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Swedish Baltic Sea fisheries during 1868–1913: Spatio-temporal dynamics of catch and fishing effort

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Abstract

The current paper summarizes catch and effort data for Swedish fisheries in the Baltic Sea prior to the standardized recording of fish catches, evaluates spatial and temporal variations and gives interpretations of selected findings. Long-term datasets (1868–1913) of species having different environmental preferences (and of different origin) – marine, migratory and freshwater – are presented for several Swedish counties extending from the Bothnian Bay to the Bornholm Basin. Herring (*Clupea harengus membras*) was the most important commercial fish-based on landings and also on the amount of historical records available. In addition, herring landings have undoubtedly fluctuated the most. Other commercially important fish were cod (*Gadus morhua*), salmon and trout (*Salmo* spp.), flounder (*Platichthys flesus*), eel (*Anguilla anguilla*) and whitefish (*Coregonus lavaretus*). Different species exhibited different patterns of catch dynamics. In general, the 1880s and the 1890s can be characterized as 'good fishing years' for the Swedish Baltic fisheries: catches of herring and cod were high while fishing effort indices were relatively stable. Sprat was not represented in the catch data and may have been recorded as herring. For several species, regions and time periods, catch–effort relationship exhibited clear coupling. However, in several cases, insufficient or lack of effort-related information hampered data interpretations. In summary, the Swedish fisheries during the late 19th century generally exploited the same species as presently (including a dominance by clupeids), but the relative contributions of individual species have changed.

Keywords: Fisheries history; Baltic Sea; Catch and effort data time-series; Swedish counties; Marine; Migratory and freshwater fish

1. Introduction

Systematic recording of fish landings in the Baltic Sea started in the 1910–1920s. Many of these original source data, for both open sea and coastal fish species at various spatio-temporal scales, have been made available through several scientific papers, reports and Internet websites (e.g., Winkler, 1991; Draganik et al., 1996; Ojaveer, 1999; Sandahl, 2003; Eero et al., 2007; Anon., 2006). However, quantitative knowledge of fisheries history of the Baltic Sea before the official recording of national fisheries statistics is very scarce, and there are no reliable biomass estimates for any fish species in the Baltic Sea before 1966 (ICES, 2006a). As a result it is difficult to provide a complete synthesis of the ecological development of the Baltic Sea, and to document the extent of its modification over long time scales, as has been done for other coastal seas and estuaries (Lotze et al., 2006; Lotze, 2007).

In order to improve understanding of the development of the Baltic fisheries in earlier periods, including documenting the species composition of landings, and quantifying fish catches and their variations in different sub-basins of the Baltic Sea, collaboration has been undertaken between historians and biologists/ecologists since 2001. The overall umbrella of these activities is the Baltic Sea sub-component of the History of Marine Animal Populations Project (HMAP). One of the main activities of HMAP has been to identify and recover historical fisheries data which are a pre-requisite for documenting and interpreting long-term dynamics of Baltic Sea fish populations, and how these populations impacted coastal societies and vice versa.

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In this study, we focus on the Swedish fisheries in the Baltic Sea. The Swedish coastline and its potential coastal fish habitat span almost 10° latitude, which in the Baltic Sea corresponds to strong horizontal variability in both temperature and salinity. As a result, the species composition of fishes exploited by historical fisheries likely includes marine, freshwater and migratory (anadromous and catadromous) species; their relative contribution to the total fishery landings likely varies spatially and temporally. Our archival investigations therefore focused on recovering data for the most important categories of fish living in the Baltic Sea: marine (herring *Clupea harengus membras*, cod *Gadus morhua* and flounder *Platichthys flesus*), migratory (salmon *Salmo* spp., eel *Anguilla anguilla* and whitefish *Coregonus lavaretus*) and freshwater fish (perch *Perca fluviatilis* and pike *Esox lucius*). The Swedish data are disaggregated spatially at county level. The relatively high spatial resolution facilitates latitudinal comparisons of the dynamics of the fisheries (by species) in various sub-areas of the Baltic Sea, i.e. the cold and less saline Bothnian Bay in the north to warmer and more saline Bornholm Basin in the south.

One of our main objectives is to understand the relative roles of fishing and environmental variability on the multi-decadal development of Baltic fish populations during the past 100–150 years. A recent review (Sandahl, 2003) of Swedish historical fisheries (post-1890) concluded that fishing mortality has traditionally been disregarded as a factor that influences fish populations, and that decreases in fish abundance are attributed to environmental changes. However fishing effort increased and technology became more advanced particularly in the late 19th–early 20th centuries (Bagge et al., 1994; Eero et al., 2007; Bager et al., 2007). As a result many Baltic fish populations may have begun to be impacted by fishing in these decades and these impacts may have been large enough to exceed those caused by natural changes in the ecosystem.

The current study, based on original data from historical archives and also national published sources, presents historical Swedish Baltic Sea fisheries data prior to 1914 after which time official fisheries catch statistics become available. Our aim is to quantify, describe and explain the spatio-temporal dynamics of fish catches and effort-related indices.

2. Materials and methods

2.1. Data sources

Statistical records of fisheries are available in the archive of the Royal Academy of Agriculture from 1864 onwards and were collected by a fisheries inspector appointed by the Royal Academy of Agriculture. The inspector collected information on the state of the fisheries (fish landings by species as well as number of vessels, gear and fishermen) during visits to the counties. The statistical material is in many cases scarce, particularly before 1874, and varies between years; most data originate from counties where fisheries were economically important. The Academy summarized and published the collected material in annual reports and journals.

Some of the data gathered by the Academy's fisheries inspector were stored by the Royal Economic Societies. Even though the Economic Societies were mainly interested in agriculture, fisheries were regarded as a subsidiary occupation in agriculture and an increased interest in fisheries can be seen from the mid-19th century. This, however, only occurred in those counties where fisheries were important, e.g. along the south coast of Sweden. During the 1880s those statistical reports became more regular as many Societies hired a special fishery assistant or inspector (Hedlund Nyström, 1982).

