baltic cod eggs (Wieland et al., 1994). Whether temperatures in cod spawning areas varied enough to directly affect cod egg survival is unknown. In any case, the cold winter temperatures and large ice coverages would have provided ice habitat for breeding of Baltic ringed and harbour seals (Reijnders et al., 1997) and therefore promoted survival of some cod predators. Alternatively the low temperatures instead may have had other indirect and positive effects on cod reproduction. These effects could include the reduced reproductive success (MacKenzie and Köster, 2004; Baumann et al., 2006), and food consumption rate of a key predator (sprat, *Sprattus sprattus*) of cod eggs (Köster and Möllmann, 2000) and the effects of low temperatures on volumes of cod reproductive habitat (MacKenzie et al., 1996). The effects of temperature on cod reproduction and the historical cod fisheries in the Baltic are therefore presently inconclusive.

These considerations suggest that the overall role of abiotic factors (salinity, temperature and possibly also oxygen) on cod reproduction and biomass was therefore relatively small (compared to the present situation) because of their counteracting effects on cod ecology. As a consequence, it is most likely that the presence of cod in the northern Baltic Proper and substantial cod fisheries in both the northern and southern Baltic Proper was due to relatively low exploitation which had not yet depleted a moderately abundant population. In other words, the historical information shows that cod and marine mammals have co-existed in the Baltic Sea while it was in an oligotrophic state. This finding may help fisheries and ecosystem managers set appropriate biomass targets for cod and its eco-dependent species (competitors and predators), and contribute to the development of multi-species and ecosystem models for the Baltic Sea (ICES, 2005b; Hansson et al., 2007).

As outlined in the Introduction, the Baltic Sea has suffered from multiple human impacts, particularly during the last 100–150 years. Its full ecological history over much longer time scales than those investigated in this study (i.e., since the retreat of glaciers ca. 10–12,000 years ago) is fragmentary and has not been synthesized. Nevertheless, it may be similar to that in other coastal and estuarine areas, in which exploitation is one of many factors which have progressively depleted abundances of the largest and/or most valuable species and even led to local extinctions (Pitcher, 2001; Worm et al., 2005; Lotze et al., 2006; Lotze, 2007). The archival material recovered here shows that one of the most important piscivorous predators in the Baltic Sea ecosystems was abundant and widely distributed during several recent centuries of the last millennium.

4. Conclusion

Historical fisheries research in the Baltic region is complicated due to the large number of countries and cultures around the Baltic Sea and the sequence of changes in political and cultural systems within countries. New original archival research in most of these countries has documented the presence and quantified the magnitude of a cod fishery in the southern and northern Baltic Sea during much of the period 1550–1860. This fishery was locally economically important, taxed by local authorities, and recorded in various governmental records. The cod fishery which existed in the late 1500s–early 1600s in the northern Baltic Proper (Stockholm area and southwest Finnish archipelagos) is particularly notable. Cod usually only occupy this part of the Baltic Sea when biomass is high. The high abundance in coastal waters of the northern Baltic Proper during the mid-late 16th Century indicates that biomass in the entire Baltic Sea was higher than at the present (early 2000s). We conclude that the Baltic Sea occasionally supported high cod biomasses before the 1960s, even though its ecosystem differed in ways which would have made cod production lower (i.e., the primary production base of the Baltic Sea food web at that time was lower, large populations of marine mammal predators were present and the salinity was lower than today). The identification of high and low cod production periods, and their duration and frequency, will be important for defining baselines and goals of fishery and ecosystem management plans.

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Appendix A. Description of archival sources related to historical cod fisheries 1550–1850

The appendix describes the archival sources which have been investigated and the fishery-economic and administrative frameworks in different Baltic countries during 1550–1850.

A.1. Danish archives

The Danish central administration expanded during the 17th Century due to a growing interest in managing the economic resources of the country. This development was accompanied by an increase in written reports and accounts prepared by public officers. The tax records and custom accounts are recognized to be the main historical sources for the Danish Baltic Sea fishery in the proto statistical period. Tax records contain information on tax payment from the fishery, which took place from the shore as the Danish Crown had a preferential claim on the shore fishery. The tax records also include rent payment of farms situated on land owed by the Danish Crown (in Danish: landgilde).

