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Baltic Sea Fisheries in Previous Centuries: Development of Catch Data Series and Preliminary Interpretations of Causes of Fluctuations

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Abstract:

Fisheries data (landings) in the Baltic Sea have been systematically recorded since the 1920s whereas the stock dynamics of most commercially important species (e.g., cod, herring) are available since only the 1960s or 1970s. In this paper we identify and describe potential archival sources of fisheries data that may be useful for investigating multi-decadal scale variability in fish landings. We present examples of some long-term datasets for previous centuries for local fisheries such as those conducted by inhabitants of fishing villages and manors. The information recovered to date includes landings of fish species (e.g., cod, herring, perch, roach, whitefish, ide, pike) of different abiotic and habitat (open sea, coastal) preferences, and human factors that could serve as indirect measures of fishing effort. This information is available for various areas of the Baltic Sea: Bothnian Sea, Gulf of Finland, Gulf of Riga, northern and central Baltic Proper, Bornholm Basin and the Belts. This material and additional material not yet recovered will provide a new perspective from which to consider factors (e. g., fishing, climate change, eutrophication, marine mammal predation) affecting long-term variations in yields and abundance. Some of the material can be used in comparative studies with fisheries in other geographic regions. This investigation is part of the History of Marine Animal Populations programme of the Census of Marine Life.

Introduction

The fish community in the Baltic Sea has been exploited for centuries, but its magnitude in terms of landings and fishing effort is relatively poorly documented. Archaeological records show that fishing was conducted along the Baltic coast since well before the Middle Ages (Makowiecki and van Neer 1996; Enghoff 1999) and written records since then show that fishing was a major factor in local Baltic economies (Sahrhage and Lundbeck 1992; Holm 1996; Jahnke 2000). These observations indicate that there is a great potential in describing how fishing and socio-economic factors have impacted both fish species and the ecosystem at multi-decadal and even longer time scales.

The long-term changes in both the fisheries and the abundance of fish in the Baltic Sea is much less well documented than in other areas (e.g., the North or Norwegian Seas; Table 1). Both the quantitative catch data series and the analytical assessments are shorter (respectively from ca. 1920 and 1960s-1970s) in the Baltic Sea than in these (Øiestad 1994; Pope and Macer 1996; Pope et al. 2001) and other areas (Jonsson 1994; Wyatt et al. 1995; Hutchings and Myers 1995). There has been one attempt to estimate cod and herring biomasses in the Baltic Sea throughout the 20th century but the reconstruction is highly uncertain due to important data gaps (Thurow 1997; Thurow 1999).

Since abundances of fish species also fluctuate due to natural causes, the effects of fishing must be interpreted relative to the entire range of environmental impacts that affect fish production and distribution. These impacts include changes in temperature and salinity conditions in the water where fish grow and survive and can have both direct (e. g., changes in growth and survival rates) and indirect (e. g., changes in predator and prey abundances) effects on fish. Changes in habitat characteristics (e. g., temperatures, prey abundances) can affect migration routes and species ranges, have direct impacts on growth and survival rates and alter habitat quality (e. g, eutrophication-induced anoxia). Environmental impacts such as these often occur slowly or infrequently require many years or even decades of observations to be recognized (Wyatt et al. 1994; Klyashtorin 1998; Beamish et al. 1999). This pattern of variability is typical for marine ecosystems; as a result the effect of major environmental changes on fish populations cannot usually be identified in most analytical assessments (e. g., virtual population analysis) of fish abundance because these assessments are usually based on relatively short time series (2-4 decades). In short, detecting many environmental impacts, and how they interact with human influences, on fish populations and ecosystems usually requires longer time series than those usually available.

Despite the socio-economic importance of fishing to Baltic societies, there has never been any coordinated attempt to recover and interpret archival material on a Baltic-wide scale in this area (Baltic-HMAP 2001; Holm and Bager 2002; MacKenzie et al. 2002). This situation may be due to the very large number of countries (nine), cultures and languages which has impaired intellectual investigation of archival material. In addition, the geopolitical situation (e. g., wars, revolutions, invasions, dictatorships, state censorship) of the Baltic Sea region during especially, but not only, the past century prevented a free exchange of experts and ideas. As a result, the development of maritime and fisheries history as a discipline in especially the formerly east-Block Baltic countries has been isolated from western countries and access to materials has been denied. For example, leading western maritime historians at the start of this project were unable to provide contacts to potential colleagues for HMAP in several Baltic countries, suggesting that either there was no fisheries/maritime historical expertise in these areas, or that any expertise that was present was not a part of the larger

international community. The state of knowledge of both the long-term development of the fishing industry and the multi-decadal changes in the Baltic fish community and the ecosystem is therefore relatively poor.

The Baltic Sea component of the History of Marine Animal Populations (HMAP) project has therefore begun to investigate the data material which can contribute to the overall HMAP and CoML objectives of understanding what lived and lives in the oceans, and how human society has impacted the diversity and abundance of marine biota. The main objective of this 2-year pilot study (2001-2002) was to identify potential data sources and evaluate their usefulness for addressing how and why marine animal populations have fluctuated in the past. This report presents an overview of the ecological and fisheries status of the Baltic Sea and of some of the activities and data sets which have been recovered so far. Some comparisons of findings in the Baltic Sea are made with data from other geographic areas (i.e., Bohuslån, Sweden; Limfjord, Denmark).

The principal focus of HMAP activities in the Baltic have therefore included the following tasks:

- -compilation and extraction of archival material most likely to be of greatest benefit to HMAP objectives;
- -developing contacts in the fisheries and maritime historical community, particularly in geographic areas where these were absent or poorly known;
- -identifying archival sources for recovery, examination and interpretation;
- -recovery of data series and catch records for geographic areas which had least information;
- -identify and apply for new funding opportunities.

Ecological and Fisheries Status of the Baltic Sea

The ecological and historical background for HMAP studies in the Baltic Sea (Fig. 1) is fully described in MacKenzie et al. (2002) and will therefore be presented only briefly here. In short, the Baltic Sea is characterized by strong vertical and horizontal gradients in temperature, salinity and oxygen due to its limited hydrographic exchange with the North Sea. These hydrographic properties limit the penetration of marine species into the Baltic Sea and species diversity is low. The fish community is therefore characterized by a mix of marine, estuarine, anadromous, catadramous and freshwater species and becomes “fresher” the farther east and north one progresses. The geographic ranges and abundances of the marine and freshwater species are therefore variable depending on the frequency and intensity of major inflows of saline, oxygen-rich water from the North Sea. These events are sporadic (ca. 1 per year during 1897-1977, but only one since then; Schinke and Matthäus 1998) and only occur following specific hydrographic and climatic circumstances (Schinke and Matthäus 1998).

The most abundant commercial fish species are presently sprat *Sprattus sprattus balticus*, herring *Clupea harengus membras* and cod *Gadus morhua callarias*. All three species have

experienced major fluctuations since the 1960s and cod is presently at its historically lowest abundance according to age-structured assessments. Fishing mortalities as estimated from these assessments are high, especially for cod, and the fishery has continued despite scientific recommendations for a closure (ICES 2001). Production in all three species is believed to be influenced by both climate conditions and species interactions (predation, competition). Warm temperatures improve herring and sprat recruitment (Kornilovs 1995; Ojaveer 1995; MacKenzie and Köster 2002); major inflows of saline water are essential for successful cod egg survival and strong cod year-classes (Plikshs et al. 1993; Köster et al. 2002). The fourth internationally assessed fish in the Baltic Sea is salmon *Salmo salar*. The salmon stocks have undergone large declines since the mid 1800s; most catches today are based on releases of artificially reared salmon. The main reason for the decline of wild salmon is human influence – river damming and pollution. It has been estimated that the natural salmon smolt production has decreased for about 20 times during the 20th century (Karlsson and Karlström 1994).

In addition to the major commercially important species, the Baltic has a high number of other exploited (e.g., flounder *Platichthys flesus*, turbot *Psetta maxima*, whitefish *Coregonus lavaretus*, pikeperch *Stizostedion lucioperca*, eel *Anguilla anguilla*, perch *Perca fluviatilis*, ide *Leuciscus idus*, pike *Esox lucius*, roach *Rutilus rutilus*, smelt *Osmerus eperlanus*) and non-commercial fish (e.g., sticklebacks *Gasterosteus aculeatus* and *Pungitius pungitius*, fourhorned sculpin *Myoxocephalus quadricornis*, sea snail *Liparis liparis*, gobies *Pomatoschistus* spp., pipefish *Nerophis ophidion* and *Sygnathus typhle*) whose habitat can be characterized as marine, anadromous, catadromous or freshwater. These species have significant roles in the ecosystem. For instance, gobies act as hosts and transmitters of parasites (Zander et al. 1993), gobies and lesser sand-eel (*Ammodytes tobianus*) dominate in fish communities in some shallow areas (Thorman 1986, Draganik et al. 1996), sticklebacks are very abundant and consume similar food resources as clupeids (Thorman 1986, Ojaveer et al. 1997), and some glacial relicts have the leading positions in demersal fish communities in deeper areas. In difference from internationally assessed and managed fish (cod, herring, sprat and salmon), research and management of these species has been a national responsibility but is now becoming more international. The biology of these species (e.g., recruitment, growth, maturation, feeding) is influenced by various natural and anthropogenic impacts (Ojaveer 2002), although there is little or no information about the long-term abundances of these species.

Three major changes to the Baltic ecosystem occurred during the 20th century: intensification of fishing activity, eutrophication and eradication of nearly all marine mammals. Other changes have also occurred including species invasions and introductions, pollution by persistent contaminants (e. g., heavy metals, PCBs) and river runoff regulation due to hydro-electric power dams. It is not clear how these changes have affected the ecosystem and its animal populations, nor is it clear what impact a reversal of these changes might have (MacKenzie et al. 2002).

Methods

An international and interdisciplinary workshop was held in February 2001 at University of Southern Denmark in which historians, archaeologists and natural scientists (plankton and fisheries ecologists, physical oceanographers, and paleo-oceanographers) were invited to discuss long-term variations in the fisheries and environment of the Baltic Sea. One of the purposes of this workshop was to assemble experts from disciplines who have traditionally

not collaborated on similar projects, but who nevertheless might have common interests or could benefit from contact with experts in related fields. Colleagues were also asked to identify which data sources (written, fossils, sediment materials) were available to investigate how fish abundance and biodiversity in the Baltic Sea has changed over time scales of several centuries. The workshop and contributed papers identified some of the ecological and historical questions that would guide the group's work in the remainder of the project (Baltic-HMAP 2001; MacKenzie et al. 2002).

Examples of these issues include the following:

Was the existing reconstruction of herring and cod biomass for the 20th century reliable?

Did the low cod and herring biomasses estimated for the early 20th century represent a temporary situation or were biomasses ever larger in previous time periods? If the latter, what were the causes for the variations?

How large were the cod and herring fisheries in the Baltic relative to those being conducted elsewhere at similar times and what role did the Baltic have in the global cod and herring fisheries?

What roles did the formerly large populations of marine mammals (seals, harbour porpoises) have on fish abundances relative to other factors (e. g., species interactions, climate-hydrographic variability)?

Some progress towards these questions can potentially be made by an original and professional evaluation and recovery of the material in various archival sources around the Baltic. The workshop identified some of the archives that might be suitable for such an investigation and historians were encouraged to initiate these investigations in close collaboration with natural scientists. Modest national projects were identified and supported by CoML; the objective of these subprojects was to identify important source materials which could contain fishery- and environmental information. This information could be landings, effort data, gear descriptions, trade of fishery products and fishing regulations. In addition, data recovery and interpretation was encouraged. Additional details of the state of some of the archives in the Baltic countries are given below.

The time periods that were considered to be of most interest were those that might contribute new knowledge to address some of the questions brought forward at the workshop. These time periods included the decades leading up to the two World Wars, and the late 1500s-1600s. The more recent period would give information related to the development of modern fishery methods and would provide data regarding the sizes of landings at a time when reconstructed abundances (Thurow 1999) appear to have been extremely low. In addition food webs in the Baltic were being changed by the government approved eradication of seals. The earlier period was chosen because there was evidence from written records that cod and herring fisheries existed, but their magnitudes and socio-economic importance were not known. In addition it coincides approximately with a period of major environmental change (Little Ice Age) whose effect on fish landings could perhaps be detectable.

Results

The national archives that have been investigated so far were located in Sweden, Denmark, Estonia, Latvia and Russia. In addition literature information has been used from all countries around the Baltic.

The state of the archives varied greatly by country, as the stat building and organisation of the administrative authorities has been far from uniform within the region. The contents of the national archives reflect the historical process of the change of hegemony over territories and the change within the practice of the central administration in each country.

During various time periods, different units (i.e., volumetric, weight and counting) have been applied for recording of 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 the Table 2.

Danish sources

The extension of the Danish central administration took place parallel with the Swedish development in the 17th century. The interest of management of the economic resources grow within the Danish central administration and the development was followed an increase in written reports and accounts done the public officers. The stock of tax records and custom accounts are recognized to be the main historical sources to the Danish Baltic Sea fishery in the proto statistical period. The 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 accounts of Bornholm and Blekinge 1580-1658 document a large size cod fishery, which took place at the coast of Blekinge in the first half of the 17th century. The counties of Skåne, Halland and Blekinge were surrendered to Sweden after the Danish defeat in the Karl Gustav War 1658 and only the island of Bornholm remained under the Danish Crown. The stock of 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 counties was reformed in 1660, the reforms did not effect the assessment of the fishing activities at first, but during the 18th century, probably already in the beginning of the century, the former tax paid in natural produce was converted to money. As sources for the studied of the marine resources they are not as riches as the early accounts, however they gives a strong indication of location and the size of the taxed fishery.