Beside journals from the Economic Societies and the Royal Academy of Agriculture, information was found in the Journal of Swedish Fisheries, first published in 1892 as an annual report. One of the editors and the pioneer for the publication of the journal was the fishery inspector at the Royal Academy of Agriculture. In 1883, he published a small booklet on the fisheries in Sweden called *Meddelande rörande Sveriges fiskerier* (Lundberg, 1883) where he presented catch and fishing effort data from 1874 onwards.

An additional data source was the Statistical Abstract of Sweden (SCB), which is kept in the National Archives of Sweden. This source is a statistical reference work which is intended to provide summary statistics on a broad range of conditions and activities in Sweden.

Statistical information was also obtained from several books (e.g., Heden, 1905–1915; Olofsson, 1945; Wachtmeister, 1914). The complete list of data sources used in our study is given in Appendix A.

2.2. Data conversions

Volumetric and weight units used in the fishing industry differ over time. In order to express landings in common units, historical volumetric and weight measurements have been compiled (MacKenzie et al., 2002) and used as conversion factors. However, when collecting additional archival material for the current paper, two additional conversions were established. According to herring processing practices in Västernorrland during the years 1889, 1912, 1913, one-third of the herring was lost by gutting during production of brined herring from fresh herring. We used the same conversion for other years in other counties of Sweden. To convert hectolitres of fresh herring into weight units, we assumed 1 hl of fresh herring weighed 100 kg (Harbitz, 1993; M. Johansen, pers. comm.).

3. Results and discussion

The archival documents confirm that the Swedish fisheries exploited several fish species in the Baltic Sea during the second half of the 19th—early 20th century. The most important marine species were herring, cod and flounder. Eel and salmon were amongst the essential migratory species, both in terms of written records and amount of landings. In addition, limited amount of information was also available for whitefish fishery. Several freshwater fish species (e.g., pike, perch) inhabit the Baltic Sea but are mainly of local importance, and therefore catch data are very limited for these species. Further details are given below.

3.1. Marine fish

There are only a few fish species of marine origin that are commercially important in the Baltic Sea. Three of them – herring, cod and sprat *Sprattus sprattus* – are currently internationally assessed and managed. Herring is probably the fish species the best adapted to environmental heterogeneity of the Baltic Sea because it can survive and reproduce in nearly freshwater conditions in river estuaries and forms several distinct local populations (Jørgensen et al., 2005; Ojaveer and Kalejs, 2005). Shorter or longer catch time-series for this species are available in 10 counties from the northernmost (Norrbotten) to southernmost (Malmöhus) county (Fig. 1) starting from 1868 in Blekinge. Total landings in the Baltic (with potential contribution of unidentified catch proportion in the Øresund by fishermen from Kristianstad) reached 137,000 tonnes in the early 1880s. Herring landings show large fluctuations within and between counties, ranging annually from less than 100 kg in Norrbotten and Kalmar counties to ca. 130,000 tonnes in Blekinge county in 1882 (Fig. 2). The mean catch per unit effort for herring was over 40 times higher in Blekinge than in more northerly counties (e.g., Västernorrland, Gävleborg) indicating relatively high herring stock size in the southern Baltic Sea at these times, and specifically in the period of the 1880–1990s. After this period, both CPUE and catch values were generally lower (Fig. 2). However, landings in the northern Baltic Sea (Västernorrland and Gävleborg) showed an increasing tendency during the 1900s. Notably, both herring landings and CPUE were higher in Västernorrland and Gävleborg counties (Bothnian Sea) than at Gotland Island (Baltic Proper).

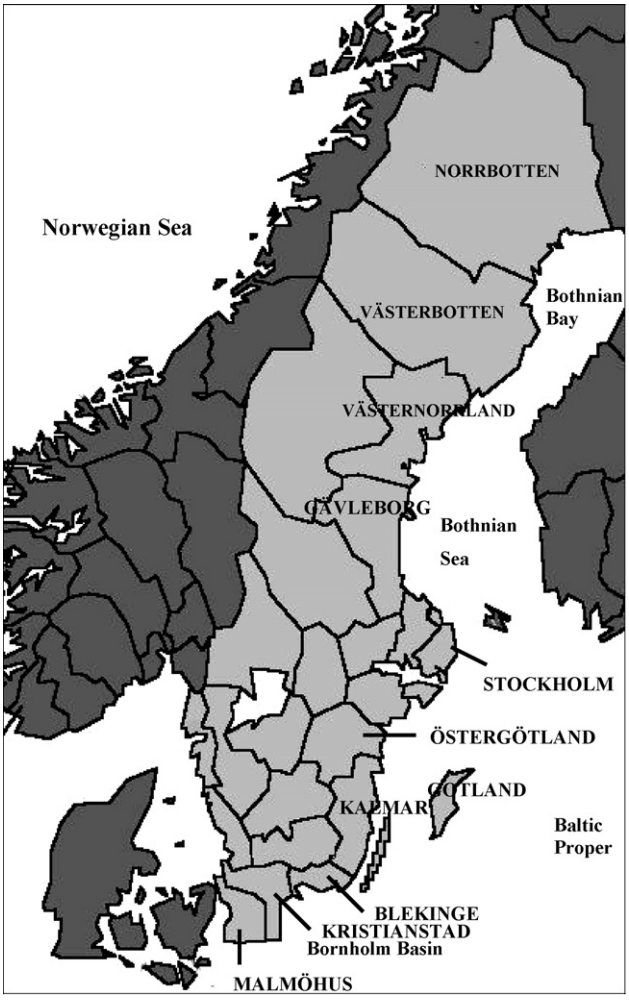

Fig. 1. Map of Sweden with location and names of counties.