The tax accounts for Bornholm and Blekinge (southeast Sweden; Fig. 1) from 1580 to 1658 document a relatively large cod fishery. The counties of Skåne, Halland and Blekinge were surrendered to Sweden after the Danish defeat in the Karl Gustav War in 1658 and only the island of Bornholm remained under the Danish Crown. Taxes and rent at this time were paid in natural produce (i.e., cod), rather than in money. There were three types of taxes at different times and places within the Danish kingdom during this period related to fisheries. These included taxes based on the income of an individual (income tax), the means of production (e.g., the number of boats), and the expected economic yield of the fishery. Taxation regulations were implemented and enforced by local representatives of the Crown so that compliance was presumably high (Jespersen, 2004). The amount of tax information is relatively large, particularly for Kristianopel (Bleking county); we therefore recovered information from this area for all years available until 1619, after which data were recovered only at approximately 5 year intervals until 1654.

The tax at Hammershus, Bornholm initially was equivalent to a license to fish, and therefore can be interpreted as an approximate indicator of fishing effort: that is, each household had to pay 100 dried cod (Danish: *told-torsk* or *skattetorsk*) for the right to fish cod, and single fishermen had to pay 50 dried cod (Fig. 2). It is not possible to calculate precisely the number of fishermen because the tax records do not indicate how many men belonged to a household. Similar tax licensing systems were in place for other fish species such as herring. The licensing practice was in place until 1609 in Hammershus county (Holm and Bager, 2001), after which the tax basis changed so that the tax was no longer on individual fishermen but instead a duty (Danish: *landgilde* or *jordebogsafgiften*) on the land rented by the fisherman. In addition, the form of payment of the cod changed from dried cod to salted, barrelled cod (Holm and Bager, 2001). Cod taxes were also paid at Kristianopel, Blekinge county. The taxation basis before 1613 is unclear but from 1613 onwards the tax basis was on the land rented by the fisherman's household.

The tax records from the reduced Danish Kingdom is almost complete for 17th and 18th Century apart from years of war. The administrative practice of the (now Swedish) counties was reformed in 1660, but these reforms did not affect the tax assessment of fishing activities until the beginning of the 18th Century. At this time, the former tax which was paid in natural produce was now converted to money. These sources are not as extensive as the early accounts for the study of marine resources, but they do give a strong indication of location and size of the taxed fishery. In addition, the accounts contain similar taxation information for fisheries involving other species, including eel, herring and haddock.

The Danish custom accounts are another important source of information regarding the commercial fishing industry before 1889. The accounts contain information on fish products, which were traded on commercial basis from the ports of Denmark to both domestic- and foreign markets. Each custom district had one or more ports or places of disembarcation and a local customs officer controlled the traffic to and from the port and collected the custom duties. A comprehensive custom register (Danish: toldruller) with tariff rate was worked out under the reign of King Christian IV (1588–1648). The statutory instrument of 12 January 1632 included instructions for the customs officer for monitoring and bookkeeping practices. This statutory instrument became the basis of legislation in the later years.

Two main categories of custom duties were used in the first half of the 17th Century: the Øresund toll and toll for the Danish crown and country. In general the custom accounts dated before the mid-19th Century have only survived in a limited number. In the late 19th Century the collection of Danish custom archives was reorganised and unfortunately a large part of the custom records were discarded. The number of archive records preserved therefore varies from one custom district to another. In general there is no connection between the degree of preservation and the volume of the custom archive as the size of the custom districts and the size of the local population was not uniform. The contents of each custom archive reflect how the activities of the customs authorities changed over time. The custom accounts include a register of imported and exported goods, a register of ships entering and leaving the port and occasionally a list of local registered ships. Monthly or quarterly status of the accounts was compiled until 1845, when new legislation (the circular of 25 February 1845) instructed that an annual status of the accounts should replace the former quarterly status. From 1878 ready printed forms was used for the annual status. The custom account was audited annually by the central custom authorities throughout the period.