The Danish custom accounts are another important source to 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 disembarkation and a local customs officer controlled the traffic to and from the port collecting the custom duties. A comprehensive custom register (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 of practice of surveillance and bookkeeping. The 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 Oeresund 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 reorganisation and unfortunately a large part of the custom records were discarded. The

number of archive records preserved 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 are including a register of imported and exported goods, a register of ships entering and leaving the port and the account occasionally also include a list of local registered ships. Monthly or quarter status of the accounts was compiled until 1845, as the circular of 25 February 1845 instruct that an annually status of the accounts should replace the former quarter status. From 1878 ready printed forms was used for the annually status. Though the period the custom account kept was audited yearly by the central custom authorities.

The custom books of Bornholm 1663-1898 and the main export ports of Sealand 1843-1900 have been examined. The Bornholm custom archive has suffered greatly from the discard in the 19th century and the records has only survive in fragmented for a limited number of years. Fish products such as salted cod and smoked salmon were regarded as dutiable consumer goods during the entity 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 (opkøber kvaser) plying between island and Copenhagen carrying live cod for the marked in the capital. The trade was helped by an exception in the custom legislation, as transport of live cod was exempt from duty by the statutory instrument of 24 December 1770.

Various committees on fisheries affairs have been investigating local and regional fisheries since the late 17th century. First and foremost the Limfjorden has been the subject of investigation. The first commission was founded in 1697, and was followed by two commissions in the 1740s. The commission work has been the fully examined (Pouelsen 2002). The study identify over fishing and damaging of spawning grounds to be the key factors in the collapse of the Limford herring stock in the early 1830'. The Limfjord is also included into the first national inquiry of the fisheries in Denmark and Norway took place on the initiative of chancellor Oeder in 1771. The reports give the first comprehensive national overview of the state of the fisheries and provides a baseline of information as regards localities of fisheries, fish species caught, numbers of fishermen and numbers of boats, types of tackle etc., whereas catch size is less adequately illuminated (Bager 1998).

Topographical literature provides a source of information on individual fisheries. Particularly valuable reports from the 1780s onwards were published by Landhusholdningsselskabet from the 1770s. The Baltic Sea fishery from Bornholm was described by Fr. Thraaup in *Bornholms Amt og Christiansø. Birdag til Kundskab om de danske Provindsers nærværende Tilstand i oeconomisk Henseende* (1839), in which various information on the state of the Bornholm fishery is given.
The first fisheries consultant A.J. Smidth's extensive travel notes 1859-63 have also been published, A*t vove for at vinde* (Grenaa, 1987). The published work provides a good basis for comparison of fishing metodes 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. Ten years later the Drechels "oversigt over vore saltevandsfiskerier" was published. 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 include the statistical fisheries, 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 and until 1977. The reports contain information on fish landed on a commercial basis in all Danish ports during the period. The information was record port by port until the mid- 1920s when the structure of the reports changed only recording the landing in lager fishing districts. The Baltic Sea LME 22 and 23 was divided in to an east Baltic Sea fishing district and a west Baltic Sea fishing district. A network of local informants provided the background material for the Fishing Reports. In the fist years of the publication the method of estimation depended on the view of the informants, but the collection of information was methodically systematised in the beginning of the 20th century as the informants was asked to use ready printed report forms.

The unit of weight and numbers used in the Fishing Report changed during the period. Until 1911 atlantic cod, atlantic salmon, european eel, northern pike, sea trout, turbot was calculated in pounds. In the same period atlantic cod were also calculated in score and turbot were calculated in pieces. From 1911 and onwards all spices except from atlantic herring was calculated in kilogram. Atlantic herring was calculated in ol until 1916 when the unit used was changed to hectolitre but only for two years. From 1918 Atlantic herring was also calculated in kilogram.

The Fishing Reports contain additional information on the number of vessels used in the fisheries. The Report distinguishes between vessels of different size. The categories of vessels used in the Fishing Reports between 1889 and 1902 were buyer smackes (opkøber kvaser), well smackes (drivkvaser), deck vessels (dæksbåde), well dinghies (damjoller) and small vessels (mindre fartøjer). In 1903 the category motor fishing vessels was included and in 1910 category buyer smacks was taken out of the list. The categories of fishing vessels were simplified in 1912 as all vessels were grouped into three categories; motor fishing vessels, sailing fishing vessels, rowing boats (Table 3). There is no distinction between vessels used for various fisheries

Estonian sources

The 17th century (until the 1680s*).* Until the 17th c. the data in fiscal sources (primarily in socage registers or lists of imposts) reveal estimates based on long-term generalisations. It means that the aim was to estimate the economic bearing capacity of taxpayers and, based on that, the taxes were imposed on them in the form of fish, seal fat etc. There are data of crisis about particularly poor years of fishing.

The 1680s. From the aspect of the documentation of sea fishing, the 1680s were the years of breakthrough in Estonia when the Swedish authorities made the taxation rate dependent on concrete resources and required that fishing also be estimated. The most thorough description of fishing and its profitableness can be found in the materials of the1680s. The respective materials on South Estonia are supposed to be kept in the National Archives of Sweden.

The 18th century. In the 18th c. 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 North Estonia taxes were imposed actually only on the

people who were capable of work. In South Estonia the questionnaires reporting on the years 1724, 1731, 1738, 1751 and 1758 were preserved. Fishing conditions were given relatively vague and indefinite estimates. The data can be observed on the 5-point estimation scale. A large part of the respective collection is kept in Moscow. The economic activities of municipal manors (the Pärnu municipal manors in the northern Gulf of Riga) were estimated more thoroughly. Saaremaa's fishing conditions and catches of single years (the 1780s) were also better documented.

The 19th century and the beginning of the 20th century. In the period of the Russian Empire there were no local statistics institutions in the Estonian area (their functions were fulfilled by the institutions of court and the police). There are only occasional data about the 19th-c. 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-c. 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 that now help to fix very poor years. Special overviews of the situation of the Baltic Sea fishing were preserved in the St Petersburg archives and a thorough elaboration of these documents takes much more time than a weeklong research travel.

Various local sources from various periods. Various archival documents from the coastal area report on catches, e.g., church registers often mention unusually good or poor years of fishing. Clarifying respective materials is most labour-intensive and often ends with a negative final result. Court archives offer much information about quarrels and violation of agreements in connection with fishing. They also indicate good and poor catches or desired and insignificant grounds of fishing but again, finding out all the data is extremely time-consuming.

In conclusion, data in the Estonian archives about fish stocks found in the Estonian area are fragmentary. Part of the concentrated data is 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. It would be purposeful to focus on a narrower key-area that would enable to systematically work through also secondary sources.

Estonian fisheries related information is available through collected contributions since the late 1800s- early 1900s (incl. information on Livland and Courland) with publication of systematic monthly journals since the 1920s, where also sporadic information on variety fisheries-related issues in neighbouring countries from the previous century could be found.

Latvian sources

For the period around the 1638, information is mainly available on the manpower and fishes paid "pro natura". The catches in 1804 were reported in the G. Jensch's Archive. Fish catches were documented by the governor of Courland.

During the 18th century, archival sources were generated mainly in Livland (east coast of the Gulf of Riga and rivers Daugava, Gauja and Salaca as well as southern part of Estonia) and Courland (open sea coast and west coast of the Gulf of Riga). However, catch of foreign fishermen (Russia gradually annexed territory of Latvia during this century) was not recorded.

Sturgeon and salmon catch data and the number of fishermen in Daugava river mouth and in some other areas for 1862 is available in the fisherman Jakob Sehl logbook. Salmon catch in some Latvian rivers for the period of 1889-1911 as well as river lamprey catch in Daugava river for the period of 1875-1912 are available in unpublished written sources.

Swedish sources

The militarization of the Swedish society, which took place in the 16th and 17th centuries was followed by a large extension of the administrative institutions, as the demand for regulation and control of the economic resources grow. The fiscal sources which was produced by the expanding state administration such as custom and tax accounts are recognized to be main sources to the Swedish Baltic Sea Fishery in the proto statistic period. The origin of the Swedish custom administration can be data back to the middle age, however the main part of the comprehensive stock of custom records kept is date after 1600, as only a few documents from the early period have survived until present days. The structure of the Swedish custom administration remained remarkable stabile through 300 years. The administration was reformed in 1636, but only few changes were made within the administrative structure until the 20th century. The Swedish custom records have not been investigated but the archive have been identified to have a large potential for establishing of time series because of the available number of records and the continuity within the custom administration.

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 county of Bohuslän 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 included data from several German and Polish harbours in the 1630' as the territory was under the hegemony of Sweden. Occasional data from present days Russian rivers can be found going back to the 1620s.

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 has been extracted, but the archive also includes statistics from Finland.

In 1864 the Royal Academy of Agriculture appoint an Inspector of Fisheries. The official duty of the inspector included the Baltic and inland fresh-waters, and the inspector collected information on the state of the fisheries through journeys around the countries. Statistical records of fisheries are available from 1864 in the archive of the Royal Academy of Agriculture. All fisheries statistics available in the record of the Academy between 18a the from the has been extracted

The Royal Board of Agriculture had during the period 1918-1948 a particular Department of Fisheries, which in turn was divided into two sub-departments. One of these was for open-sea fishery and the other sub-department for fresh-water fishery. The archive of the Department

of fishery has been investigated for the period 1918-1940, and a large number of fishing statistics for cod, herring, sprat and salmon have become available on a county scale.

The Statistical Abstract of Sweden (SCB) - kept in the National Archives of Sweden (RA) - is a statistical reference work, intended to provide summary statistics on a broad range of conditions and activities in Sweden. All information related to fishing; such as landings, number of vessels, number of seines and number of fishermen participating in the fishery of has been extracted from the Statistical Abstract.

Locations of more important Swedish counties for which historical archival research has resulted in long-term fish landing data and harbours in Blekinge and Skåne where the custom archives have been examined are displayed on Figures 1 and 2.

Quantifying the fisheries in the Baltic Sea

General

A large amount of archival material has been examined and recovered. The material has allowed the development of new time series of catch statistics for different areas and for different lengths of time. Some of this material is presented below.

Based on this material, the fisheries appear to be dominated by herring, although other species were also important. The most commonly reported species in archives that have been investigated so far were herring, cod, salmon, eel, whitefish, perch, and flatfish (mainly flounder). Other species were less common (e.g., vimba *Vimba vimba* and sturgeon *Acipenser sturio*) but occasionally present. Marine mammals were also actively hunted with the approval and encouragement of local authorities, especially seals in the late 1800s and first half of the 1900s (see below), and harbour porpoises in the Little Belt-Kattegat area of Denmark since the early 1700s (MacKenzie et al. 2002).

Below we focus on four main species or species groups: coastal (anadromous, catadromous, freshwater) fish species, cod, herring, and marine mammals. Several examples of the time series are presented for illustrative purposes.

Coastal species

Fishing activities in the Baltic began in the coastal areas (Sahrhage and Lundbeck 1992; Enghoff 1999), including the lagoons and rivers which drained into the Baltic. These fisheries were important for the local economy evidenced by over 100 different fishing gears being used in the southern Baltic coast in former Prussian waters (now Lithuania, Germany, Poland and Russian Kaliningrad region; Benecke 1881).

Fish catches in rivers at the coasts of sheltered sub-basins and in the lagoons of the Baltic Sea (e.g., Bothnian Sea, Gulf of Riga) can be used as an indicator of stock dynamics for those coastal fish which migrate upstream during spawning season and then return back to the sea. Other coastal species have specific habitat and dietary requirements. For example pike, which is piscivorous species, requires relatively clean water and is primarily influenced by destruction of spawning and nursery grounds as a consequence of decline of macrophyte beds

due to increased primary production, whereas percids and cyprinids (e.g., perch, pikeperch, roach, ruffe *Gymnocephalus cernua*, bream *Abramis brama*), most of which are primarily predators of benthic invertebrates, tolerate and can get profit from moderate eutrophication through improved food resource (Winkler 1996, Lappalainen 2002). These natural history characteristics for different species can be useful when interpreting the changes in landings of coastal fish species. In this section we present a short summary of the diversity of species which were captured by fisheries during the past several centuries.

The list of commercial fish in the northeastern part of the Baltic Sea (several places around Estonia) in the mid of the 19th century that could be identified from archival documents (Lajus and Sukhorukova 2002) included: pike, perch, roach, sturgeon, ide, herring, sprat, pikeperch, whitefish, turbot, cod, ruffe, bream, salmon, garpike *Belone belone*, sea trout *Salmo trutta*, burbot *Lota lota*, saithe *Pollachius virens*, and cyprinids' category. The most interesting species listed above is, besides sturgeon, saithe because this species has been only a very rare visitor in this part of the Baltic Sea during the 20th century; its main habitat is the North Sea and the species does not usually reproduce in the Baltic Sea due to its low salinity.