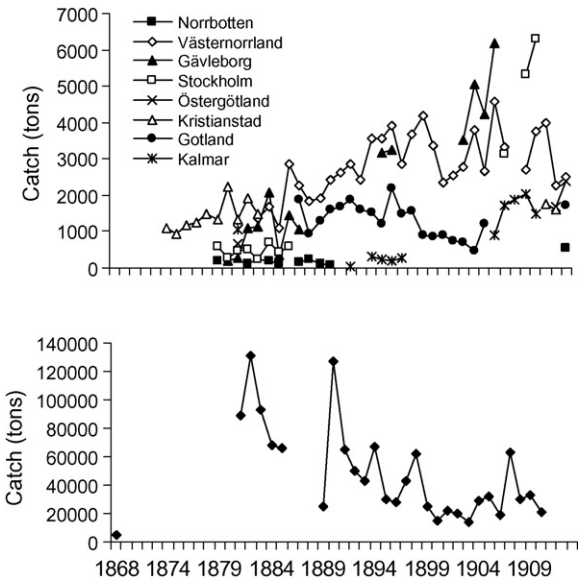

Fig. 2. Catch of herring, *Clupea harengus membras*, by Swedish counties from the Baltic Sea during 1868–1913. Lower panel—landings from Blekinge county.

The most comprehensive data related to fishing effort are available for herring. In Blekinge where the majority of the herring catch was taken, both the number of fishermen and nets exhibit ca. twofold decline during 1875–1910 whereas the number of boats declined slightly and the number of seines was stable (Fig. 3). All this corresponds to a substantial decline in herring catches: significant correlations were found between herring catch and all available effort-related parameters: r^2 was 0.56, 0.61 and 0.46 ($p < 0.01$) for fishermen, boats and nets, respectively. The long-term decrease in both catch and effort in the most important Swedish Baltic Sea fishery (i.e., Blekinge), while CPUE remained high, may be due to increased supply of North Sea herring, as has been demonstrated for Russia, Poland and Germany (Coull, 1996) or alternatively, consumption of Bohuslän herring as the last major herring fishery at Bohuslän (western Sweden) occurred during 1877–1906 (Alheit and Hagen, 1997 and references therein). Performance of Danish herring fishery at Bornholm Island during this period is described elsewhere (Bager et al., 2007). In Gävleborg, fishing effort did not show clear trends except a decline in number of full-time fishermen over time (1880–1906) whereas in Västernorrland, the number of fishermen, boats and various gears used decreased during 1886–1910 (Fig. 3). However, this decrease is slower than that seen in Blekinge. In general, the number of boats seems to be a more conservative measure than other effort-related variables in this study (i.e., number of fishermen and various gears used). Despite different types of fishing gears recorded in the statistics (especially for nets), it seems that

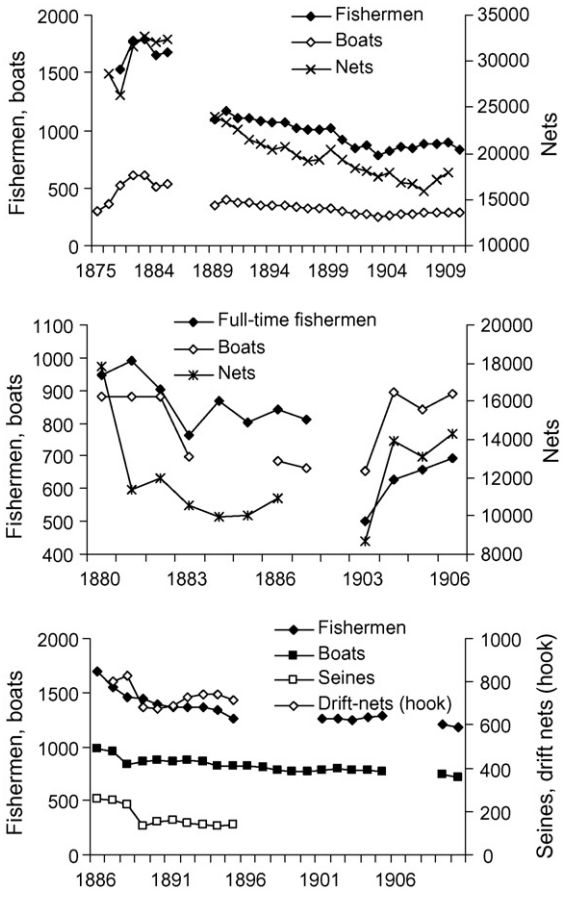

Fig. 3. Dynamics of the number of fishermen, boats and various fishing gears in herring fishery in three Swedish counties: upper panel Blekinge; intermediate panel Gävleborg; lower panel Västernorrland.

the number of fishing gears employed was higher in the south (Blekinge) than in the north (Västernorrland). There tends to be more fishermen and boats in the north (Västernorrland) than in the south (Blekinge). Seines were more important fishing gears in the north than in the south. When comparing trends in landings and effort-related data it is evident that changes in effort explain significant amounts of variation the catch dynamics in some counties: in addition to Blekinge (see above), relatively strong and significant correlation was established for the number of fishermen and herring catch in Gävleborg ($r^2 = 0.57$, $p < 0.01$). However catch–effort relationships between all the other available effort time-series to catch was weak and insignificant.

The Swedish archives we have investigated for the Baltic contain no information on sprat, even though this species is presently one of the most abundant species in the Baltic Sea. In some areas of Sweden (likely also during the time period of our archival study), it was believed that there were two kinds of herring: the large herring (*Clupea harengus*) and the small herring (*Sprattus sprattus*) and that the two size groups belonged to the same species (Malm, 1860; Yhlen, 1867 cited in Sandahl, 2003). As a result some of the herring landings may include an unknown and variable proportion of sprat; if this is true it is not possible to allocate the historical catches to the different species. The uncertainty of the species composition of pelagic fish catches in the Baltic Sea still exists and leads to uncertainty in contemporary stock assessments for herring and sprat in the Baltic Sea (ICES, 2006a). However, other historical fishery records for the west coast of Sweden (Bohuslän county, near Gothenburg) include sprat, which was a commercially very important species from at least the mid-late 19th century and onwards (Lindquist, 1964). The absence of sprat from Swedish Baltic archives could therefore represent a real lack of landings of this species by Swedish fishermen during this time period. This possibility seems unlikely because sprat was mentioned as a commercially important species in several localities in the NE Baltic Sea in the mid-19th century (J. Lajus, pers. comm.). However, although the archival material from other Baltic countries confirms that both herring and sprat were caught in the same locality, it cannot be excluded that under 'sprat' small herring was still considered (E. Tammiksaar, pers. comm.). In conclusion it is not presently possible to confirm whether Swedish fishermen did not catch sprat, or whether the Baltic sprat landed by Swedish fishermen was recorded by local inspectors as herring (apparently in contrast to the fishery reporting procedure on the west coast of Sweden).