The custom books of Bornholm 1663–1898 and the main export ports of Sealand 1843–1900 have also been examined. The Bornholm custom archive has suffered greatly from the discard in the 19th Century and only fragments of the records have survived for a limited number of years. Fish products such as salted cod and smoked salmon were regarded as dutiable consumer goods during the entire period. The custom accounts of Bornholm include all salted, smoked and fresh fish exported from the island. Export of live cod from Bornholm was introduced in 1759 and smacks with wells began (Danish: opkøber kvaser) travelling between Bornholm island and Copenhagen carrying live cod for the market in the capital. This trade was helped by a tax exception in the custom legislation, because the transport of live cod was exempt from duty by the statutory instrument of 24 December 1770 (the amounts of cod transported and other aspects related to the shipping are described in the main text).

Topographical literature provides additional information on individual fisheries. Particularly valuable reports are those published by Landhusholdningsselskabet from the 1770s onwards, which are the first publications which contain overview information on the distribution and structure of the fishing industry on a regional scale, and the description of the Baltic Sea fishery at Bornholm (Thaarup, 1839). The first fisheries consultant A.J. Smidth's extensive travel notes 1859–1863 have also been published (Grenaa, 1987), and provide a basis for qualitatively comparing fishing methods and effort in the mid-18th Century and the mid-19th Century.

The preparation for a Danish Law on Saltwater Fisheries began in 1857 but was only concluded by an Act of Parliament in 1888. The various commissions working under the Home Ministry left vast records. One result of their work was the first statistical investigation of the Danish fisheries published in 1877. Thirteen years later, Drechel's "oversigt over vore saltevandsfiskerier" was published (Drechel, 1890). The work is the first comprehensive qualitative assessment of the state of the fisheries around 1885 as regards types of gear used, ship types, etc. The publication includes fisheries data, and formed the draft of the later official Statistics for the Danish fisheries.

The Danish Annual Fishing Report was published by the Danish ministry of the interior (later the ministry of fisheries) on a yearly basis from 1889 until 1977. The reports contain information on fish landed on a commercial basis in all Danish ports during the period. The information was recorded port by port until the mid-1920s when the structure of the reports changed to record landings only in larger fishing districts. A network of local informants (e.g., customs officers, local paid and unpaid fishermen) provided the background material for the Fishing Reports. In the first years of the publication the method of estimation depended on the judgement of the informants, but the collection of information was methodically systematised in the beginning of the 20th Century when the informants were asked to use printed report forms.

The unit of weight and numbers used in the Danish Fishing Report changed during the period (Table 1; Thestrup, 1991). Atlantic cod, Atlantic salmon, European eel, northern pike, sea trout, and turbot weights were given in pounds until 1911. In the same period Atlantic cod were also calculated in score. From 1911 and onwards all species except herring were calculated in kilograms.

A.2. Estonian archives

During the 17th Century until the 1680s, the data in fiscal sources (primarily in socage registers or lists of imposts) reveal estimates of the importance of the fishery based on long-term generalisations. These estimates are qualitative because the objective at this time was to estimate the general level of economic activity of taxpayers; based on this information taxes were imposed in the form of fish, seal fat, etc. The sources therefore contain information about fishing crises due to particularly poor years of fishing, but the information is not resolved to species.

During the 1680s, the documentation of sea fishing increased because Swedish authorities, who now ruled Estonia, made the taxation rate dependent on concrete resources and required that fishing also be estimated. The most thorough description of fishing and its profitability can be found in the materials of the1680s (presumably held in the National Archives of Sweden) but these have not yet been investigated.

In the 18th Century the Swedish taxation management was formally continued but, under the drastic fall in the number of population, the estimation of the profit made on fishing lost its practical significance. In northern Estonia taxes were imposed only on the people who were capable of work. In southern Estonia the questionnaires reporting on the years 1724, 1731, 1738, 1751 and 1758 are preserved in Moscow at the State Historical Archives of Russia. Fishing conditions were only described in a general manner but could potentially be ranked on a 5-point qualitative scale. The economic activities of municipal manors (the Pärnu municipal manors in the northern Gulf of Riga) were estimated more thoroughly. Fishing conditions and catches for single years (the 1780s) are also better documented for the manor at Saaremaa Island (Estonian west coast).

