SWEDEN'S FISHERIES CATCHES IN THE BALTIC SEA (1950-2007)[1]

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ABSTRACT

A catch data reconstruction for Swedish fisheries in the Baltic Sea, from 1950-2007, was undertaken, which estimated IUU catches, including unreported landings, discards, and recreational catches. These IUU catch estimates were added to a reported data foundation based on the officially reported landings as presented by the International Council for Exploration of the Sea (ICES) on behalf of the Swedish government. The total estimated reconstructed Swedish catch in the Baltic Sea for the 1950-2007 time period was 31% larger than the officially reported landings, and peaked in 1998 at 390,000 t. The total estimated IUU catch consisted of 1.09 million t unreported landings, 0.52 million t discards, and 0.63 million t of recreational catches.

INTRODUCTION

Fisheries have a heavy impact on processes within marine ecosystems. The extraction of fish has a direct impact through the removal of biomass, and indirectly affects the ecosystem by altering conditions within the food web (Botsford *et al.*, 1997; Pauly *et al.*, 2000). Thus, in order to foster a better understanding and foundation for ecosystem-based resource management, knowledge of total fisheries removals is important.

There are several components of fisheries catch that are often not recorded, but affect fish mortality rates. Illegal, Unreported and Unregulated (IUU; Bray, 2000) catches, including discards, unreported landings and recreational catches all contribute to the under-estimation of catches. The *Sea Around Us* Project at the Fisheries Centre, University of British Columbia (www.seaaroundus.org), has developed a method for catch reconstruction which aims to account for IUU catches through estimation approaches (e.g., Zeller *et al.,* 2007; Zeller and Pauly, 2007). Depending on the data and knowledge available, more or less of the estimation has to be based on interpolations between assumption-, and information-based 'anchor points' (Zeller *et al.,* 2006). To justify the uncertainty around such estimates, one has to consider the alternative which usually implies an interpretation of zero catch when no reported data are available (Zeller *et al.* 2006). In statistical terminology the assumption that all IUU components are zero is 'precise' but not 'accurate'. In contrast, a clearly described method developed to fill in knowledge gaps using anchor points, and assumption-based approaches can be used to construct a conservative estimate of such IUU components, which is more 'accurate' (i.e., closer to the true value), although possibly less statistically 'precise', than zero.

In the Baltic Sea, the annual reported landings of cod declined in the beginning of the 1990s after a previous tenfold increase since the 1930s (Thulin and Andrushaitis, 2003). For many years, the European Union (EU) has set quotas higher than the International Council for the Exploration of the Sea (ICES) has recommended (Lövin, 2007). ICES recommendations are based on formal stock assessments which endeavor to keep exploited population sizes within safe biological limits. Since 1993, ICES includes an estimate of unallocated catches (here assumed to represent unreported landings), plus discards, to the number they base their recommendation on (ICES, 2007a). The estimates are based on numbers that

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stock assessment working group members from the different countries present in the stock assessment working group for their countries' unallocated catches (Y. Walther, pers. comm., Swedish Board of Fisheries; H. Degel, pers. comm., DTU Aqua). The numbers are presented in the stock assessment working group reports as a total for the stock in the Baltic Sea so that a particular country's contribution (or lack of data) cannot be identified (ICES, 2008a). For example, due to current lack of hard data, Sweden decided not to report any unallocated catches to the working group (Y. Walther, pers. comm., Swedish Board of Fisheries). Therefore, the total unallocated catches reported in tables in the working group reports do not contain Swedish unallocated catches. Hence, when the modeling of the stock is done to prepare material for stock assessments, Sweden's unreported catches are modeled as zero (Y. Walther, pers. comm., Swedish Board of Fisheries).

When striving for sustainable management, it should be obvious to base recommendations on numbers of all fish that are removed from the population each year. It does not matter if the fish are reported or not, it will still be dead, and not be part of the population and ecosystem from which it came, hence, even an approximate estimate for Swedish unallocated catch is better than zero, as it would be more accurate. The purpose of this study was to contribute to a better understanding of the fish stocks in the Baltic Sea by reconstructing Sweden's total fisheries catches from 1950-2007. It is hoped that this work will improve management's attempts to set sustainable catch levels, and it also aims to highlight the importance of unaccounted components of the total catch. The catch reconstruction considers and conservatively estimates unreported landings, as well as discards and recreational catches, and starts at 1950 to avoid faulty interpretations of the results due to natural fluctuations, as well as to provide a more comprehensive historic baseline understanding with respect to present and future impacts and uses. Officially reported landings data, here taken as the publicly available ICES catch data by species, area and year (ICES, 2009), and referred to as 'ICES landings statistics', were adjusted with Swedish national landings data, and ICES stock assessment working group reports, to create the best estimate of commercial landings. The estimated commercial landings, referred to as 'ICES landings statistics + adjustments' formed the reported data foundation to which estimated unreported landings, discards, and recreational catches were added to reconstruct estimates of Sweden's total catch from 1950 to 2007. A key point of the approached used here was that if information on unreported landings, discards, or recreational catch was not available, conservative estimates were made throughout the time period considered here for all of Sweden. The commonly used reason for not doing so, i.e., the unavailability of 'hard' data, was not acceptable, as otherwise it would mean the continued assumption of 'zero' catch for this component of the catch.