There are two cod stocks in the Baltic Sea: western Baltic cod in ICES sub-divisions 22–24 and eastern Baltic cod in ICES sub-divisions 25–32. The borderline between these stocks is located just west of Bornholm (Bagge et al., 1994). Reproduction areas of the eastern cod stock are confined to the southern Baltic Sea, due to oxygen and salinity requirements for successful fertilization and egg development (Vallin et al., 1999). When cod biomass is high, the horizontal distribution expands to the northern Baltic Proper and penetrates the large gulfs in the northeastern Baltic (Bagge et al., 1994; Aro, 2002). Cod fishery data are available for six southerly counties starting from 1868 (Kalmar county). Thus, information for the cod fishery is more spatially restricted than for the herring. The total annual cod catch calculated on the basis of the data available was at most ca. 2100 tonnes with generally higher levels in the 1880s and 1890s (Fig. 4). Both cod catches and catch fluctuations were notably lower than those of herring. Highest catches over time were taken in two southern and southeastern counties—Blekinge and Gotland whereas cod catches were very low in some nearby counties (i.e., Kristianstad and Kalmar). Longer cod landing time-series from Blekinge and Gotland counties indicate a general decrease in landings after the relatively high values in

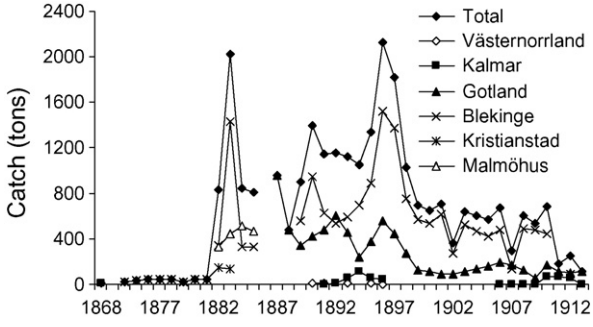

Fig. 4. Catch of cod, *Gadus morhua callarias*, in Swedish counties from the Baltic Sea during 1868–1913.

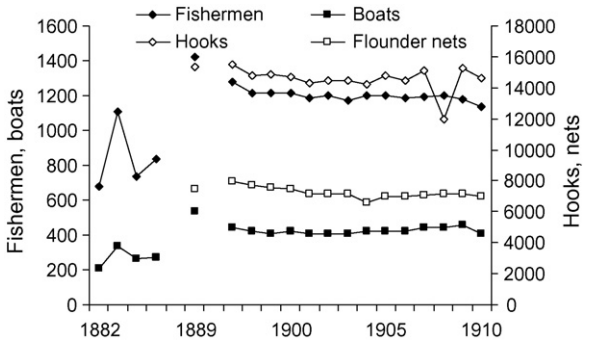

Fig. 5. Dynamics of the number of fishermen, boats and various fishing gears in cod fishery in Blekinge county during 1882–1910.

the 1880s and 1890s (Fig. 4). This temporal pattern is similar to that seen for herring. Cod landings were higher in the south than the north (Västernorrland). Effort-related data (number of fishermen, boats, hooks and nets) are available only for Blekinge county for years 1882–1910. The numbers of fishermen and "flounder nets" used in cod fisheries have generally decreased, whereas the numbers of boats and hooks fluctuated without trend. The decline in both fishermen and 'flounder nets' coincided with the decline in cod catches ($r^2 = 0.73$ and 0.51, respectively; $p < 0.01$); catches varied independently of the number of boats and hooks (Fig. 5).

Flounder was another common species landed by Swedish fishermen but it was economically less important than herring or cod. Catch statistics for flounder are available only for three southeastern and southern counties (Gotland, Kalmar and Blekinge) starting from 1883 in Blekinge. Flounder landings reached 440 tonnes and annual catch dynamics do not show clear trends as was apparent for herring and cod. Catches of flounder were notably smaller than for cod and herring. Long-term catch trends in the three countries are not unidirectional because there was an increase in Kalmar and Gotland counties but a decrease in Blekinge. Similar to herring and cod, the highest landings of flounder occurred in Blekinge county (Fig. 6). Although the number of "flounder nets" registered under and used for the cod fishery is available (Fig. 5), no reliable effort-related data is available for Swedish flounder fishery in the Baltic Sea: these "flounder nets" probably had a different design from the cod nets but whether and to which extent they were also used in flounder fisheries remains unknown.

3.2. Migratory fish

Baltic salmon spawn in rivers draining to the Baltic Sea and this group of populations (i.e., those spawning in rivers east of 13°E) is assessed and managed internationally (ICES, 1979, 2006b). Historically, Baltic salmon stocks started to decline in the mid-19th century when German salmon begun to disappear. This decrease has been especially fast since 1940 where there was a rapid hydroelectric power production and most of Swedish rivers were dammed. In addition, pollution and M74 syndrome have contributed to further decline of salmon stocks. Prior these serious human interventions, salmon spawned in 60–70 rivers, 40 of which were Swedish rivers flowing into the Gulf of Bothnia (Karlsson and Karlström, 1994). To start compensating for the loss of natural populations (ca. 20-fold decrease since the beginning of the 20th century) stocking of alevins was initiated as early as the 1860s and the first smolt releases were made ca. 1950 (Karlsson and Karlström, 1994). Currently the majority of catches is based on survival of artificially released salmon.