In the period of the Russian Empire (during the 19th and beginning of the 20th Century), there were no local statistical institutions in the Estonian area. Their functions were instead fulfilled by the court institutions and the police. There are only occasional data about the 19th-Century coastal fishing in court materials. Statistically it was more important to take account of the number of fishing boats and the people who earned their living by fishing as well as the prices of foodstuff (incl. fish). The conditions of the 19th-Century coastal fishing were inspected by the provincial authorities as well as the central authorities in St. Petersburg. They were primarily concerned with reports of crises. Special overviews of the situation of the Baltic Sea fishing were preserved in the St. Petersburg archives and a thorough elaboration of these documents requires new dedicated investigations.

Various other archival documents from the coastal area report on catches. For example, church registers often mention unusually good or poor years of fishing; presumably these refer to the economically most important species such as herring. Court archives contain information about disputes and violation of fishing agreements. They also indicate good and poor catches or the locations of desirable and insignificant fishing grounds. However, this information has not been recovered because of time restrictions.

In summary, data in Estonian archives about fish stocks found in the Estonian area are fragmentary. The archives contain qualitative and quantitative information regarding Baltic fishing, but most information is qualitative. Some of the registered data are kept in the National Archives of Sweden and the State Historical Archives of Russia. Further research is possible only by the inclusion of the materials in the archives mentioned above. Landings data are available for several coastal and freshwater species (e.g., herring, eel, pike, ide, whitefish; MacKenzie et al., 2002b; Lajus et al., 2007), but there is relatively little quantifiable information about cod fishing in Estonian waters. There is therefore a lack of Estonian cod landings data during the period of interest of the current study and we may well speculate whether such data exist at all. However, Russian archives confirm that

cod was captured in several locations around the Estonian and also Latvian coasts in the early 1850s (see below).

A.3. Finnish archives

During the late 1500s and early 1600s, cod were exported from western-southwestern Finland to Stockholm, Sweden. At that time, this part of Finland was under Swedish authority. The cod that were exported to Sweden were used for both consumption by the local Stockholm community, as well as a tax payment to the Swedish king. The amounts exported for consumption are recorded in Stockholms Tullräkensper (Tull och accis, Stockholm, vol. 307–423). The cod exported as tax payment has not yet been compiled from archival sources, and the tax rate (e.g., a proportion of the landings, or a flat amount of cod per year per fisherman) is not known.

The cod exports for consumption are recorded in units of lispunds (1 Swedish lispund = 8.5 kg; Table 1); however the records do not indicate whether the exported cod was whole, gutted (i.e., without internal organs), salted or dried and salted. In our calculation of the total amount exported per year for consumption, we have assumed that the weights represent fresh cleaned weights; if the exported cod product had been processed dried or salted, then the true weight of cod landed and exported may be somewhat higher than the values shown below. The export data are therefore potentially underestimated.

A.4. Latvian archives

We found little information in the Latvian historical archives regarding the cod fishery (landings, exports, effort) before the late 19th Century. Some evidence of cod fisheries was given in publications of 16th Century archives found in former Konigsberg (now Kaliningrad). They described general cod fishing and exports near the present city of Liepaja (Blesse, 1929) and state that 80 fishermen families were living in Perkone (a district described as having 3 miles coastline south of present Liepaja) in 1583–1584. Perkone fishermen paid annual duties comprising 6 tonnes of cod (Arbusow, 1924). At the turn of the 18th Century, 10–11 tonnes of cod were on average caught annually in Courland (open sea coast of Latvia and west coast of the Gulf of Riga; Derschau and Keyserling, 1805). Quantitative information, including landings for some other species (e.g., herring, flounder), is available from the mid-late 1600s, as is a more detailed description of the archives which have been investigated (Gaumiga et al., 2007).