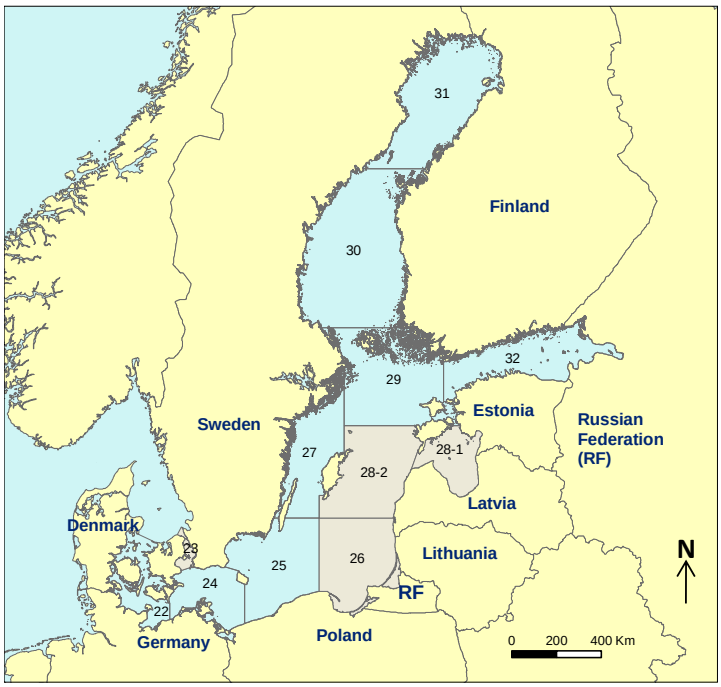

Figure 1. Map of the Baltic Sea with ICES subdivisions and surrounding countries. Sweden's coastline borders ICES subdivisions 23-25, 27 and 29-31.

Swedish fisheries in the Baltic Sea can be described as being commercial and recreational. The commercial fishery is dominated by cod, herring and sprat, whereas the recreational fishery is more diverse. Important in terms of management is that recreational catches of some species are higher than those reported in the commercial fishery.

Commercial fisheries

The commercial fisheries mainly target cod, herring, and sprat (ICES, 2007a). During the 1970s and early 1980s, the conflict between countries about fishing rights in the North Sea, and the declaration of Exclusive Economical Zones (EEZ) in 1982, made it hard for Swedish west coast fishers to continue their

North Sea fishing. As a consequence they increased their fishing in the Baltic Sea (Anon., 2005a; Lövin, 2007). This happened when herring stocks appeared high, the cod was about to reach a peak biomass, and the government subsidized fisheries (Anon., 2005a; Lövin, 2007). Together, these circumstances created the foundation for a buildup of overcapacity in the Swedish fishing fleet in the Baltic Sea (Anon., 2005a; Lövin, 2007), which is an underlying driving force of IUU fishing (Hultkrantz, 1997; Sporrong, 2007).

Sweden covers much of the west side of the Baltic Sea (Figure 1), and has a diverse small-scale fishery along its coast (Gårdmark *et al.,* 2004). The small-scale fishery has often been combined with other employment, such as industrial, agricultural or forestry work (Johansson *et al.*, 2005). In the northern part of Sweden (ICES subdivision 30 and 31; Figure 1), herring has been the most important species for this small-scale fishery, and it was mainly caught with traps and nets (Johansson *et al.*, 2005). In the 1960s, smaller trawlers showed up that fished for herring during the ice free season in the north, and during the winter further south in the Baltic (Johansson *et al.,* 2005). Salmon (*Salmo salar*), sea trout (*Salmo trutta*), whitefish (*Coregonus lavaretus*), and vendace (*Coregonus albula*), as well as some freshwater/brackish species such as northern pike (*Esox lucius*) and European perch (*Perca fluviatilis*) are other targeted species (Johansson *et. al.,* 2005). In ICES subdivision 31 (Figure 1), fishing for vendace roe with pair trawlers has been an important commercial fishing activity (Johansson *et al.,* 2005). Along the southern east coast of Sweden, i.e., ICES subdivision 27 and northern part of 25 (Figure 1), the small-scale fishery target herring, whitefish, pike, perch, salmon, eel (*Anguilla anguilla*), and some marine species, such as flounder (*Platichthys flesus*) and cod (Anon. 2005a). In the southern part of ICES subdivision 25 and in 23 (Figure 1), cod is by far the most important species for the small-scale fishery and it is mainly caught with gillnets. The decline in landings of cod in the 1990s did not change the importance of cod, as this was offset by increased price (Anon., 2002). Other targeted species are herring, sprat, salmon, and eel (Anon., 2002).

Between 1945 and 1970, the number of commercial fishers decreased from 16,000 to 5,200 (Anon., 1978), due to manpower requirements for national industrialization and increased effectiveness of fisheries enforced by decreased profitability (Johansson *et al.*, 2005). The decrease has continued and today 1,880 people are registered as commercial fishers in Sweden. In reality, there are more people involved in fishing operations since only the fishing boat's skipper has to be registered.