Until the end of the 19th century, salmon were mainly caught while ascending rivers to spawning areas and also in the open Baltic Sea; offshore drift gillnet fishing for salmon in feeding areas intensified remarkably after the 1940s (Karlsson and Karlström, 1994). The original archival catch records presented in this study – since the 1870s in Kristianstad and Blekinge counties and since the late 1880s in Västernorrland county – suggest a substantial decline of salmon catches in all three counties (Fig. 7). In Blekinge and Västernorrland, which contain major spawning rivers for Baltic salmon, and therefore play an important role in the salmon fishery in Sweden, the decrease in catches between the 1880–1890s and the 1900–1910s was on average fourfold. However, 'salmon' may have been used not only for *Salmo salar* but also for trout *Salmo trutta* in historical documents (K. Awebro, unpubl. data). Therefore, it is impossible to make reliable differentiation between these two species in historical catch records.

Eel, whose stock size in the Baltic Sea is based on immigration from reproduction areas in the Sargasso Sea, has been the subject of targeted fisheries in the Baltic Sea region at least already from the Neolithic period (Lõugas, 1999). Eel landings data allow establishment of long-term time-series for five counties in southeastern and southern Sweden (Gävleborg, Gotland, Kalmar, Blekinge, Kristianstad and Malmöhus). In addition, some data for individual years ("snapshot" data) are available

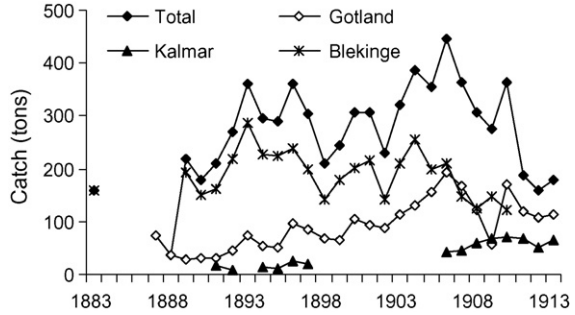

Fig. 6. Catch of flounder, *Platichthys flesus*, in Swedish counties from the Baltic Sea during 1883–1913.

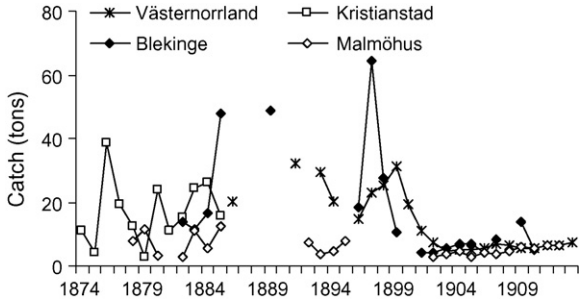

Fig. 7. Catch of salmon, *Salmo salar*, in four Swedish counties from the Baltic Sea during 1874–1913.

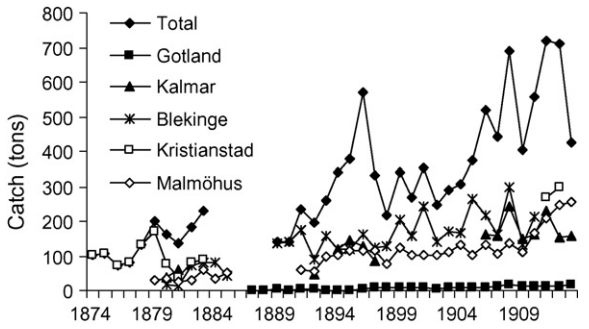

Fig. 8. Catch of eel, *Anguilla anguilla*, in Swedish counties from the Baltic Sea during 1874–1913.

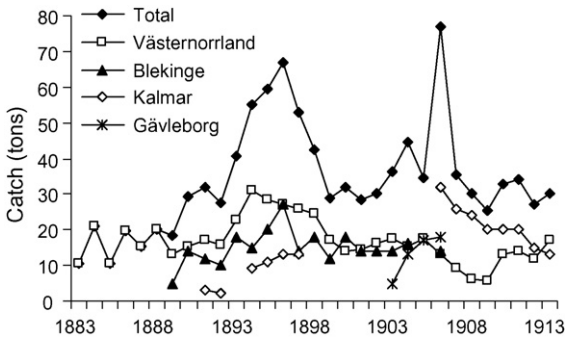

Fig. 10. Catch of whitefish, *Coregonus lavaretus*, in Swedish counties from the Baltic Sea during 1883–1913.

from northern counties (Västernorrland and Gävleborg). The total catch in these counties shows a clear increasing trend over the period studied with the highest catch of over 700 tonnes taken during 1911–1912 (Fig. 8). In all counties in the southeast and south, eel landings clearly show an increasing trend and in most cases, eel catches are substantially higher in the south and southeast than in the open (Gotland) and northen Baltic (Gävleborg). Fishing effort-related information is available for two southern counties—Blekinge (1880–1910) and Kristianstad (1874–1883). Traps and spears were used in eel fisheries, and the number of traps used exceeded that of spears in all years we have data for. The use of spears was prohibited in the 20th century. While the number of fishermen and boats was relatively stable over time, the number of fishing gears, and especially of traps, increased substantially in Blekinge (Fig. 9). All the catch–effort relationships were statistically significant (r^2 was 0.43, 0.28, 0.60 and 0.37, respectively for fishermen, boats, traps and spears; $p < 0.05$).

European eel catches in the Baltic Sea have exhibited a continuous decrease since 1955 (HELCOM, 2002); presently the species is severely depleted and qualifies for the IUCN Red List of Endangered Species (ICES, 2006c). The reasons for the low stock status include exploitation, barriers to migration (e.g., dams, intakes and turbines), disease and parasites. A recent proposal for eel management policy includes a recovery plan with low fishing quotas and other restrictions (ICES, 2006c). If this policy was implemented and environmental conditions (e.g. access to high quality river habitats) were improved, populations could potentially recover in the coming decades.