One of the longest continuous datasets on coastal fish catches that has been recovered so far (Lajus and Sukhorukova 2002) were derived from the K.E. von Baer archive in St. Petersburg for Suuremõisa (Grossenhoff manor) on Hiiumaa island (west of Estonia, see Fig. 3) for 1796-1851 (Fig. 4). This is the same archive which contained herring landings data for the same time period (see below the section on herring). The species captured were ide, roach, perch and pike. The data available represent fish catches for spring fisheries; in the autumn peasants were allowed to keep their catches for personal consumption. Ide and pike, which are still important commercial fish in this region, underwent a sharp decrease during the 10-year period in 1841-1851 (Fig. 5). This decrease was explained by Baer to be due to river overgrowth.

Several other datasets on landings (from 1870's and 1880s to 1940) of different species (eel, salmon, pike, perch, whitefish) were created for several counties of Sweden. These are based on archival studies in Swedish archives. Only eel, which do not reproduce in the Baltic Sea, exhibit an increase of catches over the years investigated (Fig.6), although landings of the species have decreased in some areas in the southern Baltic since the 1950s (Winkler 1991) and sharp drop of catches was recorded in the NE Baltic since the early 1940s (Ojaveer 1999). Whitefish, which requires cold and clean water and is very susceptible during embryonic development to temperature conditions (Sõrmus 1992), has showed an increase in catches on the 20th century (Fig. 7). In several other regions of the Baltic Sea, whitefish catches exhibit declining tendency since the 1950s-1960s. Salmon landings showed high annual variability with no clear trends in five Swedish counties (Figure 8). As the artificial propagation of salmon in the Baltic Sea began as early as in the 1860s (Karlsson and Karlström 1994), the displayed data-series probably do not solely represent the development of landings of the wild stocks, but include artificially reared salmon as well. Surprisingly, historical archival evidences on landings data on traditional coastal commercial fish like percids, cyprinids and pike were too fragmental to characterise amount of landings of these fish taxa in Swedish counties.

For several Baltic countries, official catch statistics is generally available since the 1920s-1930s. Long-term data-series on the development of landings of only a few coastal fish (pike and pikeperch) is available for some areas in the southern Baltic from earlier times - since the end of the 19th century. For several migratory fish (vimba, salmon, twaite shad *Alos fallax*,

whitefish *Coregonus lavaretus*, trout *Salmo trutta*) the data are available only since the 1950s (Winkler 1991, 1996). Catches of fish other than cod, herring, sprat and salmon reach nowadays to ca 50 000 tons (Lindquist 2001), they are especially important in NE Baltic Sea but also in all coastal areas around the Baltic Sea.

Sturgeon has for centuries been the target of Baltic coastal and riverine fishing. The fish is native to the Baltic Sea and its presence can be dated back to the Neolithic and Bronze Ages in the northeastern parts of the basin (e.g., Lõugas 1999, Enghoff 1999). Sturgeon has historically been a very important component in the local fish fauna, especially in Polish waters (Mackowiecki 2000a,b). For instance, at the turn of the 10th century, sturgeon accounted for 54% of fish remains at coastal archaeological sites. Since the 11th-12th centuries, sturgeon started to decline.

Until very recently it was known that the Baltic sturgeon belongs to a species *Acipenser sturio*. However, the most recent studies have shown that the North American sturgeon *Acipenser oxyrinchus* colonised the Baltic during the Middle Ages (ca 1200 years ago) by replacing locally native *A. sturio* stock. The subsequent decline of *A. sturio* and the further establishment of *A. oxyrinchus* (incl. during the Little Ice Age) may be due to different temperature requirements for reproduction for these species (Ludwig et al. 2002). Thus, the literature data on archaeological excavations presented in this paper (Fig. 9) probably represent mixture of the above-mentioned two sturgeon species and data before the 9th century is necessary to reveal development of the native *A. sturio* in the Baltic Sea.

A large amount of other evidence indicates that sturgeon was an extremely valuable and abundant species. For examaple, sturgeon occupied the fourth position among the most frequently mentioned fish in grants and registers (Makowiecki 2001 and references therein). Sturgeon was also mentioned as a commercial species in the formerly Prussian waters since the 13th century, and in Estonian and Latvian waters and in estuaries of the southern Baltic coast (Germany) in the 19th and early 20th centuries (Benecke 1881, Schneider 1912, Winkler 1991, 1996). Some indication of the importance of sturgeon as a commercial species in several locations along the Baltic southern coast - Memel (currently Klaipeda), Pillau (Baltijsk) and Danzig (Gdansk) in the late 16th and 17th century characterises the fact that several thousand tons of pickled sturgeon was exported from Pillau during this period annually. The sturgeon fishery was probably very effective and perhaps too intense during this period. This resulted in appearance of small (young) sturgeons in fish markets in 1716. In order to protect young individuals, fishing limitations for sturgeon were implemented in 1717 (Benecke 1881).

However, these and later regulations have not been effective in preventing a further decline in catches which continued to fall even during the 20th century (Fig. 9). As an evidence, only 29 findings of sturgeon has been recorded in Estonian waters since the 1880s (Mikelsaar 1984). Although the species has sporadically been found in the Baltic Sea from time to time (the last finding in the northern Baltic Proper in 1996), probably as immigrants from the adjacent North Sea (Debus 1995), the fish has been documented most recently in commercial official catch statistics in 1918 in the NE Baltic (Uzars et al. 2002). Due to its reduced abundance, stocking activities began in the former Soviet Union and artificially reared sturgeons (e.g., species *A. ruthenus*, *A. baerii*, *Huso huso*) were released into the Baltic Sea in the middle of the 20th century. However, these stocking activities did not result in formation of viable sturgeon populations. In difference, records on catches of exotic sturgeon species increasingly occur in the commercial and recreational fisheries in the southern Baltic in the

1980s and the 1990s, including the following species: *A. baerii, A. gueldenstaedtii* as well as hybrids from different parental species such as *H. huso* x *A. ruthenus, A. baeri* x *A. ruthenus* (Gessner et al. 1999). Similarly, several recent findings of small sturgeons in the NE Baltic (during the last decade) are probably escapees from aquaculture cages. However, the native sturgeon has been classified as a rare species in the Baltic Sea (e.g., Winkler 1996) and appears only seldom in catches. Currently, sturgeon is on the Red-List in some Baltic countries as an almost extinct species (e.g., Fricke et al. 1996). This situation has occurred mainly to historically excessive levels of fishing, but also due to deterioration of the coastal and riverine habitat (e. g., damming, eutrophication, pollution). A special project (under HELCOM) on the artificial rearing of sturgeon and release into wild has been undertaken as a measure to restore the sturgeon population in the Baltic Sea.

The long fishing tradition in the Baltic had relatively early consequences for the later catch rates of some of the most desirable species (e. g., sturgeon, salmon, pike). This led to the development of various fishing regulations and some conservation measures. For example, some fishing gears and methods were forbidden in the 13th century and regulations were in place to prevent fishing near river mouths so that migration would not be inhibited (Table 4, Benecke 1881).

Salmon regulations also came into place in other rivers when catches became too low. Due to low catches in some Latvian rivers in the mid 1800s, Prof. K.E. von Baer on behalf of a government commission concluded that the fishery was too intensive. As a result all salmon fishing on some rivers was prohibited for 3 years in the 1850s (Uzars and Gaumiga 2001).

Herring

The herring fishery appears to have been one of the most important fisheries in the Baltic, at least in terms of quantities of landings. As a result the archival reports of herring fisheries appear to be documented more thoroughly, probably reflecting its greater importance to local economies and societies. The oldest evidence of herring fishing in the Baltic is provided by archaeological evidence. Recovery of herring bones in coastal fishing villages along the Baltic indicates that herring fishing has occurred for centuries, if not millennia (Enghoff 1999; Lõugas 1999, Makowiecki 2000, 2001; Mackowiecki and Van Neer 1996). The location of such bones far from the coasts indicates inland transport and trade of fish products.

Quantifiable herring fisheries existed at least since the late 1500s in the southern Baltic (present-day southern Sweden; Holm and Bager 2002) when herring fishermen were obliged to pay a tax in herring for permission to fish. Other records show that herring fishing continued into at least the 1700s and likely later in Danish (now Swedish) provinces in the southern Baltic (Holm and Bager 2002).

Private manor owners in Estonia (Fig. 3) also captured herring in the late 1600s and maintained their own records of landings. Examples of these records are shown in Fig. 10. For some municipal manors in Estonia in the late 1700s, only fragments of questionnaire estimates were found from the archives (Table 5). One of the longest recovered time series of herring landings is from Suuremõisa (the Grossenhoff manor) in western Estonia (Fig. 11). This series covers the period 1796-1851 and is described by the scientific investigations of Karl von Baer (Lajus and Sukhorukova 2002). The catches were made in spring using the

same amount of the same gears and nets, and there is no evidence of a decrease in effort. In fact, the main reason for Baer's expedition was to find out why the catches had dropped near the end of the series in spite of strong demand for herring. There were also autumn fisheries in these same area, but no landings data are available because peasants were allowed to keep their catches for personal consumption.

The fluctuations are therefore due to either environmental variations or possibly to fishing-induced population reductions. The former explanation is probably more likely because the overall level of fishing in the Baltic at this time was much lower than now. The large decrease of herring catches in other parts of Estonia (especially in the eastern Gulf of Finland; Fig. 12) at the end of the 1840s may be due to a reduction in salinity: Baer suggested that this could have happened because there was an increase in riverflow from the nearby Narva river (Lajus and Sukhorukova 2002). The increase in riverflow was attributed by Baer to changes in the surrounding watershed (e. g., destruction of forests, removal of a fortress which previously had partly blocked river flow). In contrast, the herring catch did not show similar drastic changes in Võiste (Waist) in the Gulf of Riga.

During the more recent period near the start of the 20th century, spatially resolved time series of herring landings are available for several locations along the Swedish east coast (Fig. 13). These can be used to indicate the geographic variability in herring landings and enable comparisons to be made latitudinally. While the landings data have not been adjusted for different levels of effort or gears, it is likely that the effort and technological differences within Sweden among areas were relatively small. If this assumption is true then the raw landings data themselves can be interpreted to reflect ecological changes in factors affecting the production or distribution of herring to the local fishermen. It can be seen for example, that the herring landings are much larger in the south than in the north (Fig. 14), as is the case today (ICES 2001) and as might be expected for a marine species located at the edge of its salinity tolerance limit. Moreover some of the north-south variability could be due to temperature differences experienced by the different populations. This possibility can be evaluated using proxy environmental data for the Baltic Sea such as the North Atlantic Oscillation index or winter ice conditions.

The recovered material could potentially allow one to extend backwards the existing international catch time series (Fig. 15), and therefore to compare and interpret total herring landings in the Baltic in the 20th century with those in previous centuries and in other areas (e. g., Bohuslån, Limfjord, North Sea, Norway). This comparison will be done in the near future, although it is recognized that such comparison must be regarded as preliminary because the Baltic time series before 1900 are so far based on incomplete material; many archives around the Baltic have not been yet been investigated and some of these are in countries known to have been major herring fishing nations (i. e., Germany, Poland).

Herring fisheries at Bohuslån, Sweden (Skagerrak) and Limfjord, Denmark

We next consider as a basis for comparative purposes the herring fisheries in two neighboring areas of the Baltic Sea. These areas are Bohuslån, Sweden and Limfjord, Denmark.

The Bohuslån herring fishery has had several strong and poor periods during the last 500 years and there are indications that these fluctuations have occurred for even longer periods (Alheit and Hagen 1997; Corten 1999). The fluctuations had important economic and social

consequences for the region and therefore there exists some written documentation about these periods which can be used to infer when these periods occurred. Quantities of the annual catches have been presented earlier for the last major herring period 1877-1905 (Alheit and Hagen 1997), but for most of the earlier periods, the magnitudes of the landings are poorly known except in general terms (e. g., good, very good, etc.). However an investigation of the Swedish archives indicates that quantitative landings data for the previous herring period in the mid-1700s are available. These data will be combined with those from the later period and a new time series developed for a period lasting nearly 150 years.

A second important herring fishery occurred in the Limfjord, northern Denmark (Poulsen 2002). The Limfjord is an estuary with little exchange to the Kattegat and until 1825 had no exchange to the west with the North Sea. As result of its limited contact to the surrounding marine areas, it had a low salinity (5-15 ppt). The salinity has increased to ca. 30 ppt after 1825 due to permanent storm damage to the isthmus (known as Agger Tange) separating the fjord from the North Sea.

The Limfjord herring fishery, as well as fisheries for other species in the fjord (e.g., eel, plaice *Pleuronectes platessa*), has now been documented by a University of Southern Denmark master's thesis (Poulsen 2002). The herring fishery had been the greatest Danish fishery in the seventeenth and eighteenth centuries and remarkable written records of landings and effort data exist for this fishery (Fig. 16). Salted herring, *Clupea harengus*, known as the *Aalborgsild*, was exported to the Baltic region bringing prosperity to the whole of Northern Jutland. Landings were highest in the first three decades of the eighteenth and nineteenth century, when annual landings often exceeded 10,000 tonnes. These landings although smaller than during the strongest Bohuslån herring periods are nevertheless large for a relatively small enclosed estuary such as the Limfjord and also in comparison to newly – recovered herring landings from other areas in the Baltic Sea. For example, mean annual herring landings in one of the more productive areas in southeast Sweden (Blekinge) were ca. 2500 t during the late 1800s- early 1900s (Fig. 14) and therefore much lower than in the Limfjord during the late 1600s-early 1700s and in the early 1800s. Landings in other parts of the Baltic (e. g. western Estonia) were also lower (Fig. 13).