Recreational fishing (non commercial fishing)

The waters along the Swedish coast are either private or public. The waters out to 300 m from shore are private, and so are waters in bays and inside straits that are less than 600 m wide (Bruckmeier and Höj Larsen, 2008). However, north of Stockholm these inshore waters' fishing rights have been public since the 1950s due to governmental ownership. In public waters, every Swedish citizen is allowed to fish with hand gear and a restricted number of other gears, such as traps and gillnets (Anon., 1993). In private waters the basic right to fish belongs to the property owner. However, other people can fish with hand gear and in some areas also with other gears (Anon., 2007a). There are some exceptions, for example, fishing for salmon with gears other than hand gear is only allowed for property owners north of Stockholm even though the fishing rights are public (Anon., 2007a), and since 2007 a special license is required to fish for eel. Recreational fishing includes household consumption fishing, as well as sport fishing that is done entirely for recreational purposes. Between 1947 and 1975, a tenfold increase of recreational fishers occurred, from 200,000 to 2 million (Anon., 1978), and one reason for the rise was an increase in leisure time (A. Paulrud, pers. comm., Swedish Board of Fisheries). The number of recreational fishers is believed to have stayed about the same until the 1990s (Nilsson, 1991), when it increased throughout the 1990s (Norström *et al.*, 2000). Subsequently, however, a decline has been documented, and in 2006 the number of recreational fishers was estimated at 1 million (Anon., 2007a).

The aim of the present study is to present a reconstruction of likely total catches by Swedish fishers in the Baltic Sea from 1950-2007, including estimates of all types of IUU, such as unreported landings, discards and recreational catches.

METHODS

Collection of Swedish fishery statistics started early with annual statistics available since 1913 (Lundgren 2007). Swedish fisheries data are presented as catch (live weight) and landings (dressed weight) in tonnes. Here, Swedish catch data are defined as 'landings' to differentiate it from 'catch', which in this study refers to all catches taken from the Baltic Sea, i.e., including unreported landings, discards, and recreational

catches. The focus of the Swedish statistics is the revenue from the commercial fishery, and the reported data are based on information from first hand purchasers, the registered homeport of vessels, and fisher's logbooks. The data are thought to be reliable, although not all landed fish have to be reported (e.g., quantities <50 kg have no reporting requirements), and some unreported trade is known to occur (Lundgren, 2007).

However, since the focus of Swedish statistics is on commercial fisheries revenue, the landings data lack substantial components which constrain the estimations of total catches taken from the Baltic Sea. The estimates of unreported landings, discards, and recreational catches are all components that are missing in the official statistics. The reconstruction method used consists of a five step approach. First, the officially reported ICES catch data, here referred to as 'ICES landings statistics', were examined. ICES landings statistics are here defined as representing the officially reported data, as this data source is the only publicly available data set, covers all taxa landed, all countries, all years and all areas of the Baltic Sea back to 1950. Thus, all subsequent steps of reconstruction are deemed to comprise Illegal, Unreported and Unregulated (IUU) data. Four IUU components were considered: a) *'adjustments'* to reported landings data with landings data from other reliable and accurate sources, such as ICES stock assessment working group data and national data sets; b) *'unreported'* landings data; c) *'discards'* and d) *'recreational'* marine catches. To derive estimated time series of the unaccounted IUU components, linear interpolations were done between assumption- and information-based 'anchor points'.

ICES landings statistics

The term 'ICES landings statistics' is used throughout to refer to ICES catch data by taxon, statistical reporting area and year (ICES, 2009). These data were considered to represent the officially reported data.

Illegal, Unreported and Unregulated (IUU) catches

Adjustments to reported landings

ICES landings statistics were adjusted for some years with data obtained from ICES stock assessment working group reports for cod (ICES, 2008a), flounder (ICES, 2008a), herring and sprat (ICES, 2008a), and by Swedish national landings data (e.g., Anon., 1952; Anon., 1984; Anon., 2003b) for other minor species (Table 1). ICES landings statistics + adjustments are therefore the reported data foundation on which unreported landings, discard and recreational estimates were built.

ICES stock assessment working group data (ICES, 2008a) were used to adjust ICES landings statistics; for cod in 1965-1975, because of missing catches taken in the Baltic Sea by vessels from the west coast (Table 2; ICES, 1974), for herring and sprat in 1990-2007, due to misreporting of area and species (B. Sjöstrand pers. comm., Swedish Board of Fisheries), and for flounder 1990-1999 due to misreported catches from the cod fishery (ICES 2008a).

ICES landings statistics for salmon were generally identical to Swedish national data; however, from 1999-2003 they were about 100 t lower than the Swedish national data. Hence, Swedish national data replaced ICES landings statistics for the entire time period, except 1978 when Swedish national data are incomplete. Due to missing data in ICES landings statistics for sea trout, ICES landings statistics were replaced by Swedish national data for the entire time period, except 1978. For some species, ICES landings statistics were missing from 1950-1969 (1976 for common dab [*Limanda limanda*]) and therefore adjusted by Swedish national data for that period. Swedish national data for flounder were deemed more reliable 1970-1972 and therefore replaced ICES landings statistics for those years. The data for sprat varied substantially in the earlier period, which was thought to be partly explained by sprat being reported as 'industrial fish' in the Swedish national data. Therefore, half of the catches reported as 'industrial fish' were treated as sprat for certain years, and for those years Swedish national data were used to adjust ICES landings statistics (Table 1). The adjustments made with Swedish national data where ICES landings statistics were missing, have been subtracted from the categories 'Finfishes nei' (Miscellaneous marine fishes), 'Flatfishes nei' (Pleuronectiformes), and 'Freshwater fishes nei' (Miscellaneous freshwater fishes), in ICES landings statistics to avoid potential double accounting.