In the Baltic Sea, the European whitefish is represented by three forms: the sparsely rakered sea-spawning whitefish, the sparsely rakered anadromous whitefish and the higher raker count whitefish of the eastern Baltic Sea (Sõrmus and Turovski, 2003). The largest sea-spawning whitefish populations inhabit the Gulf of Bothnia (Lehtonen, 1981). Long-term data series for the whitefish catches are available for three counties (Blekinge, Kalmar and Västernorrland) and fragmentary data exist for three northern counties (Norrbotten, Västerbotten and Gävleborg). The data series for 1883–1913 suggests an increase in catches until the mid-1890s, when total annual landings were ca. 60 tonnes, and a decline afterwards (Fig. 10). Except for a single catch estimate for Norrbotten county (ca. 80 tonnes), annual landings by counties are low and rarely exceed 35 tonnes. A few available landing figures for the two northernmost counties (Norrbotten and Västerbotten) indicate that whitefish catches are likely substantially higher in the north than in other counties and therefore, the total annual landings might be substantially underestimated. Ten-year dynamics of fishing effort-related data indicates ca. threefold increase of the number of fishermen and boats in Västernorrland (from 1886 to the early 1890s) and a slight decline afterwards while the number of gears remained relatively stable (Fig. 11). The general increase in whitefish catches in this county until the mid-1890s was probably due to increasing fishing effort (r^2 between catch and the number of big fykes and seines 0.77 and 0.68, respectively, $p < 0.01$), and was likely too high to be biologically sustainable. However, effort data are not available for later years, and in some areas, when available, are given jointly for perch, pike and whitefish

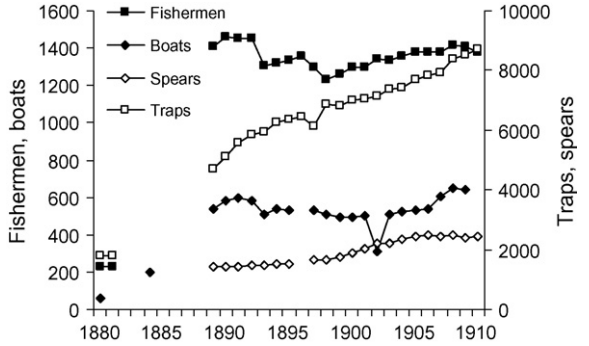

Fig. 9. Dynamics of the number of fishermen, boats and various fishing gears in eel fishery in Blekinge county during 1880–1910.

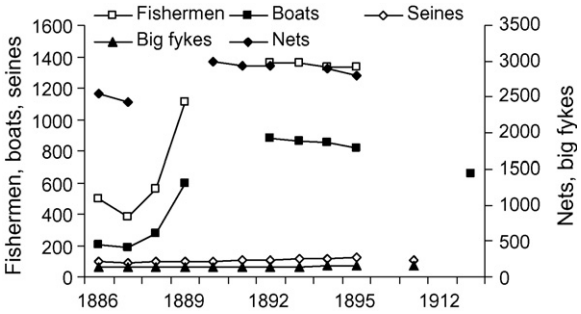

Fig. 11. Dynamics of the number of fishermen, boats and various fishing gears in whitefish fishery in Västernorrland county during 1886–1913.

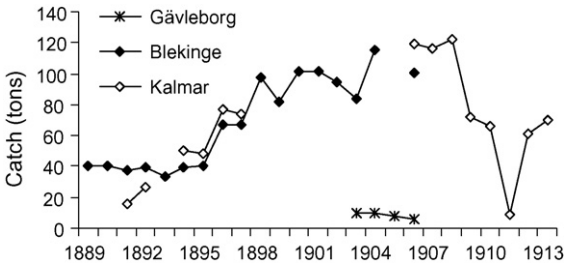

Fig. 12. Catch of pike, *Esox lucius*, in three Swedish counties from the Baltic Sea during 1889–1913.

fisheries (e.g., Blekinge). As a result, the influence of fishing effort on whitefish landings is difficult to quantify reliably.

3.3. Freshwater fish

In the archival documents, fish landing data from marine and freshwater environments were kept separately. Thus, all the catch data for freshwater fish included in the current study originate solely from catches made in the Baltic Sea (i.e., catches from Swedish rivers and lakes are excluded). Freshwater fish inhabit the Baltic Sea mainly in coastal areas, and their importance in the total Baltic fisheries is low (the share of landings by all fish species other than herring, sprat and cod in the Baltic marine area is <10% of landed biomass; HELCOM, 2002) but socio-economically important at regional scale. All freshwater fish are managed nationally or locally in the Baltic Sea. There exist several recently completed or ongoing research and assessment activities at various levels (e.g., Adjers et al., 2001; HELCOM, 2006; ICES, 2005, 2006d) which form scientific basis for management advice.

For Swedish fisheries during the given time period, catch and effort-related data are rather limited: some data are available for pike and perch. The catch data for pike in Blekinge, Kalmar and Gävleborg counties for 1889–1913 suggest that total catch increased until the end of the 1910s with one single very high catch peak (226 tonnes in 1906) but all other annual landings remained below 150 tonnes. The limited data also suggest that pike landings were higher in the south (warmer but more saline conditions) than in the north (colder, but less saline water) (Fig. 12). Effort data are too fragmental to evaluate trends or data variability at annual scale.

Perch landings time-series were established for Kalmar and Blekinge for 1889–1913 and snapshot data exist after 1901 for Västerbotten, Gävleborg and Malmöhus. Total catch exceeded 150 tonnes only once (1894). After high values in the 1890s and early 1900s, catches declined afterwards. The spatial pattern of perch catches indicate that more saline conditions in the south-west and harsh climate regions in the north (i.e., Malmöhus and Gävleborg) are characterized by lower catches than intermediate regions; the difference in landings between the extreme and intermediate counties may be as high as two orders of magnitude (Fig. 13).

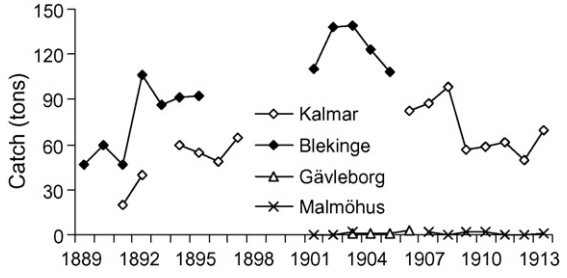

Fig. 13. Catch of perch, *Perca fluviatilis*, in four Swedish counties from the Baltic Sea during 1889–1913.