The high landings of herring from Limfjord have not been sustained to the present and the fishery collapsed around 1830. This may be due to ecological changes associated with the influx of salt water after 1825. However since herring is a marine-brackish water species the it is unlikely that the higher salinity had a direct physiological effect on the species. Instead it is likely that fishing effort was a more important factor that caused the decline. Fishing intensity was high and increasing for many decades prior to the collapse and catch per unit effort indices were already decreasing (Poulsen 2002). The years 1800-1830 witnessed an overall increase in fishing effort, and in particular in one part of the Limfjord (Løgstør) where it doubled in the 1820s (Fig. 17). Moreover the new seines were used in places never before exploited in this way. Huge seines were dragged along the bottom in the shallow waters which, according to several accounts, was right on top of the spawning beds of the herring. Contemporary accounts explain how the seines were filled with larvae. These observations suggest that fishing had several deleterious effects on the reproduction and recruitment of this populations. First the fishing activity captured pre-recruits which had no chance to spawn; second the fishing activity probably damaged eggs on spawning sites and possibly the spawning habitat (e. g., substrate structure) itself; third, intensive fishing removed a large amount of spawners. These three factors probably were key factors which would contribute to a population collapse and reduction of landings by 70-90% in the middle decades of the

1800s. Herring landings have never again reached the high levels of the 1800s and have only recovered to moderate levels (ca. 4000 t) in the mid 1900s.

The demographic consequences of the disappearance of the herring from Limfjord were significant. More than 2,000 fishermen were fully or partly dependent on the Limfjord herring fishery in the 1820s, but this number was reduced by 90% in the 1860s. As a result fishing effort also fell drastically.

Cod

The cod fishery in the Baltic Sea also has an ancient history and archaeological studies have found cod bones on Bornholm and in other coastal areas along the Baltic (Enghoff 1999). These finds are from the 6th-7th and 11th centuries AD. Cod taxes (i.e., taxes paid in kind as cod) have been levied since at least the 1400s-1500s (Otterlind 1984; Holm and Bager 2002). The records of taxes paid are some of the oldest known written records of the cod fishery in the Baltic (Fig. 18).

The amount of cod paid as tax for several years in the late 1500s and early 1600s shows some variations. The causes of these variations are unclear but could be related to the following:

- ✓ changes in the level of taxation that individual fishermen were obliged to pay,
- ✓ the actual landings if the tax rate was a proportion of linked to the landed cod levels as a constant proportion;
- ✓ changes in the taxation base (i.e., changes in the number of fishers obliged to pay tax due to entry or withdrawal from the fishery).

However regardless of the cause or even the extent of the variations, the existence of the cod tax demonstrates that the local cod stock was sufficiently large and accessible to encourage participation in the fishery and to stimulate local authorities to impose a tax.

The cod landed was not always used for local consumption in the immediate village or town. A proportion of it was exported to neighbouring towns and even to other more distant parts of the Baltic; for example, much of the cod exported from one of the Swedish towns in 1630s was transported to the Hanseatic towns along the southern Baltic coast (Fig. 2, 19). Records of these exports show that the trade in cod was active throughout the 17th century but was highest in the early decades of the 17th century and decreased from ca. 1620 to 1650 (Fig. 20). The exports generally fluctuated at a lower level during the rest of the 1600s and the entire 1700s. It is not known why the exports decreased by so much (ca. 3-4 fold) or even whether the decrease is artifactual (e. g., due to changes in reporting systems, loss of records). However this initial investigation of the cod export archives suggests that the Hanseatic towns and villages may have been an important consumer of cod from the Baltic. If this is true, there may be additional information about the Baltic cod trade and Baltic cod landings in the archives of former Hanseatic towns.

During the mid-late 1700s a new development occurred in the Baltic cod fishery. Fishermen started to transport live cod from Bornholm to the Copenhagen fish market for sale in the Danish capital. This fishery relied on specially-designed boats called smacks (kvaser in Danish) and the deployment of these boats is recorded in the Danish fishery archives (Fig. 21; 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. Each smack typically made 3-4 trips to Copenhagen per year (Fig. 22), although the bigger smacks made more trips than the smaller ones (Fig. 22). The total number of trips by all smacks was 70-80 (Fig. 23).

An indication of the amount of live cod transported to Copenhagen by these boats is possible for 1836. During that year, the number of cod transported by each smack operating from Bornholm was recorded. If the mean weight of a live cod is 900 g (typical value based on current fish weights in commercial catches; ICES 2001), then the smacks would have transported 94 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; pers. comm.), although the number of cod transported per smack depends on smack size (Fig. 24). However assuming a value of 300 kg, then the smacks would have transported at least 24-30 t per year during the early 1830s, given the assumed trip frequency and smack numbers. Alternatively if one assumes that (1) the number of cod transported per smack was similar to that observed in 1836 (mean N = 4200 cod; Krøyer 1866), (2) there were 18 smacks operating per year, (3) each smack made 4 trips to Copenhagen and (4) each live cod weighed 900 g, then the export would have been 272 tonnes per year during 1832-1835.

Swedish cod landings data on a spatially resolved basis show that the southern areas dominated the catches in the late 1800s and early 1900s (Fig. 25). These landings are very low compared to the levels later in the 20th century (Fig. 15). Latvian and Danish cod landings for respectively the eastern/central Baltic and the area around Bornholm are also much lower than later in the 20th century (Fig. 26).

It is useful to attempt to compare the landings in the late 1800s-early 1900s with those in the 1600s and 1700s. A preliminary comparison is possible because the different measuring units and the process state of cod (e. g., salted, dried, live) have been accomodated by applying conversion factors to bring the data sets to common units. The time series (Fig. 27) shows that cod landings in the Baltic were very low (usually 10-20 t per year) in comparison to late 19th century levels and especially 20th century levels. As with the Baltic herring catch data, it must be emphasized that the time series is preliminary and based on an incomplete examination of all possible archives; data from Germany, Poland and Finland have not been evaluated yet.

Most (90%) of the landings shown in the time series were found in Danish and Swedish archives. Despite a preliminary search of Estonian, Latvian and Russian archives by local historians in those countries, 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. The low recovery of cod data from those countries could be a consequence of absence of cod from the coastal waters of these countries, lack of fishing interest in the species, loss and destruction of cod-related fishery records and archives, or export of archives to other countries.

Marine mammals

Two species of seal (grey: *Halichoerus grypus* and ringed: *Phoca hispida*) have been very abundant in the Baltic but now are at very low levels (Harding and Härkönen 1999). The harbour porpoise has also declined in abundance during the 20th century. All three species have been the targets of directed hunting. Seal kills in the late 1800s-early 1900s increased (Fig. 28), partly due to a bounty system in place at the time (Table 6). Most of the kills were in the northern part of the Baltic. The seal hunt was not regulated in the Baltic Sea until the late 1960s, since when the quota system was implemented. Sharp decline in seal population abundance, caused by too intense hunting, marine pollution and unfavourable climatic conditions led to the total ban of seal hunting since 1980.

Overall conclusions

The raw material for assessing the long-term variability in fish landings in the Baltic is becoming available. Much of the new knowledge will be derived by a continued and intensified examination of the large amount of archival material located and recovered here. This will have to include both quantitative and qualitative interpretation of the new data series now available. In addition, new studies will have to be initiated to cover topics, areas, countries and time periods not represented in this pilot study.

Our knowledge of the magnitude of fishing in the Baltic Sea in past centuries and decades is becoming richer although it is still incomplete. For example some trends and fluctuations in the landings and export of various species (e. g., herring, cod, eels) are evident, but these variations could be partly due to the ongoing and incomplete nature of the archival retrieval and interpretation process. It is therefore premature to attribute the variations to specific factors. Nevertheless it is now becoming possible to quantify the magnitude of the historical (pre-20th century) Baltic fisheries. This information could be helpful when attempting to estimate historical levels of biomass, long-term sustainable yields and the overall structure and function of the Baltic food web. Moreover comparison of landings trends during similar periods throughout an area can facilitate interpretation of causes of fluctuations in landings (Ravier and Fromentin 2001).

Fishing was clearly an important economic and social activity in the Baltic Sea region since at least the 1500s. Its importance is seen in the decision and commitment of local authorities to levy taxes on the most profitable fisheries. Indeed in many instances the taxes paid were in fish (Holm and Bager 2002), rather than other forms of compensation. There was an active export and import of fish products among towns and countries which stretched throughout and beyond the Baltic. In some instances when fisheries started to decline in some areas for certain species, authorities or private individuals developed regulations to conserve populations and protect habitats. These regulations suggest that fishing activity was already depleting local populations and that actions were needed to ensure continued supply and economic benefits. This is consistent with the historical effects of fishing and exploitation of the seas observed in many other areas (Jackson et al. 2001). In addition, the implementation of fishing regulations may also have been associated with local or regional market conditions (e .g, to restrict supply).

The impact of fishing activities on the local and regional economies has fortunately been recorded and these records will be invaluable for interpreting variations in landings and fishery-related activities (e. g., trade, employment). This will make it easier to describe the

ecological and economic impact of fishing on respectively the fish populations and the regional economy.

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Table 1. Comparison of data sources for evaluating multi-decadal trends in fishery landings and fish abundance in three marine ecosystems in the Northeast Atlantic. See text for details.

Locations of data sources recovered or identified	**Baltic Sea**	**North Sea**	**Norwegian Sea**
Fishery institutes -spawner and recruit abundance -landings	Cod: 1966+ Herring: 1974+ Sprat: 1974+ Landings: 1910s+	Cod, haddock, whiting: 1920+ Landings: 1920s+ several species	Cod: 1947+ Herring: 1905+
Written archival sources of landings	Some late 1500s+ Others late 1800s+	Some late 1500s+ Others late 1800s+	Late 1500s for cod and herring
Archaeological sources (e. g., fishing village remains)	Yes	Yes	Yes
Geological sources (e.g., sedimentary evidence)	Yes for environmental changes	Yes for environmental changes	Yes for environmental changes

Table 2. Different units of fish catch records used in the Baltic countries during the 17th-20th century, as found in archival research within the national HMAP projects.

Unit	**Conversion**	**Timeperiod**	**Country**	**Species**
Volumetric units				
Barrel		1681-1687	Estonia	herring
Barrel	108,21 litre	1663-1843	Denmark	cod, herring, salmon
Barrel	126,6 litre	1754-1888	Sweden	herring, mackerel
Barrel	120 litre	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 litre	1873-1912	Sweden	herring
Kulmit	14.1 litre	1838-1851	Estonia	herring
Loof	42.3 litre	1840-1851	Estonia	herring
Val(ar)	0,04 barrel	1874-1910	Sweden	herring
Zuber	0.2 barrel	1846-1851	Estonia	herring
Åm/fat	157 litre	1801-1810	Sweden	herring
Weight units				
Lispund	7,97 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	0,4984 kg	1663-1838	Denmark	all species
Pood	16.38 kg	1911	Latvia	several species
Pound	0,500 kg	1839-2002	Denmark	all species

Ton (barrel)	10 lispund (85 kg)	1796-1851	Estonia	herring, ide, roach, perch
Ton	1000 kg	1881-1910	Sweden	herring
Ton	1000kg	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 3. The categories of vessels used in the Fishing Reports in Denmark during various sub-periods between 1889-1920.

1889-1902	**1903-1909**	**1910-1912**	**1913-1920**
Buyer smackes (opkøber kvaser)	Buyer smackes	Well smackes	Motor fishing vessels
Well smackes (drivkvaser)	Well smackes	Deck vessels	Sailing fishing vessels
Deck vessels (dæksbåde)	Deck vessels	Well dinghies	Rowing boats
Well dinghies (damjoller)	Well dinghies	Small vessels	
Small vessels (mindre fartøjer).	Small vessels	Motor fishing vessels	
	Motor fishing vessels		

Table 4. Development and occurrence of fishing regulations in some areas of the south-eastern Baltic Sea (Benecke 1881).

Country	Year	Species targeted	Intended location of regulation	Nature of regulation
Presently Russia and Poland	1280	Probably several species	Vistula lagoon, river estuary	Special licence needed to fish with selected gears (e.g., eel traps), fishing ban in river mouth in order to protect fish on their migration routes
Presently Russia and Poland	1318	Probably several species	Vistula lagoon	Ban of eel nets (named as Alvaten and Kütel in German)
Presently Lithuania and Russia	1589, the first fishing rules	Probably several species	Curonian lagoon, rivers	Temporal closures (spawning season) and total ban for selected fishing gears, fishing ban on Sundays, requirement to apply for a special licence to fish with selected gears
Prussia (presently Germany, Lithuania, Poland and Russia)	1640 (revised fishing rules)	Probably several species	Vistula lagoon, Curonian lagoon, rivers	Probably similar as above
Prussia	1717	Sturgeon	Coastal sea area	Closed fishing areas
Prussia	1738, 1787 (revised fishing rules)	All species	Vistula lagoon	Mesh-size limits, closed fishing areas, ban of several fishing practices (gears), requirement to release all spawning fish, limitations on number of fishing gears allowed per fishers
Prussia	1792 (revised fishing rules)	All species	Curonian lagoon	Fishing ban on Sundays and holidays, mesh-size limits, closed fishing areas, ban of selected fishing gears (also by regions)

Table 5. Available historical questionnaire fragments on estimates on herring *Clupea harengus membras* catch in municipal manors of Pärnu (Estonia) in the 18th-19th century (Must 2002).