It would have been preferable to have one source of official landings data to form a baseline, but due to incomplete, odd, or missing data in the ICES landings statistics, the various additional sources listed above were used to adjust ICES landings statistics to get a more comprehensive baseline of reported

commercial landings data (Table 1). An optimal source for commercial landings data should have been the data from the ICES stock assessment working group reports (although only for species with stock assessments) that are known to attempt adjustment of reported landings data based on additional information. However, data as presented in these working group reports lack transparency with regards to country-specific accounting of each catch component (e.g., landings, unallocated, discards, recreational). This lack of country-specific transparency makes the use of stock assessment report data very difficult when focusing on country- rather than stock-specific catches.

Unreported landings

Unreported landings are thought to be the largest component of IUU catches in the Baltic Sea (Sporrong, 2007), especially if illegal is defined as pertaining to 'without permission' rather than quota violations. Information on unreported landings was obtained through interviews and literature (including grey literature and media reports). While some anchor points could be found starting in the late 1980s (Table 2), no information could be found for the pre-1980 period. Thus, a few assumptions were made to create anchor points for 1950 and 1980 so that linear interpolations could be done. In 1950, there were fewer incentives to underreport landings due to a lack of quota limitations (Eero *et al.,* 2007), however, there was also less enforcement for reporting landings (Anon. pers. comm., Swedish Board of Fisheries). Therefore, the unreported landings for all species (except salmon, see below) in 1950 were assumed to be 5% of reported landings, which is thought to be conservative. To reflect the introduction of quotas, and the associated stronger incentives for underreporting, starting in the 1970s (Søndergaard, 2007), 1980 was used as a break point. Thus, for 1980, half of the value for the first post-1980 data anchor point was applied. This rule was applied to all species, except salmon (see below), even though not all have quotas. For species without any information on unreported landings, an estimated percentage was derived from anchor point data for cod in 1987, and herring and sprat in 1993 (see paragraph 'other species' for details). Percentage rates were linearly interpolated between anchor points (Table 2), and applied to ICES landings statistics + adjustments to derive a complete time series of estimated unreported landings.

Table 1. Species specific adjustments to ICES landings statistics by year.

Common name	ICES landings	ICES stock assessment reports	Swedish data[a]
Cod	1950-1964, 1976-2007	1965-1975	-
Herring	1950-1989	1990-2007	-
Salmon	1978	-	1950-1977, 1979-2007
Burbot	1970, 1979-2007	-	1950-1969
Dab	1950-1975[b], 1977-2007	-	1976
Flounder	1950-1969[b], 1973-1989	1990-1999	1970-1972
Perch	1970, 1974-1975, 1979-2007	-	1950-1969
Sprat	1950-1955, 1964-1968, 1973-1974, 1978-1986, 1988-1989	1990-2007	1956-1963[c], 1969-1972[c], 1975-1977[c], 1987
Whitefish	1970-1972[d], 1974-2007[d]	-	1950-1969
Pike	1970, 1974-1975, 1979-2007	-	1950-1969
Sea trout	1978	-	1950-1977, 1979-2007
Turbot	1950-1961, 1970-2007	-	1962-1969
Vendace	1970-1972, 1974-2007	-	1950-1969

[a] data from yearbooks of Swedish fisheries statistics 1950-1993, e.g., Anon. (1952). For 1999 onwards, data are available at www.fiskeriverket.se. [b] taxonomic mislabeling between common dab and European flounder 1956-1959, and 1972. [c] half of the non-species-specific industrial fishmeal catch for that year was added to the sprat catch. [d] European whitefish and 'whitefish nei' combined.

Cod: Based on information on reported and unreported landings of cod in the harbor of Härnösand in 1987 (P.-O. Larsson, pers. comm., Swedish Board of Fisheries, retired), a conservative anchor point for unreported landings was calculated for 1987 (Table 2) based on the assumption that there were no other unreported landings in Sweden that year (see next paragraph for details). Anchor points for 1950 and 1980 were derived according to the assumptions described above. In recent years three different sources (Anon., 2004a; 2007c; 2008b) were combined to derive an average percentage used as anchor points for 2006 and 2007 (Table 2; see next

paragraph for details). A linear interpolation was done between anchor points (Table 2) to derive a complete time series of estimated unreported cod landings.

The Swedish reported landings of cod in the harbor of Härnösand were 10,000 t in 1987. Based on observations and on other information, the total landings of cod by Swedish (85%) and Finnish (15%) fishers in that harbor that year was however estimated to be 30,000–40,000 t (P.-O. Larsson, pers. comm., Swedish Board of Fisheries, retired). To remain conservative, the lower value (30,000 t) was used to estimate unreported landings in 1987. First the Finnish part of the catch was extracted (30,000 – [30,000 x 0.15] = 25,500). Secondly, the reported landings were extracted (25,500 – 10,000 = 15,500 t), resulting in a conservative 15,500 t of assumed unreported cod landings in this harbor in 1987. The harbor in Härnösand was deemed different compared to the Swedish harbors in the southern parts of the Baltic Sea, where unreported landings were more difficult to accomplish (P.-O. Larsson, pers. comm., Swedish Board of Fisheries, retired). The unreported Swedish landings (15,500 t) in the harbor of Härnösand accounted for 31% of Sweden's total reported landings (50,186 t) in 1987. Thus, 31% was used as an unreported landings anchor point in 1987 based on the likely very conservative assumption that there were zero unreported landings in all other Swedish harbors in 1987. Half of this value (0.5 x 31% = 15.5%) was used as an anchor point for 1980, and 5% as an anchor point for 1950 based on the general assumptions explained above (Table 2). In later years, 2004-2007, three different estimations of unreported cod landings have been made. In 2003 the unreported landings were at least 10% (Anon., 2004a), in 2005-2006 it was 21.4% (Anon., 2007c), and in 2007 there were indications that it was 8% (Anon., 2008c). There are reasons to believe that Anon. (2004a; 2008b), being estimates of the Swedish Board of Fisheries (8% and 10%) are minimum estimates, since the Swedish Board of Fisheries (being a government agency) has to base their statements on detected and officially reported records. Thus, it is highly unlikely that someone will report their own cheating to a government agency (Hultkrantz, 1997). However, the European Commission's study (21.4%; Anon., 2007c), has been criticized for its statistical methods (R. Lundgren, pers. comm., Swedish Board of Fisheries). Therefore, the three values were averaged, deriving 13.1% as an anchor point for 2006 and 2007 (Table 2).