4. Conclusion

Our historical fisheries investigations have identified and recovered several new catch and effort data series for the Swedish Baltic fisheries extending from the northernmost to the southernmost regions. These data have revealed the species composition and magnitude of landings, as well as the development of fishing effort and use of various gears. Landings were dominated (in biomass) by herring (possibly including an unknown proportion of sprat), cod and flounder. Migratory and freshwater species comprise smaller proportions of total landings. Salmon and eel landings were much higher than in the early 2000s, and wild populations of these species in the Baltic are presently very low. Our comparison of historical catch and effort data shows that for several species, counties and time periods, landings significantly co-varied with effort indicators, but that in other circumstances this coupling was absent or impossible to evaluate because of limited availability of effort-related data. Whether the fishing effort was sufficient to affect local abundances of the different species is however unclear, and would require additional data (e.g., catch and effort data for other areas of the Baltic which are occupied by individual populations and species) and analysis. These data demonstrate potential levels of historical abundance and baselines for population recovery, and allow geographic comparison of the importance of fisheries in the Baltic (e.g., for herring and cod) with fisheries in other areas (e.g., Bohuslän in western Sweden, Limfjord in Denmark and the North Sea).

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Appendix A

List of sources used

1. *Archives: National Archive of Sweden*
   - Kungliga Lantbruksstyrelsen: 420163.02 Kungl. Lantbruksstyrelsens fiskeribyrå med föregångare. HIb Fiskeristatistik, olika slag av fisken.
   - Bidrag till Sveriges officiella statistik. Kungl maj: ts befallninghavfande femårsberättelser: jemte sammandrag 1856/1860, 1863–1912. Stockholm 1863–1912.
2. *Journals and Annuals*
   - Blekinge läns kungliga hushållningssällskaps tidskrift. Karlskrona 1867–1914.
   - Ekonomisk quartalskrift för Blekinge län. Karlskrona 1852–1865.
   - Gotlands läns kungliga hushållningssällskaps verksamhet. Visby 1834–1902.
   - Gävleborgs läns kungliga hushållningssällskaps tidskrift. Gävle 1861–1887.
   - Gävleborgs läns kungliga hushållningssällskaps handlingar. Gävle 1888–1902.
   - Kalmar läns södra kungliga hushållningssällskaps tidning. Kalmar 1839–1841.
   - Kalmar läns södra kungliga hushållningssällskaps handlingar. Kalmar 1842, 1858, 1873–1897.
   - Kalmar läns södra kungliga hushållningssällskaps periodiska skrift. Kalmar 1869–1914.
   - Kristiansstads läns kungliga hushållningssällskaps förhandlingar. Kristianstad 1860–1885.
   - Malmöhus läns kungliga hushållningssällskaps handlingar. Malmö 1868–1870.
   - Malmöhus läns kungliga hushållningssällskaps kvartalskrift. Malmö 1972–1914.
   - Stockholms läns kungliga hushållningssällskaps handlingar. Stockholm 1858–1864.
   - Stockholms läns kungliga hushållningssällskaps tidning. Norrtälje 1875–1914.
   - Uppsala läns kungliga hushållningssällskaps handlingar. Luleå 1861–1889.
   - Västerbottens läns kungliga hushållningssällskaps tidskrift. Umeå 1866–1889.
   - Västerbottens läns kungliga hushållningssällskaps handlingar. Umeå 1911–1913.
   - Västernorrlands läns kungliga hushållningssällskaps handlingar. Härnösand 1850–1866.
   - Kungliga Lantbruksakademiens tidskrift. Stockholm 1862–1876.
   - Kungliga Lantbruksakademiens handlingar och tidskrifter. Stockholm 1877–1914.
   - Svensk fiskeritidskrift. No. 1 (1892)–23 (1914).
3. *Published sources* (*incl. books*)
   - Anon., 1915–1916, Uppsala läns kungliga hushållningssällskap 1815–1915. Uppsala.
   - Anon., 1939, Kristianstads läns kungliga hushållningssällskap 125 år. Kristianstad.
   - Bring, S., 1947, Stockholms läns och stad hushållningssällskap 1847–1947. Stockholm.
   - Hellström, P., 1902, Norrbottens läns hushållningssällskaps femtioårsberättelse för 1850–1900. Luleå.
   - Hilldoft, E., 1911, Kalmar läns södra kungliga hushållningssällskap 1811–1911. Kort historik. Kalmar.
   - Ihre, M. F., 1841, Berättelse om Gotlands läns nu femtioåriga hushållningssällskap. Visby.
   - Johnsson, P., 1930, Kristianstads läns hushållningssällskaps historia. Lund.
   - Norbottens läns hushållningssällskap 1850–1950. Minnesskrift, 1950, ed. Wanhainen, Anjou, Arwidsson. Luleå 1950.
   - Sprinchorn, C.K.S., 1922, Malmöhus läns hushållningssällskaps historia. Lund.
   - Stjernquist, O., 1897, Stockholms läns hushållningssällskaps verksamhet 1847–1896. Arkivstudier. Stockholm.

References

Adjers, K., Appelberg, M., Eschbaum, R., Lappalainen, A., Lozys, L., 2001. Coastal Fish Monitoring in Baltic Reference Areas 2000. Kala- ja Riistaraportteja no. 229. Finnish Game and Fisheries Research Institute, Helsinki, p. 15.

Alheit, J., Hagen, E., 1997. Long-term climatic forcing of European herring and sardine populations. Fish. Oceanogr. 6 (2), 130–139.

Anon., 2006. http://www.seaaroundus.org. Sea Around US Project (visited 30.11.2006).

Aro, E., 2002. Fish migration studies in the Baltic Sea—a historical review. ICES Mar. Sci. Symp. 215, 361–370.

Bager, M., Søndergaard, M.K., MacKenzie, B.R., 2007. The development of fisheries at Bornholm, Denmark (Baltic Sea) during 1880s–1914. Fish. Res. 87, 146–154.