Year	**Estimate**
1772	Sufficient
1778	Satisfactory this year
1784	Some pretty bad years in the whole area
1790	Some pretty good years
1799	Good in previous years, bad this year
1803	Pretty good

Table 6. Bounty paid per killed seal in Finland and Sweden in local currency.

Finland		**Sweden**	
Year	**Finnish marks**	**Year**	**Swedish krones**
1909	3	1900	3
1925	30	1913	4
1928	50	1925	6
1943	100	1928	10
1963	150	1948	15
1964	40 (new currency)	1965	30

Figure 1. Map of the Baltic Sea with bordering countries and main sub-basins. Locations of important former Prussian towns for sturgeon fishery and Swedish counties referred in the text or other figures are also indicated (Kristianstad and Malmöhus counties form currently the county of Skåne).

Figure 2. Map of the Southern Baltic Sea with towns of the Hanseatic League, towns at the northern coast of present days Poland and Germany, which imported cod from Blekinge in the 17th century, locations on Bornholm which exported salted herring from the harbours of Blekinge in the 17th century and harbours in Blekinge and Skåne where the custom archives have been examined.

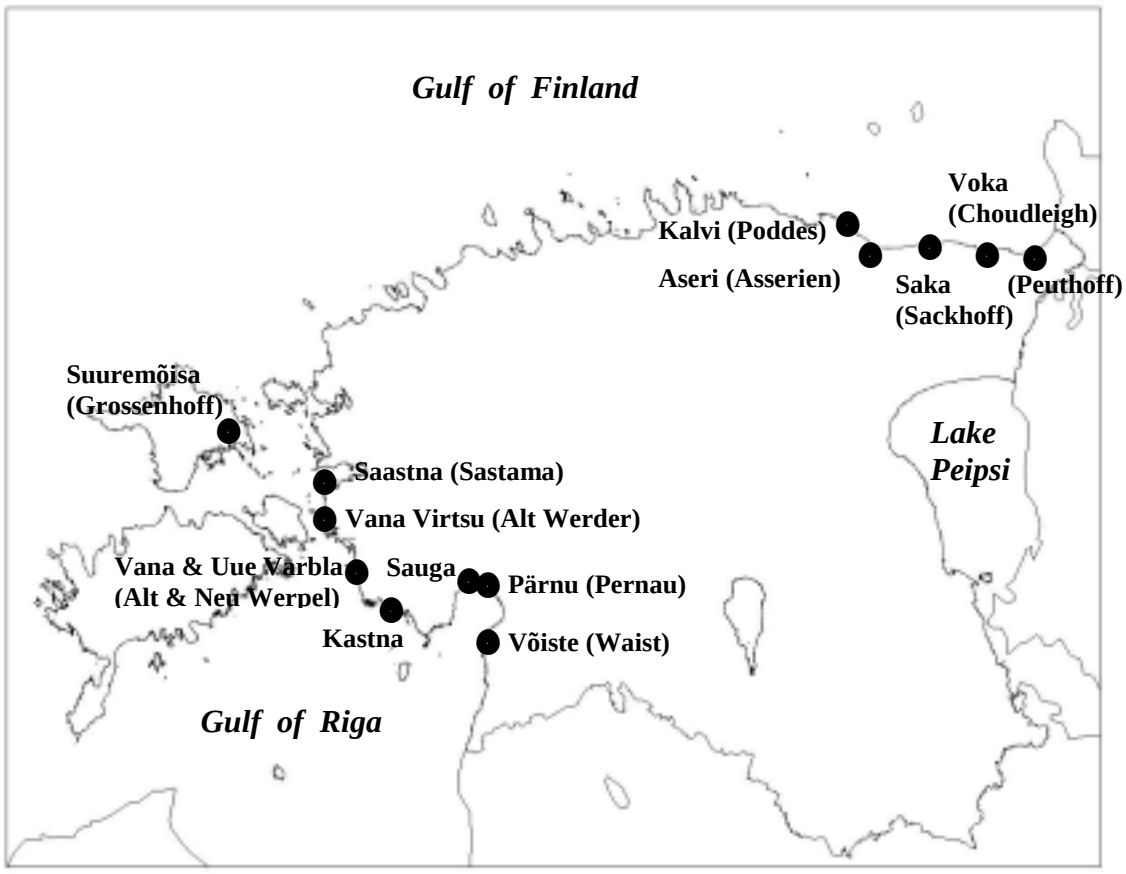

Figure 3. Locations of manors in Estonia where historical data on fish landings for various time periods are available. Name in parenthesis denote old name of a given location found in archives.

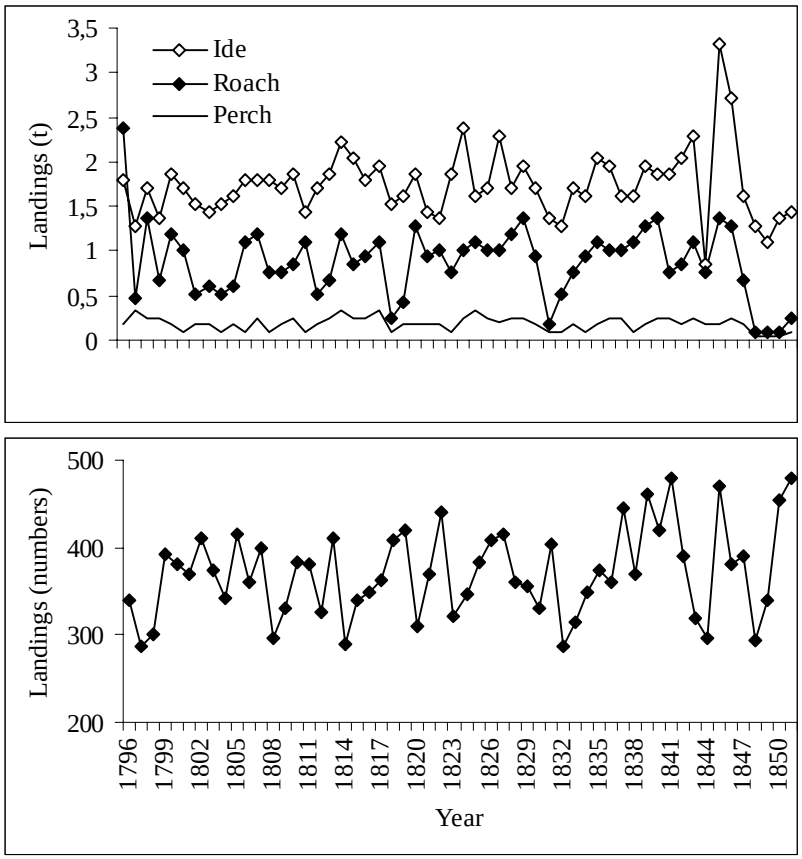

Figure 4. Landings of ide *Leuciscus idus*, roach *Rutilus rutilus* and perch *Perca fluviatilis* (upper panel) and pike *Esox lucius* (lower panel) in Suuremõisa (Grossenhoff manor) at Hiiumaa island west of Estonia in 1796-1851.

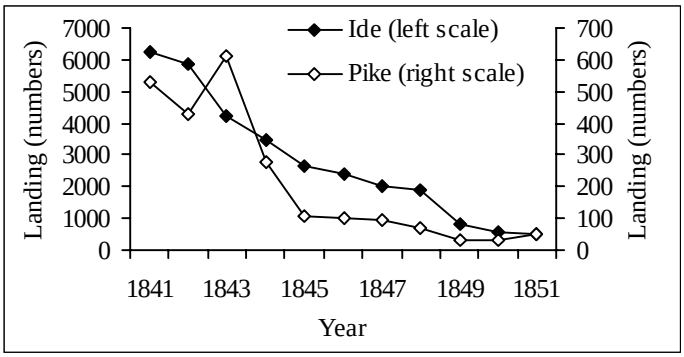

Figure 5. Riverine catches of ide *Leuciscus idus* and pike *Esox lucius* in Kloostri manor (Klosterhoff) in western Estonia in 1841-1851.

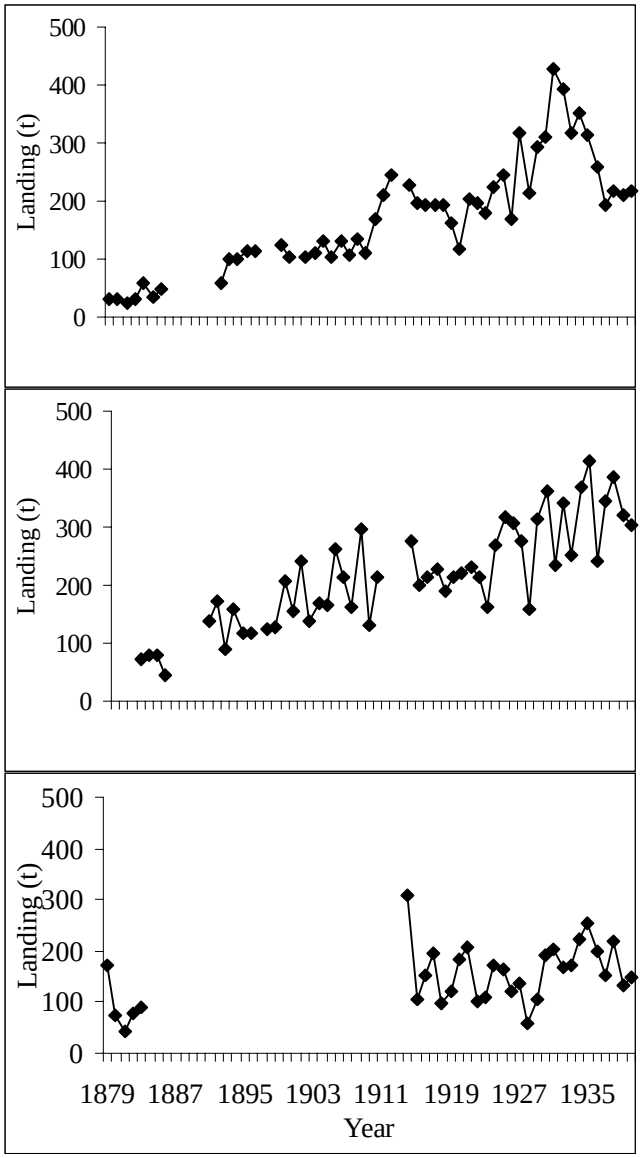

Figure 6. Landings of eel *Anguilla anguilla* in Malmöhus (upper panel), Blekinge (intermediate panel) and Kristianstad (lower panel) counties in Sweden in 1879-1940.

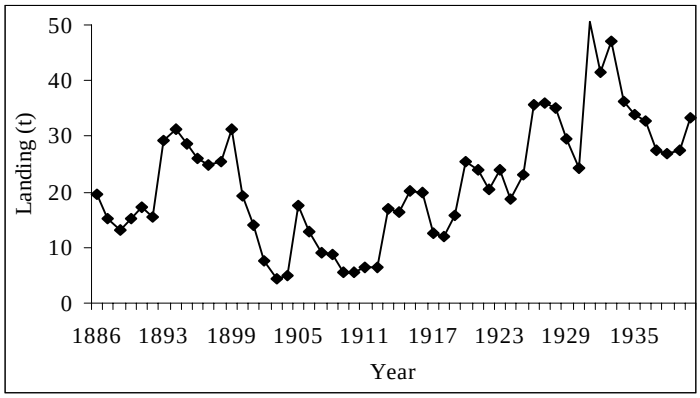

Figure 7. Landings of whitefish *Coregonus lavaretus* in Västernorrland county in Sweden in 1886-1940.

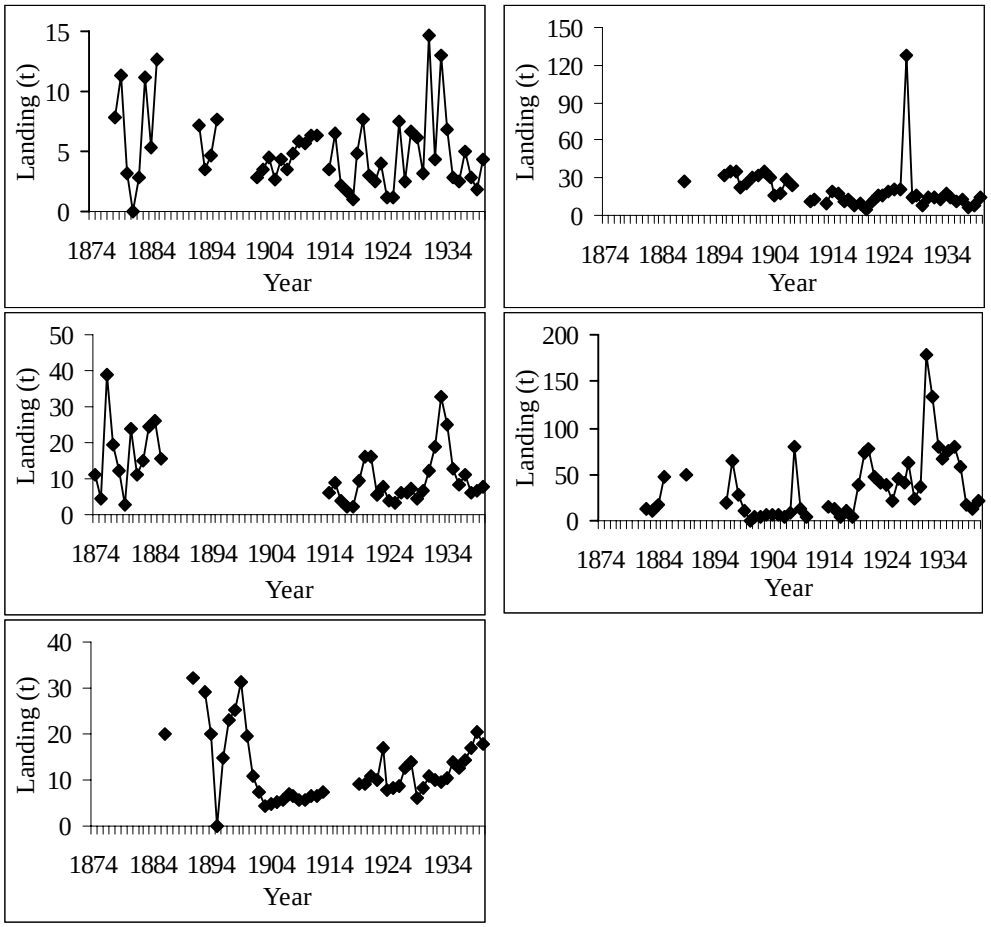

Figure 8. Landings of salmon *Salmo salar* in counties of Malmöhus (upper left), Kristianstad (intermediate left), Västernorrland (lower, left), Blekinge (upper right) and Halland (lower, right) in Sweden in 1874-940.