Table 2. Unreported landings anchor points (% of reported landings). Dashes (-) indicate interpolated or expanded values.

Year	Cod	Herring & sprat	Salmon[a]	Eel	Vendace	Others[b]
1950	5.0[b]	5.0[b]	-	5.0[b]	5.0[b]	5.0[b]
1951-1979	-	-	-	-	-	-
1980	15.5[b]	12.5[b]	6.7[c]	9.9[b]	10.0[b]	6.8[b]
1981	-	-	9.1	-	-	-
1982	-	-	5.4	-	-	-
1983	-	-	5.6	-		-
1984	-	-	5.6	-	-	-
1985	-	-	4.8	-	-	-
1986	-	-	5.7	-	-	-
1987	31.0	-	5.3	-	-	-
1988	-	-	6.3	-	-	-
1989	-	-	6.6	-	-	-
1990	-	-	6.8	-	-	13.5
1991	-	-	7.1	-	-	-
1992	-	-	6.9	-	-	-
1993	-	25.0	7.1	-	-	-
1994	-	-	7.2	-	-	-
1995	-	-	7.8	-	-	-
1996	-	-	7.8	-	-	-
1997	-	-	8.0	-	-	-
1998	-	-	9.0	-	-	-
1999	-	-	9.4	-	-	-
2000	-	-	8.9	-	-	-
2001	-	-	8.8	-	-	-
2002	-	-	9.8	-	-	-
2003	-	13.0	9.6	-	-	-
2004	-	-	7.8	-	-	-
2005	-	10.0	8.7	-	20.0	-
2006	13.1	-	8.5	19.8	-	-
2007	13.1	-	9.4	15.0	-	6.8

[a] based on ICES stock assessment working group report (Table 2.1.1 in Anon., 2008c). [b] assumption based anchor points, see text. [c] average of the three first years of data, based on general assumptions.

Herring and sprat: The trawl fishery for herring and sprat is generally a mixed fishery, the catch often containing both species (ICES, 2008a). Therefore, they have been treated together with the assumption that the fractions of unreported landings are the same for both species. The catch is generally stored in chilled water onboard fishing vessels, resulting in absorption of water into their bodies, resulting in excess

weight. This has been adjusted for through a 'water adjustment factor' permitted by authorities. This factor has decreased over the years due to better knowledge on how much water the fish bodies absorb (L.E., Palmén pers. comm., Swedish Board of Fisheries). Some officials and fishery representatives acknowledge that underreporting of as much as 50% occurs (Anon., 2004a), and this information was used together with the difference in the water adjustment factor to derive anchor points (see next paragraph for details). Anchor points for 1950 and 1980 were based on the general assumptions explained above. A linear interpolation was done between the anchor points (Table 2), to derive a complete time series of unreported landings for herring and sprat.

In 1993, the water adjustment factor that fishers were allowed to subtract from the landings as water was 20%. In 2003 it was reduced to 13% and in 2005 to 5%. Hence, the 'excessive' water adjustment factor (i.e., the difference compared to 5%, which was 15% in 1993-2002, 8% in 2003-2004) has been used to estimate part of the unreported landings. Also, some officials and fishery representatives acknowledge that underreporting of as much as 50% occurs (Anon., 2004a). To stay conservative, this was reduced to 25% and used as an anchor point for 1993 (of which 15% is thought to be due to the 'water adjustment factor'). This was the first anchor point and therefore half of that (0.5 x 25% = 12.5%) was used for the break point in 1980, and 5% was used as an anchor point for 1950 based on the general assumption explained above. In 2003 the water adjustment factor was decreased from 20% to 13%, therefore the unreported landings estimate was also reduced by the same amount (25% - [20 – 13] = 18%) and used as an anchor point. In 2005 the water adjustment factor decreased from 13% to 5%, with a corresponding reduction in the unreported landings estimate (18% – [13 – 5] = 10%) for use as an anchor point in 2005.

Salmon: Information about the so-called 'Midsummer salmon' (i.e., sales that are not reported; Hultkrantz, 1997),and illegal fishing activities during closed salmon run periods (U. Steinbash, pers. comm., Swedish Coast Guard) was obtained, but was not detailed enough for deriving anchor points. Instead, estimated total unreported catches of salmon in the Baltic Sea, including rivers, from 1981 to 2007 from the ICES salmon and trout working group report (Table 2.1.1. in ICES, 2008b) were used. In this source, estimates of recreational catches were included in the Swedish reported landings from 1988 onwards, and could not be distinguished from commercial landings. Therefore, in order to avoid double accounting and remain conservative, Sweden's fraction of the total Baltic Sea catch per year was multiplied by the lower limit of the 95 % probability interval (see Table 2.1.1. in ICES, 2008b) to derive Sweden's unreported landings (see next paragraph for example). The unreported landings were then converted into percentages based on Sweden's reported landings, and used as anchor points between 1981 and 2007 (Table 2). The average of the first three years of data (1981-83) was used as anchor point for 1980 (Table 2), and carried back fixed to 1950 to derive a complete time series.