A.5. Russian archives

Before the second half of the 18th Century, the Baltic coast of the Russian state was very short and included only the eastern part of the Gulf of Finland. In these waters cod occur only very rarely; thus it is no surprise that in the Russian archival documents for this early period cod has not been mentioned. The most complete source of information on fisheries for this early period are the scribe books (cadasters), which describe the economic activities and use of resources, including the fisheries. These documents are stored in Moscow in the Russian State Archives of the Ancient Documents (RGADA). Investigations into this and several other Russian archives (Lajus et al., 2007) have shown that fishing was dominated by anadromous species such as salmon (*Salmo salar* and *Salmo trutta*), vimba bream (*Vimba vimb*a), whitefish (*Coregonus lavaretus*), ide (*Leuciscus idus*) and others.

The large expansion of the territory of the Baltic coast under Russian authority took place in the 18th Century, when Estland (now Estonia), Courland (now mainly Latvia) and Livland (now mainly Lithuania) were joined to the Russian Empire. However, the Russian archives do not contain descriptions of fisheries or catch records for these regions for the 18th Century and only very few were found for the 19th Century. The most valuable archival collection, which provides us some quantitative data on catches in Estonia in the first half of the 19th Century is the personal archive of famous Baltic-German zoologist Karl Baer, who worked about half of his life in Russia (Lajus et al., 2007), and summarized some of his findings in scientific literature (Baer, 1853). This archive forms several voluminous archival file series on the Baltic Sea fisheries. Part of his archives is held in the St. Petersburg Branch of the Archives of the Russian Academy of Sciences (PFA RAN). According to these documents, among which the most interesting is the Report of Carl Schultz (Baer's assistant) about his trip along the coast of the Baltic Sea from Riga to Pernau (Pärnu) in 1851, only few notes regarding cod fisheries were found.

Studies of Baer's original archive shows that fishing in the northeastern Baltic Sea in the early 1850s was strongly dominated by herring. Other more frequently occurred target species included salmon, whitefish, eel, flounder, several cyprinids, pike and also sturgeon (Lajus et al., 2007). Cod fishing was therefore not as important as for instance the herring fisheries in the Gulf of Riga. Schultz wrote: "As soon as the fishing of the Baltic herring becomes unsuccessful, fishermen begin to catch whitefish, eel, codfish and flounder with lines" (PFA RAN, f. 129, inv. 1, f. 488). On another page he stated, however, that about two miles from the mouth of the Dvina River in the direction to the sea, cod are caught in quite large amounts as the sea bottom is stony there. Cod fishing is also mentioned near Saaremaa Island (Fig. 1). Cod were present in the eastern Gulf of Finland in the 1860s and one small cod (23 cm) was caught in Neva Bay (Kessler, 1864).

A.6. Swedish archives

Fiscal sources such as custom and tax accounts produced by the state administration are the main sources which contain information regarding the Swedish Baltic fishery in the proto statistic period.

The Swedish customs administration dates from the Middle Ages, but most of the custom records which are still available begin after 1600; only a few documents from before 1600 have survived to the present. The volume of customs records expanded during the 16th and 17th Centuries because of an increasing demand for regulation and control of the nation's economic resources.

The structure of the Swedish custom administration remained remarkably stable for approximately 300 years. The administration was reformed in 1636, but only few changes were made within the administrative structure until the 20th Century. The Swedish *fishery* administration can be dated back to the beginning of the 17th Century. A Director general for the fisheries in the Kingdom of Sweden (generaldirektör för fiskerierna i riket) was appointed in the fist half of the 17th Century and a position as director general for the herring fisheries in the county of Bohuslän (western Sweden) was established in the 1660s. The national fishery administration also included Finland and the Baltic provinces. The material from the 17th Century has not yet been thoroughly investigated, but the archive includes data from several German and Polish harbours in the 1630s because parts of these territories were under Swedish jurisdiction.

During the Age of Freedom 1719–1772 the Swedish Parliament played a major part in Swedish political life. A special division of Parliament was in charge of matters concerning fisheries. New methods were discussed at almost every parliamentary session, as the Parliament sought to improve the statistics of the fisheries. The records of the Parliament division for fisheries has been identified and examined. Only statistics related to the Swedish fishery have been extracted, but the archive also includes statistics from Finland.

A description of Swedish fisheries for cod and other species in the Baltic from ca. 1870–1913 is given elsewhere (Ojaveer et al., 2007).

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