Bagge, O., Thurow, F., Steffensen, E., Bay, J., 1994. The Baltic cod. Dana 10, 2–28.

Coull, J.R., 1996. The Sea Fisheries of Scotland. A Historical Geography. John Donald Publishers, Glasgow.

Draganik, B., Maksimov, Yu., Kuczynski, J., Dlugosz, R., Milosz, J., 1996. Harvesting turbot (*Psetta maxima* (L.)) in the Polish and Lithuanian fisheries zones. ICES CM 1996/J:31.

Eero, M., MacKenzie, B.R., Karlsdottir, H.M., Gaumiga, R., 2007. Development of international fisheries for the eastern Baltic cod (*Gadus morhua*) in the eastern Baltic Sea from the late 1880s until 1938. Fish. Res. 87, 155–166.

Harbitz, G.P., 1993. Fra havets sølv til kystens gull. Norsk sildemelsindustri, Oslo, pp. 1884–1990.

Heden, J.A., 1905–1915. Västernorrlands läns kungliga hushållningssällskap, Stockholm, pp. 1805–1904.

Hedlund Nyström, T., 1982. Svenskt havsfiske. En bibliografi. Del 1, Lund.

HELCOM, 2002. Environment of the Baltic Sea area 1994–1998. In: Baltic Sea Environment Proceedings, No. 82.B.

HELCOM, 2006. Assessment of coastal fish in the Baltic Sea. In: Baltic Sea Environment Proceedings, No. 103A.

ICES, 1979. Review of Baltic salmon research. In: Christensen, O., Larsson, P.O. (Eds.), ICES Cooperative Research Report 89, 124 pp.

ICES, 2005. Report of the study group on Baltic fish and fisheries issues in the BSRP, June 9–13, 2005, Riga, ICES CM 2005/H:05.

ICES, 2006a. Report of the Baltic fisheries assessment working group, April 18–27, 2006, Rostock, ICES CM 2006/ACFM:24.

ICES, 2006b. Report of the Baltic salmon and trout assessment working group, 29 March–6 April, 2006. ICES CM 2006/ACFM:21.

ICES, 2006c. Report of the ICES/EIFAC working group on eels, January 23–27, 2006, Rome, ICES CM 2006/ACFM:16.

ICES, 2006d. Report of the study group on Baltic fish and fisheries issues in the BSRP, February 20–23, Vilnius, ICES CM 2006/BCC:03.

Jørgensen, H.B.H., Hansen, M.M., Bekkevold, D., Ruzzante, D.E., Loeschcke, V., 2005. Marine landscapes and population genetic structure of herring (*Clupea harengus* L.) in the Baltic Sea. Mol. Ecol. 14, 3219–3234.

Karlsson, L., Karlström, Ö., 1994. The Baltic salmon (*Salmo salar* L.): its history, present situation and future. Dana 10, 61–85.

Lehtonen, H., 1981. Biology and stock assessments of coregonids by the Baltic coast of Finland. Finnish Fish. Res. 3, 31–83.

Lindquist, A., 1964. Zur fischereihydrographie der sprotte (*Clupea sprattus*) an der schwedischen Westküste. Inst. Mar. Res. Lysekil, Ser. Biol. No.15.

Lotze, H., 2007. Rise and fall of fishing and marine resource use in the Wadden Sea, southern North Sea. Fish. Res. 87, 208–218.

Lotze, H.K., Lenihan, H.S., Bourque, B.J., Bradbury, R.H., Cooke, R.G., Kay, M.C., Kidwell, S.M., Kirby, M.X., Peterson, C.H., Jackson, J.B.C., 2006. Depletion, degradation, and recovery potential of estuaries and coastal seas. Science 312, 1806–1809.

Lõugas, L., 1999. Postglacial development of fish and seal faunas in the Eastern Baltic water systems. In: Benecke, N. (Ed.), The Holocene history of the European vertebrate fauna: modern aspects of research. Arhäologie in Eurasien. Band 6. Deutsches Archäologisches Institut, Eurasien Abteilung, pp. 185–200.

Lundberg, N.R., 1883. Meddelande rörande Sveriges fiskerier, Stockholm, 1883–1888.

MacKenzie, B.R., Awebro, K., Bager, M., Holm, P., Lajus, J., Must, A., Ojaveer, H., Poulsen, B., Uzars, D., 2002. Baltic Sea fisheries in previous centuries: Development of catch data series and preliminary interpretations of causes of fluctuations. ICES CM 2002/L:02.

Malm, A. H., 1860. Berättelse om Bohus läns hafsfiske 1859.

Ojaveer, E., Kalejs, M., 2005. The impact of climate change on the adaptation of marine fish in the Baltic Sea. ICES J. Mar. Sci. 62, 1492–1500.

Ojaveer, H., 1999. Exploitation of biological resources of the Baltic Sea by Estonia in 1928–1995. Limnologica 29, 224–226.

Olofsson, A.G., 1945. Gotlands läns hushållningssällskap. Minnesskrift, Uppsala, pp. 1791–1941.

Sandahl, A., 2003. A historic perspective on Swedish fisheries—was everything better before? Examensarbete 2003:10 Institutionen för Systemekologi, Stockholms Universitet.

Sõrmus, I., Turovski, A., 2003. European whitefish, *Coregonus lavaretus* (L.) s.l., Baltic Sea forms. In: Ojaveer, E., Pihu, E., Saat, T. (Eds.), Fishes of Estonia. Estonian Academy Publishers, Tallinn, pp. 121–130.

Vallin, L., Nissling, A., Westin, L., 1999. Potential factors influencing reproductive success of Baltic cod, Gadus morhua: a review. Ambio 28, 92–99.

Wachtmeister, H., 1914, Blekinge läns kungliga hushållningssällskaps historia 1814–1914, Karlskrona.

Winkler, H., 1991. Changes of structure and stock in exploited fish communities in estuaries of the southern Baltic coast (Meckelnburg-Vorpommern, Germany). Int. Revue Hydrobiol. 76, 413–422.

Yhlen, G.V., 1867, Bohusläns hafsfiske 1866, Lysekil.