To more clearly illustrate the approach, for example, in 1990 Sweden's reported landings of salmon (including river catch and estimated recreational catch) was 1,468 t, and the total reported landings for the Baltic Sea was 5,636 t (as reported in Table 2.1.1. in ICES, 2008b). The 95 % Confidence Interval of the estimated unreported landings was 324 t – 2,512 t (Table 2.1.1. in ICES, 2008b). Therefore, Sweden's fraction of the total landings (1,468 t / 5,636 t = 0.26) was multiplied with the lower 95% Confidence Interval value (0.26 x 324 t =84.4 t) to derive estimated unreported salmon landings of 84.4 t for Sweden in 1990. Sweden's reported marine landings in 1990 was 1,249 t (ICES landings statistics), and the unreported landings were converted into a percentage (84.4 t / 1,249 t = 6.8%), which was used as an anchor point for unreported marine salmon landings in 1990 (Table 2).

European eel: Eel, being a high value species, is likely to have a larger black market than other species (Hultkrantz 1997), and today about 15% of eel catches are thought to be sold directly to restaurants (Anonymous, pers. comm., Swedish Coast Guard) and are assumed to be unreported. Hence, this was used as an anchor point for 2007. An eel fishing license became mandatory in 2007, and only available to fishers who caught more than 400 kg·year^{-1} in 2003-2005 (Sweet and Salt, 2006). After this regulation the reporting of catches improved and in the area of Stockholm the number of licensed fishers reporting their catch increased from 54% to 86% (Anon., 2008a). The improved reporting was assumed to be the same in the rest of the country based on various information (Ask and Westberg, 2006; Anon. 2008d). The percentage change in reporting was applied, and added to the unreported fraction in 2007 to derive an anchor point in 2006 (Table 2). Anchor points for 1950 and 1980 were derived based on the general assumptions described above, and linear interpolation was used to derive a complete time series of unreported eel landings (Table 2).

Vendace: Vendace is a pelagic species mainly caught by trawl, and nearly all catches are taken in ICES area 31 (Ask and Westerberg, 2006). In 2008, the Swedish Tax Agency investigated the fishery for vendace and found sales of several tonnes of vendace roe that were never reported (Nordlund, 2008). Hence, a rough estimate of $^2/_3$ (i.e., 66%) unreported catches of vendace is not unlikely (U. Steinbash, pers. comm., Swedish Coast Guard). To remain conservative, and due to uncertainties about roe to live weight conversions, 20% was used as anchor point for 2005. Based on the general assumptions explained above, 10% and 5% were used for 1980 and 1950, respectively. Linear interpolation was used to get a complete time series of estimated unreported vendace landings (Table 2).

Other species: Due to lack of information for 'other species', an anchor point in 1990 was derived based on the average of the earliest anchor points for cod, herring, and sprat. Since those species are profitable and therefore assumed to have more underreporting (Hultkrantz, 1997), the average rate of underreporting was divided in half (i.e., [[31 +25 +25] / 3] / 2 = 13.5%). Half this rate was assumed for 1980 (i.e., 0.5 x 13.5% = 6.8%), and 5% for 1950 based on the general assumptions explained above. Based on the assumption that unreported landings may have decreased in later years, half of the value for 1990 (0.5 x 13.5% = 6.8%) was used as an anchor point for 2007 (Table 2).

Table 3. Discards (%), based on Anon. (2006b).

Common name	2004 discard
Brill	38.0[a]
Common dab	33.4
European flounder[b]	48.0
European plaice	34.0
Turbot	38.0[a]
Other species	6.4

[a] average of other flatfishes; [b] not used as anchor point for flounder.

Discards

Several discard based mortalities have been treated separately here: boat-based discard, underwater discard, seal-damaged discard, and ghost-fishing. Swedish sampling of boat-based discarding behavior started in 1995-96, and mainly focused on cod (Anon., 2007b). Therefore, for all taxa, except cod, salmon, flounder, herring, sprat and vendace, boat-based discard data from a Danish study was used (Anon., 2006b; Table 3).

Herring, sprat, and vendace were assumed to only have underwater discards since the pelagic fishery is considered a relatively 'clean' fishery with little unutilized by-catch (Icelandic Fisheries, 2009). For flounder in 1989, Bagge (1989) was used. However, due to a very small sample size and the sampling restriction to cod trawl fishery, Bagge (1989) was not deemed as reliable as Anon. (2006b) for any other taxa.

Seal populations in the Baltic Sea have increased by approximately 8% per year since 1990 (Karlsson *et al.*, 2007), and this has resulted in an increase in damage to, and loss of catch due to seals. The economical value of the total loss of catches in 1997 and 2004 due to seal damage, was estimated to 22 million and 32.9 million Swedish Kronor (SEK; Table 4), respectively (Anon., 2005b; Hemmingsson and Lunneryd, 2007). In 1997 the loss in salmon fishery, targeting salmon, sea trout, and whitefish, was estimated to 14 million Swedish Kronor.