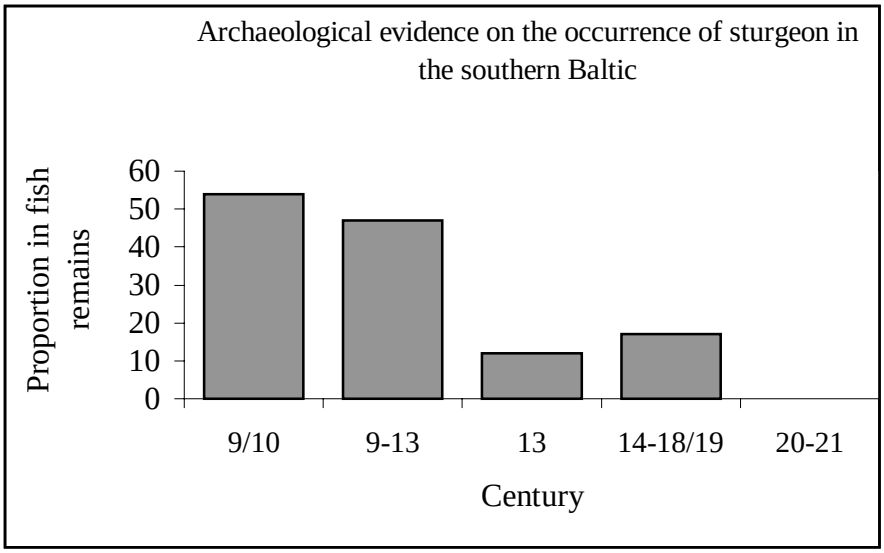

Figure 9. Decline of sturgeon population in Polish waters since the 9th century (data from Makowiecki 2001).

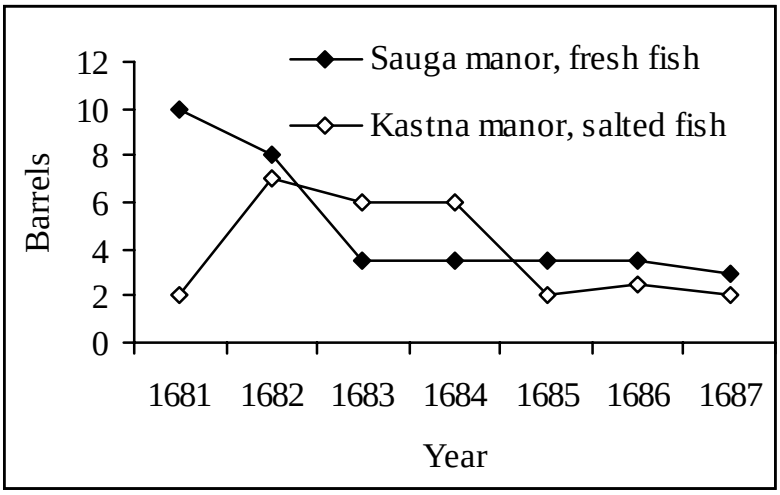

Figure 10. Landings of herring (*Clupea harengus membras*) in Sauga and Kastna manors (southwest of Estonia, Must 2002).

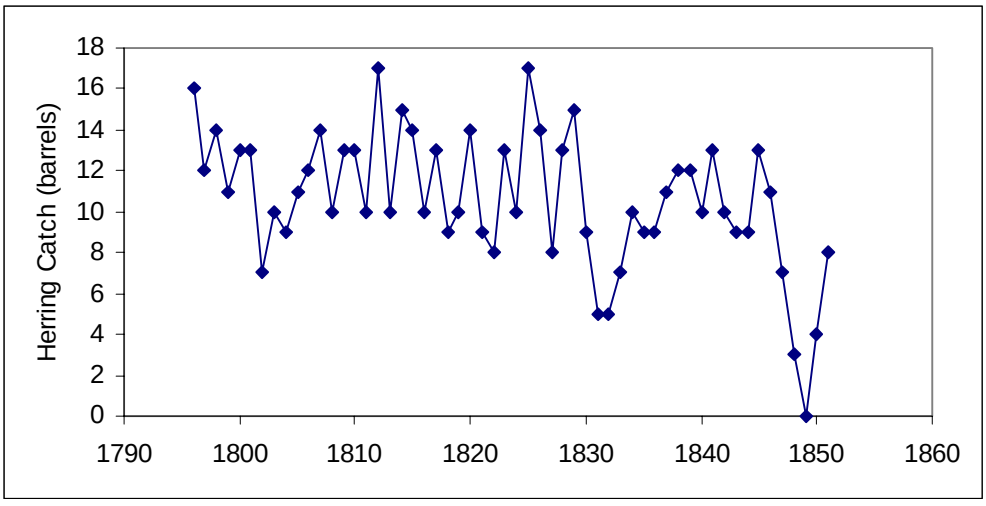

Figure 11. Landings of herring (*Clupea harengus membras*) in Suuremõisa (Grossenhoff manor) in 1796-1851. Landings are based on data contained in the archives of Prof. Karl von Bær (Lajus and Sukhorukova 2002).

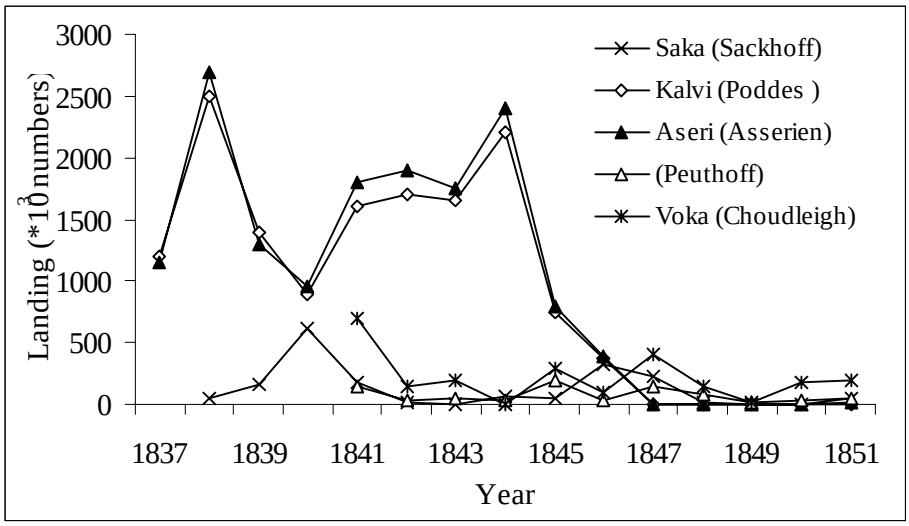

Figure 12. Landings of herring *Clupea harengus membras* in manors at the Estonian coast in the eastern Gulf of Finland in 1837-1851 (Lajus and Sukhorukova 2002).

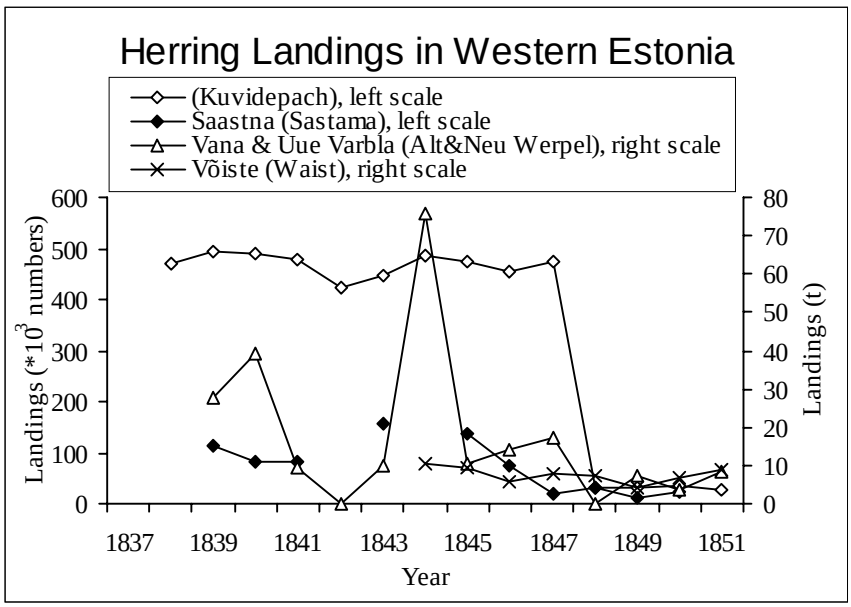

Figure 13. Landings of herring *Clupea harengus membras* in manors at the Estonian west coast and the Gulf of Riga in 1837-1851 (Lajus and Sukhorukova 2002).

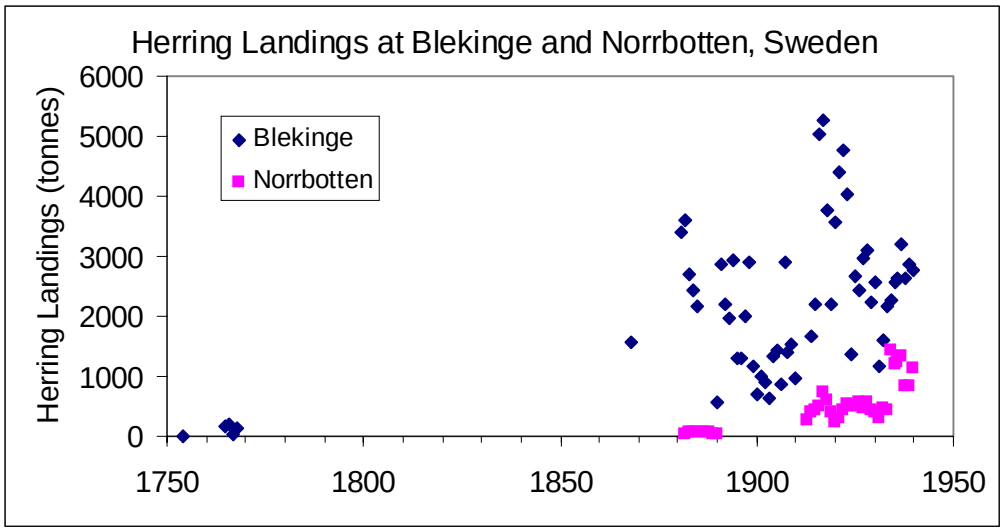

Figure 14. Landings of herring *Clupea harengus membras* at Blekinge (southeast Swedish coast; Fig. 1) and Norrbotten (northeast coast, Sweden).

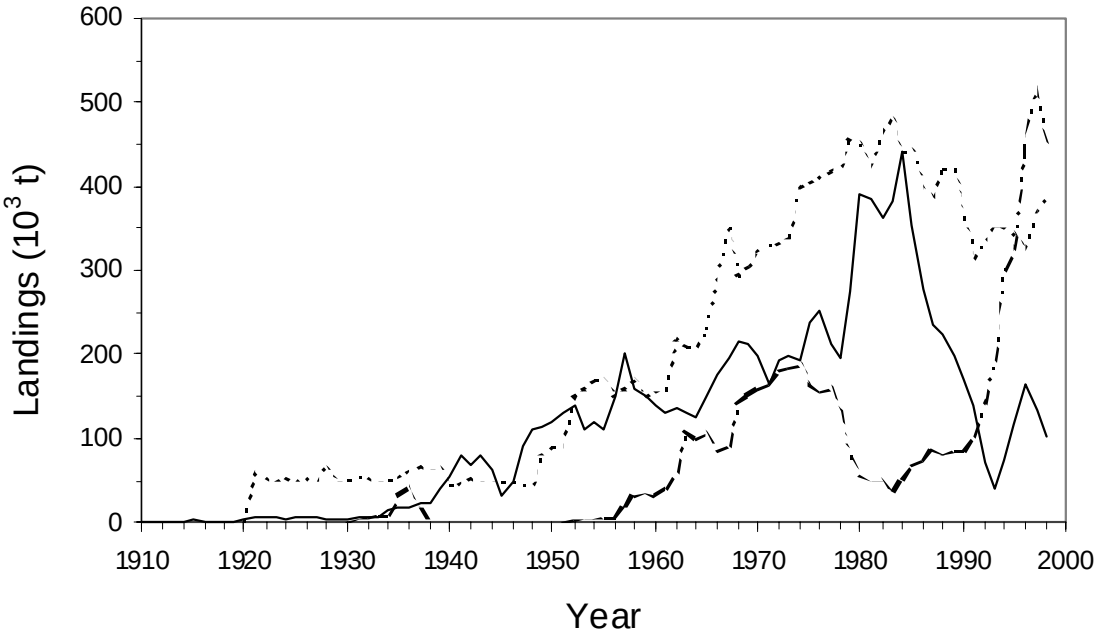

Figure 15. Total international landings of herring (dotted line), cod (solid line) and sprat (chained line) in the Baltic Sea (ICES Subdivisions 22-32) during the 1990s as reported to ICES (MacKenzie et al. 2002).