Table 4. Economic seal-damaged discard loss.

Year	Loss (million SEK)		
	Total	Salmon fisheries[a]	Other fisheries[b]
1997	22.0	14.0	8.0
2004	32.9	9.5	23.4
Ratio	-	-	0.3[c]

[a] including sea trout and whitefish; [b] excluding salmon fisheries; [c] The loss in 1997 was only about 30% of the loss in 2004

Table 5. Seal-damaged discards (tonnes) in the Baltic Sea.

Common name	2004[b]		1997[a]	
	Loss	Salmon fisheries	Loss	Salmon fisheries
Cod	896	-	306	-
Herring	431	-	147	-
Salmon/ Sea trout[c]	-	157	-	231
Eel	15	-	5	-
Flounder	3	-	1	-
Perch	79	-	27	-
Whitefish	-	83	-	122
Turbot	0.1	-	0.0	-

[a] Hemmingsson and Lunneryd (2007). [b] (Anon. 2005c). [c] Separated based on reported landings for each year.

The 2004 data were used to estimate seal-damaged discarding for that year as follows: the economic loss in 2004 was converted into weight by using the price per kilo given in the report together with the monetary loss for each of the reported species (Table 5). To derive a discard percentage, the loss in weight was divided by the nationally reported landings for those species (see next paragraph for example).

Salmon and trout were reported together and therefore the same discard percentage was applied to both. The derived percentage for each species was used as an anchor point in 2004 (Table 5).

For example, the economic loss due to seal damage to catches of perch (1.7 million SEK) was converted into weight by using the price (20 SEK/kg). The total Swedish loss of perch was thus estimated as 85 t, of which 7.6% was from fishing on the west coast which is not a part of the Baltic Sea considered here. The loss in the Baltic Sea (85 t – [85 t x 0.076] = 78.5 t) was divided by the reported landings of perch from the Baltic Sea (105 t) to derive the seal-damaged discard percentage (78.5 t / 105 t = 74.8%) which was used as an anchor point for perch in 2004. The estimated total loss (22 million SEK), and the estimated loss in the salmon fishery, (14 million SEK), were available from 1997 (Table 4). Due to lack of detailed information on species composition and prices in 1997, the fractions of species and the prices from 2004 were used to estimate seal-damaged discarding in 1997 as follows: the fraction of whitefish in the salmon fishery, and the prices for salmon/trout and whitefish, from 2004, were used to convert the economic loss (14 million SEK) to loss in weight of whitefish and salmon/trout in 1997. The loss in salmon fishery for both years was then excluded from the total loss for the respective year, and the remaining loss in 1997 was divided by the remaining loss in 2004 deriving a change over time in percentage (Table 4). Based on the fraction and the already calculated values for 2004, a loss in tonnage could be derived for 1997 (Table 5).

Table 6. Boat-based discards (%), based on individual sources, and also seal-damaged discards for salmon. Dashes (-) indicate interpolated rate.

			Salmon discards	
Year	**Cod**	**Flounder**	**Boat-based**	**Seal-damaged**
1950	[a]	[b]	[c]	0.0
1951-1979	[a]	[b]	[c]	0.0
1980	[a]	[b]	9.0[c]	0.0
1981	[a]	[b]	12.2	-
1982	[a]	[b]	7.2	-
1983	[a]	[b]	7.6	-
1984	[a]	[b]	7.4[d]	-
1985	[a]	[b]	6.8	-
1986	[a]	[b]	7.7	-
1987	[a]	[b]	7.5	-
1988	[a]	83.2	8.1	-
1989	[a]	-	8.7	-
1990	[a]	-	10.0	-
1991	[a]	-	9.8	-
1992	[a]	-	9.6	-
1993	[a]	-	10.2	-
1994	[a]	-	9.4	-
1995	[a]	127.7	10.6	-
1996	9.1[a]	56.9[e]	11.0	-
1997	4.7	66.4[e]	10.7	30.5
1998	15.6	146.7	11.5	-
1999	-	-	12.6	-
2000	7.1	-	7.6	-
2001	5.9	-	12.1	-
2002	5.9	-	14.4	-
2003	8.0	-	14.0	-
2004	4.5	184.9	11.8	22.1
2005	10.5	417.9	12.2	[i]
2006	14.7	[g]	14.0	[i]
2007	[f]	[g]	[h]	[i]

[a] average rate for 1997, 1998 and 2000 carried back to 1950. [b] 1988 rate carried back to 1950. [c] average rate for 1980-1982 carried back to 1950. [d] break point when seal-damaged discards replaces boat-based discards. [e] assumption based rate (see text), [f] average 2004-2006 rate carried forward. [g] 2004 rate. [h] 2006 rate. [i] 2004 rate.

The weight was then converted to a percentage as explained above. To remain conservative, it was assumed that seal damage prior to 1980 was minimal, and was therefore set to zero. Linear interpolations were done between the three anchor points (1980, 1997, and 2004), and the percentage anchor point in 2004 was carried forward to 2007.

Underwater discards account for fish that die after escaping deployed, actively fishing gear. The underwater discard rate for the herring trawl fishery was estimated at 8.85% (Rahikainen *et al.*, 2004). Sprat is likely to have a very similar if not higher underwater discard rate (M. Rahikainen, pers. comm., FGFRI). To remain conservative, an underwater discard rate of 5% was applied to the estimated total landings (ICES landings statistics + adjustments + unreported landings) by trawl for the two species. For vendace, a more conservative underwater discard rate of 2.5% was applied due to lack of other information.