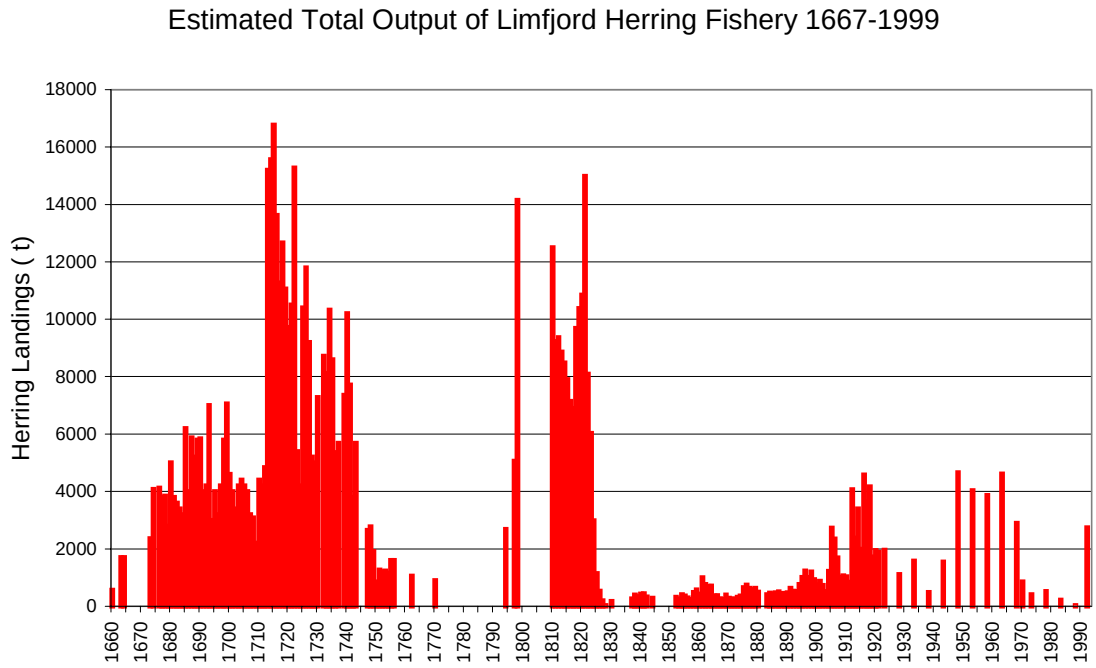

Figure 16. Estimated total landings of herring in Limfjord, Denmark during 1667-1999 (Poulsen 2002).

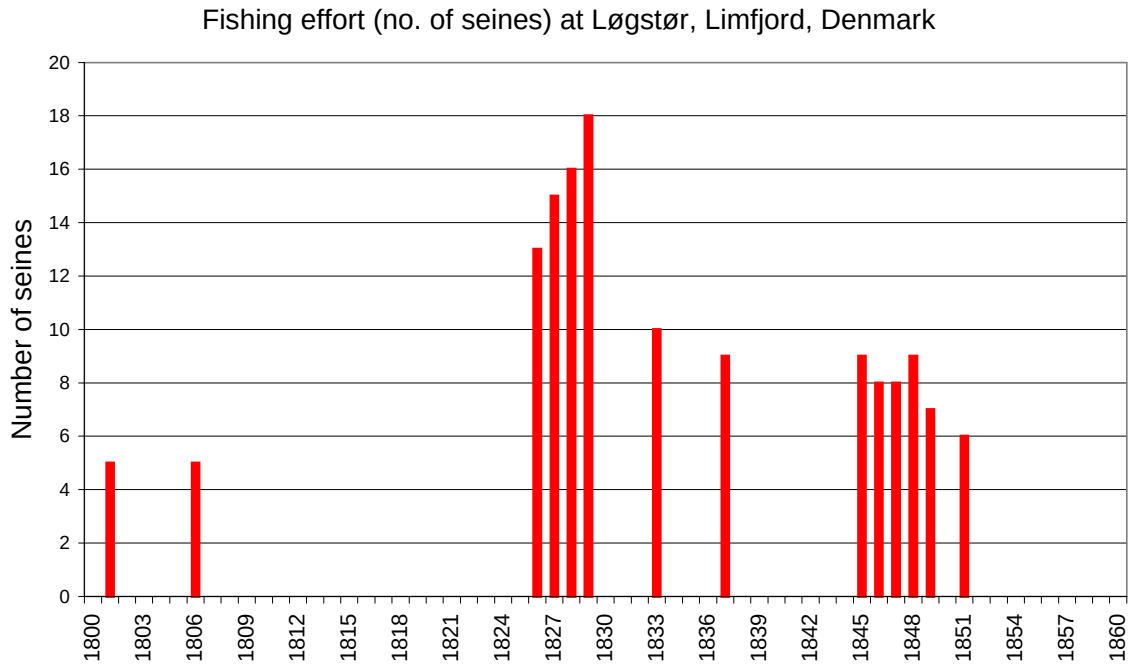

Figure 17. Effort deployed in the Limfjord, Denmark herring fishery during the 1800s, as indicated by the number of seines used at one location (Løgstør). Seines were only one type of gear used; traps were also widely used (Poulsen 2002).

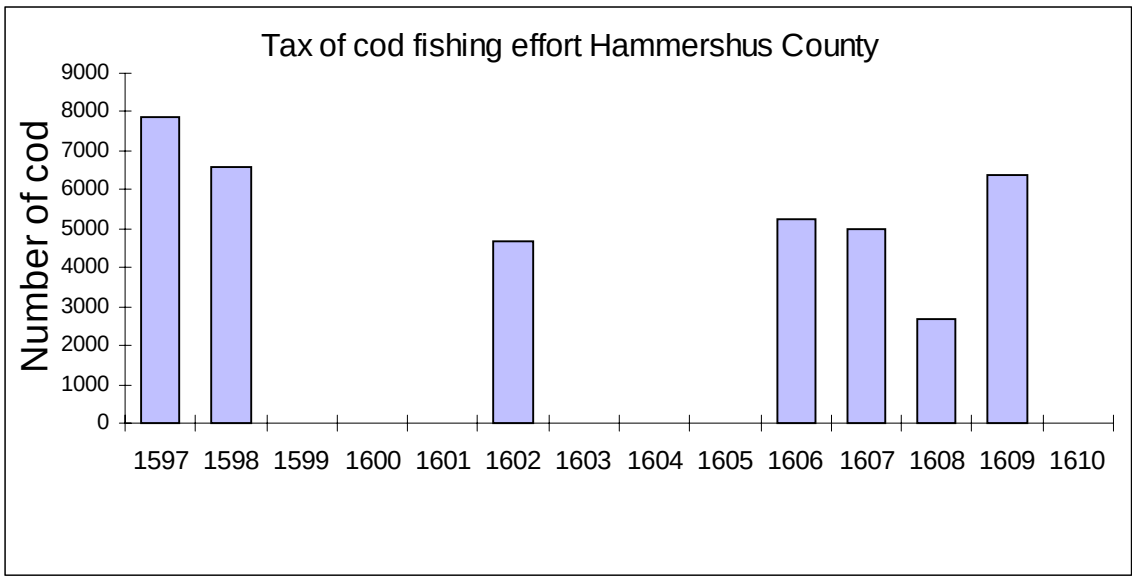

Figure 18. Numbers of cod paid as tax by fishermen in Hammershus County, Bornholm, Denmark during 1598-1609 (Holm and Bager 2002).

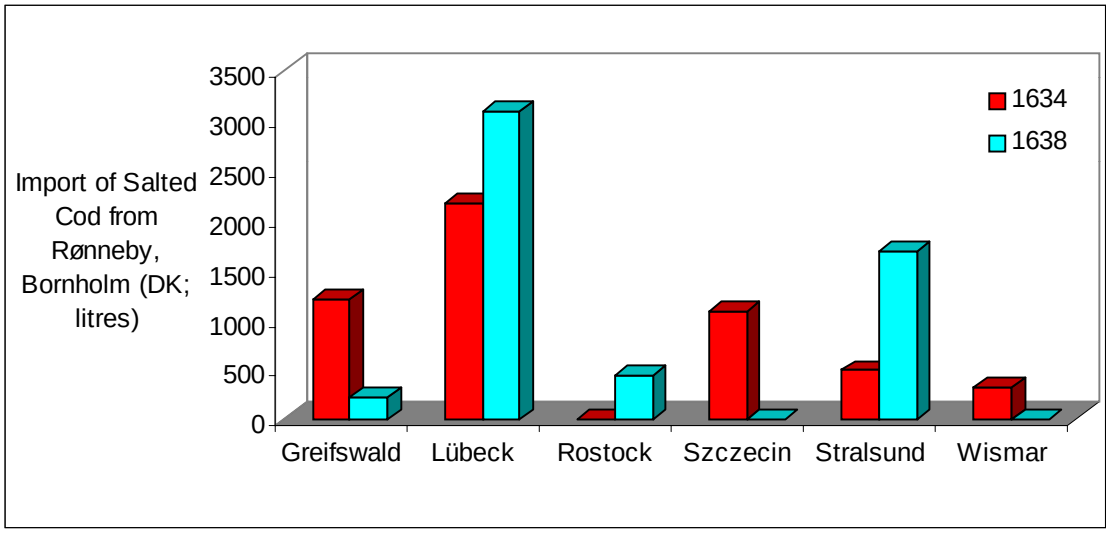

Figure 19. Import of salted cod from Borhnolm Denmark by Hansa towns along the southern coast of the Baltic Sea during 1634 and 1638 (See figure 1 for locations).

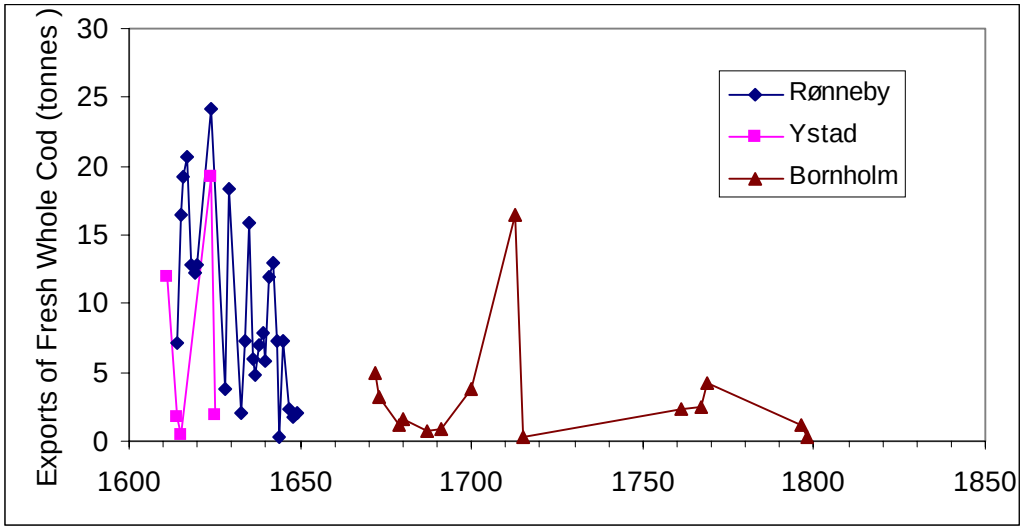

Figure 20. Exports of fresh whole cod from Bornholm and southern Sweden during the 1600-1800s.

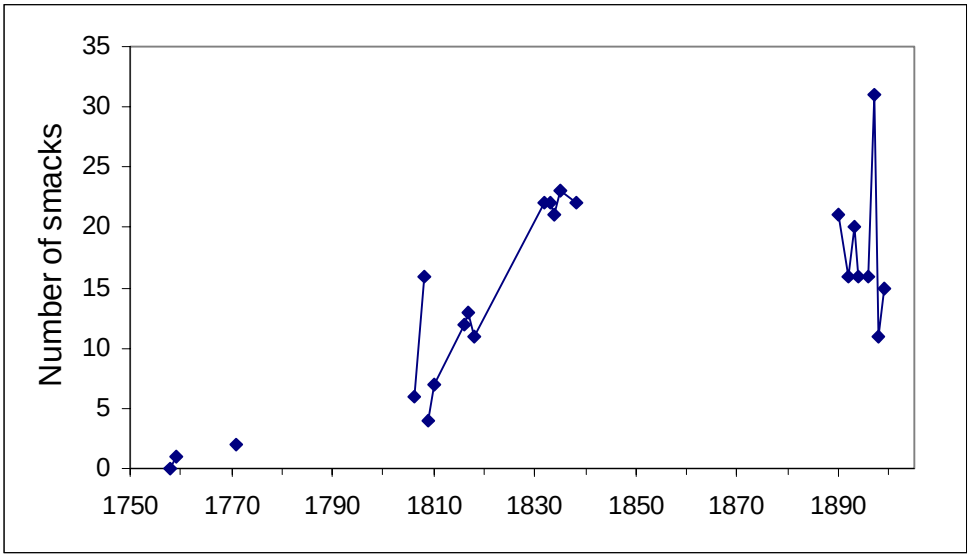

Figure 21. Increase in the number of fishing smacks participating in the export of live cod from Bornholm. Smacks were boats capable of transporting live cod to primarily Copenhagen.

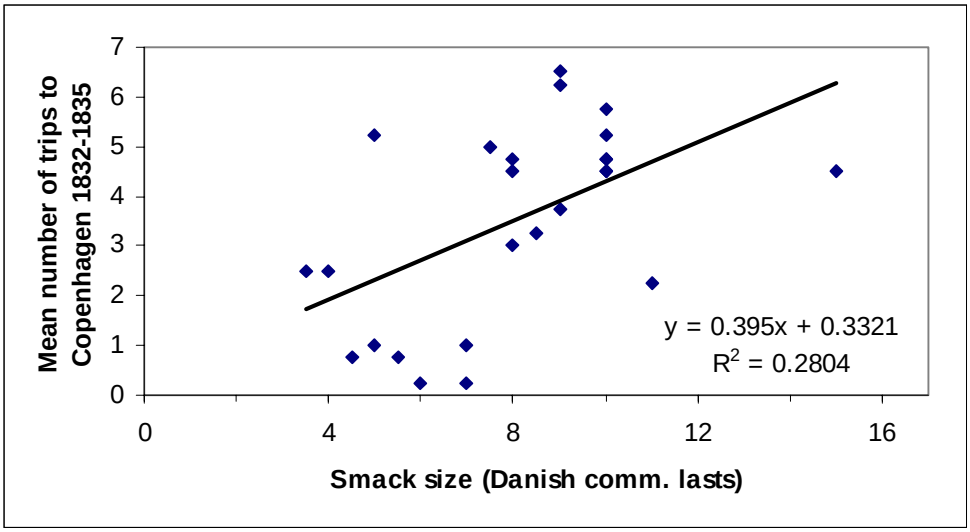

Figure 22. Relationship between number of smack trips per year to Copenhagen carrying live cod and smack size.

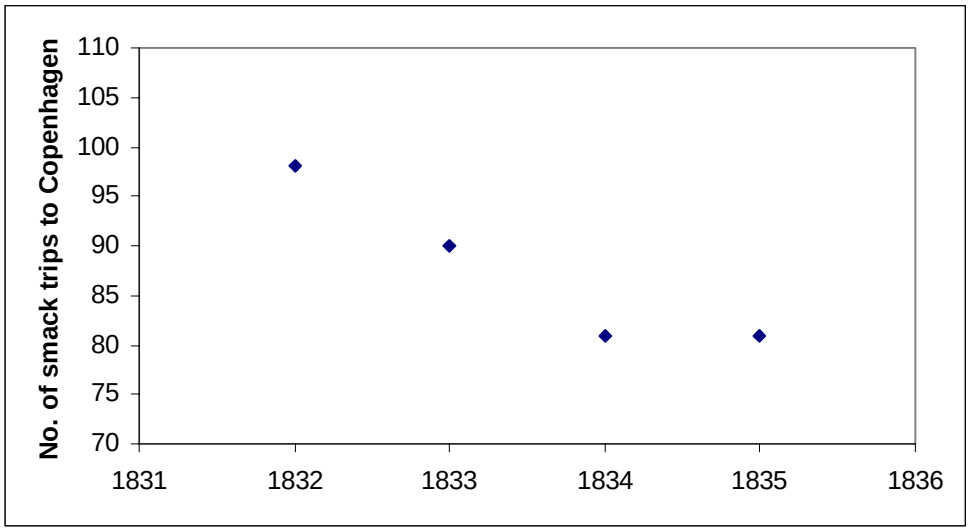

Figure 23. Number of trips made to Copenhagen per year by smacks carrying live cod.

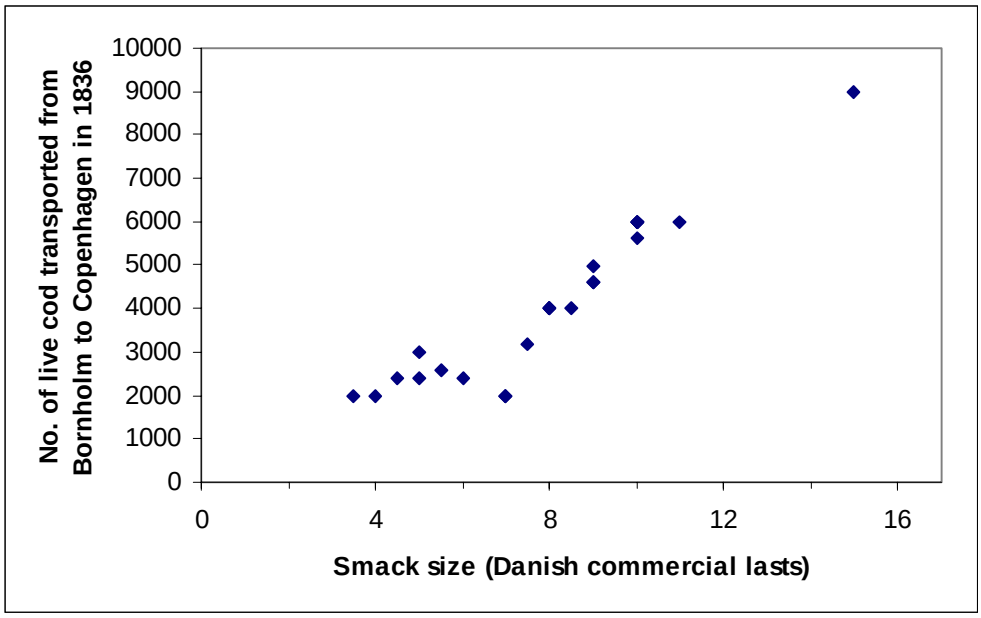

Figure 24. The effect of smack size on number of live cod exported per smack from Bornholm to Copenhagen.

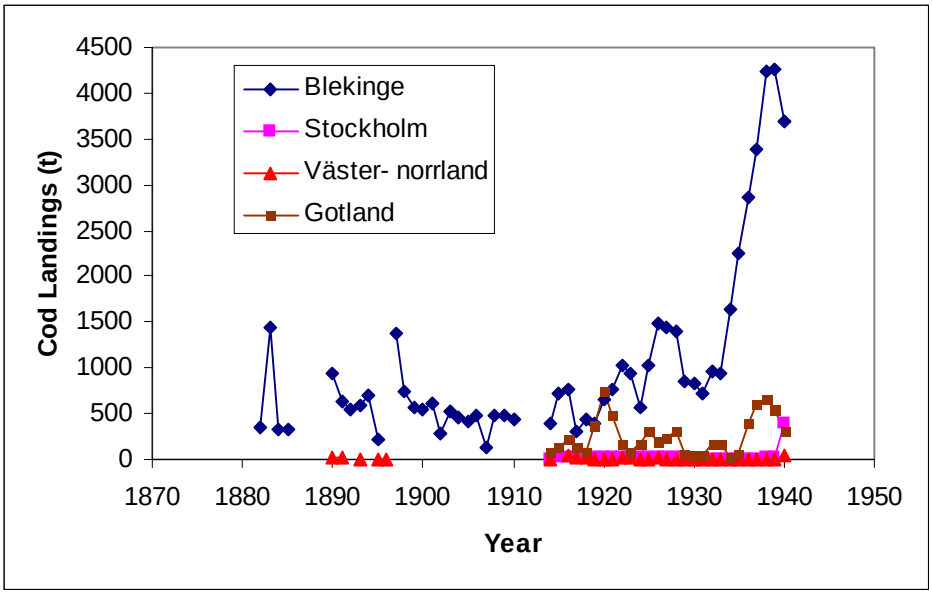

Figure 25. Spatially-resolved landings of cod along the Swedish Baltic coast during the late 1800s-early 1900s.

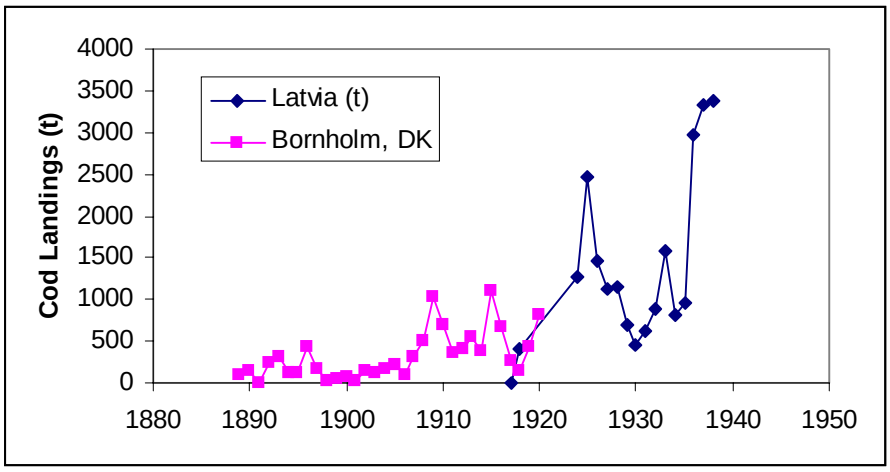

Figure 26. Landings of cod at Bornholm, Denmark and Latvia (ICES Subdivisions 26 and 28; (Uzars and Gaumiga 2001).

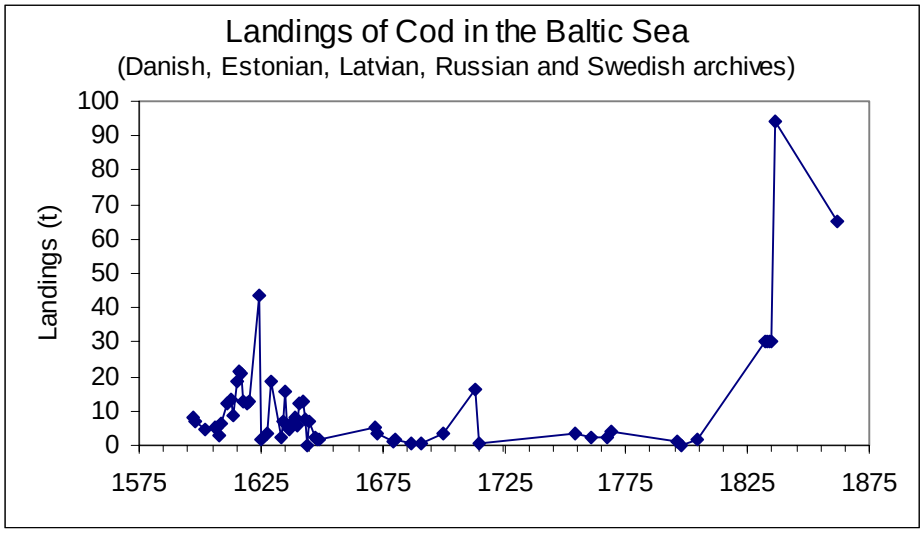

Figure 27. Preliminary estimate of the total landings of cod in the Baltic Sea as estimated from various archival sources in several Baltic countries. Most (90%) of the landings indicated here were made by Denmark and Sweden.

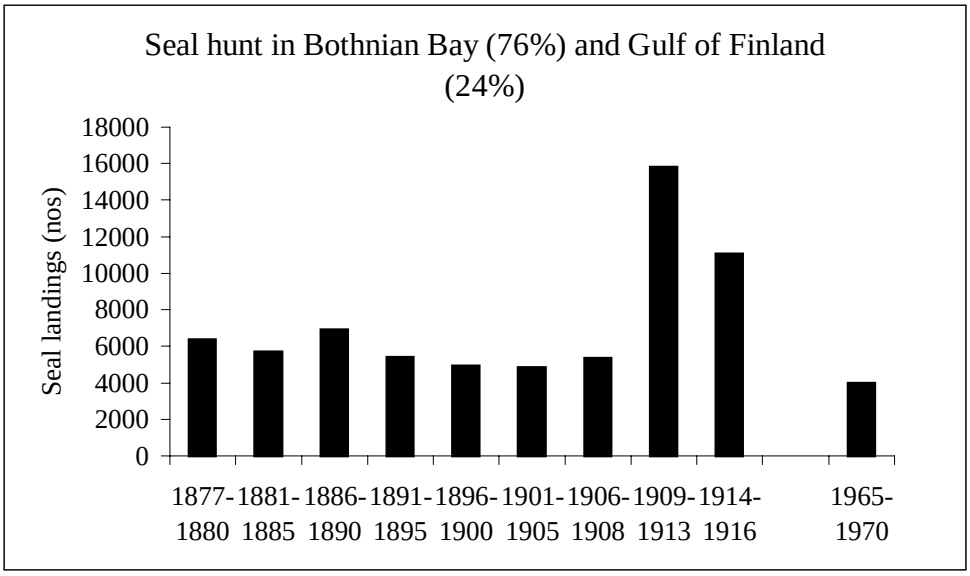

Figure 28. Mean annual catch of seals (grey seal *Halichoerus grypus* and ringed seal *Phoca hispida*) by periods of years in Finland during 1877-1916 and 1965-1970.