Fishing gear that is lost during fishing operations and continues to catch fish contributes to ghost-fishing. Brown *et al.* (2005) estimated a ghost-fishing catch of cod of 0.1-3.2% of landings, based on gear-retrieval rates by trawlers. Based on the assumption that the ghost-fishing behavior of lost gear is the same for all other species, except the pelagic species herring, sprat, and vendace, an average of 1.65% was applied as ghost-fishing catch rate to estimated total landings (ICES landings statistics + adjustments + unreported landings) of all species.

Cod: Swedish sampling data for boat-based discards for 1997, 1998 (ICES, 2001) and 2000-2006 (Anon., 2007b) were available. The study by ICES (2001) was deemed incompletely sampled and lacked mean

weight data. Missing data were complemented with averages from sampled periods from the same study. The discard rate for 1999 was derived by interpolation between 1998 and 2000 anchor points. Discards of cod between 2000 and 2006 were reported as a percentage of landings in the cod trawl fishery, for 2006 also gillnet fishery discard rate (0.02%) was reported (Anon., 2007b). The same rate was applied to the gillnet catch for the other years, 2000-2006. The proportion of the total catch caught by the different gears (51% - 72% trawl, and 23% - 48%gillnet), was used to find the weight of the total discards per year. The total boat-based discards were then divided by the total reported landings to derive anchor points as a percentage from 2000-2006 (Table 5). The boat-based discards varied between 4.5% and 15.6%, and were deemed conservative. The average of the first three years of data was used as an anchor point in 1996 and carried back to 1950 (Table 6). This implies that the discard pattern is assumed to have been the same since 1950 which is unlikely due to the development of more selective gear types, changes in market demands and fishing behavior etc. However, since it is known that discards occurred in earlier years (Eero *et al.,* 2007), and that the estimated discards in recent years (Table 6) are likely minimum values, this problem has been ignored. For 2007 an average of the three last years of data was used. Seal-damaged discards and ghost-fishing catches were added to the boat based discards for cod.

Herring and Sprat: Underwater discards of herring in the trawl fishery in subdivision 30 were estimated to be 8.85% (Rahikainen, *et al.* 2004). To remain conservative, discarding of 5% was applied to that part of herring and sprat catches that were caught by trawl (Table 7). The ratio of trawl versus other gear types for herring was interpolated between anchor points. The weight of underwater discards was then divided by reported landings to derive a percent underwater discard per year, which thereafter was applied to the estimated total landings (ICES landings statistics + adjustments + unreported landings).

Table 7. Fraction of herring and sprat catch (%), caught by trawl (Anon., 1952; 1984; 2003b)[a].

Year[b]	Herring	Sprat
1951	24	-
1960	61	-
1982	94	100
1987	83	100
1991	96	100
1992	94	-
1999	96	100
2000	98	100
2001	97	100
2002	97	100
2003	96	100
2004	96	100
2005	97	100
2006	98	100
2007	98	100

[a] as of 1999 available online at Swedish Board of Fisheries, www.fiskeriverket.se. [b] Note: not a continuous time series.

Salmon: As no Swedish data were available, the ICES salmon and trout working group report (ICES, 2008b) was used (Table 6). Swedish discards were derived the same way as Swedish unreported landings. For example, for 1990 Sweden's reported landings of salmon (including river catch and estimated recreational catch) was 1,468 t, and the total reported catch for the Baltic Sea was 5,636 t. The 95% Confidence Interval was 481 t – 1,245 t (ICES, 2008b). Thus, applying the assumptions outlined above for unreported landings, Sweden's fraction of the total catch (1,468 t / 5,636 t = 0.26) was multiplied with the lower 95% CI value for discards (0.26 x 481 t =125 t), to derive an estimate for salmon discards in 1990. The discards were then converted into percentages based on reported marine landings, and the average of the first three years with data, was used as an anchor point in 1980 and carried back to 1950 (Table 6). However, from 1983, the estimated seal-damaged discards were larger than the calculated discards based on ICES (2008b), hence only seal-damaged discards were used for the rest of the time series.

Flatfishes: Boat-based discarding of flatfishes is common in the bottom trawl fishery for cod (Anon., 2007b). European flounder is the most abundant flatfish in the Baltic Sea, and discarding of this species in the cod fishery is substantial, especially for bottom trawls (Anon., 2001; 2008a). Due to paucity of useful data on discards of flatfishes other than flounder, the boat-based discards percentages from Anon. (2006b) were used as anchor points in 2004 for brill, dab, plaice, turbot, and 'other taxa'. Discards were presented for dab, flounder and plaice and their average discard rate was used for brill and turbot (Table 3). These anchor points were then used, unaltered throughout the entire study period as information on changes in discard patterns over time was unavailable (see Zeller *et al.*, this volume).

Information on discards in Bagge (1989) was used as an anchor point in 1988. This was carried back to 1950 due to lack of information on changes in discards patterns over time. Anchor points for 2004 and 2005 were derived based on estimated discards in ICES area 24 and 25 (Gårdmark *et al.*; 2006), divided by the total Swedish landings of flounder presented in the working group report, hence thought to be conservative. Linear interpolation was used to complete the time series. However, in 1996 and 1997, the reported landings of flounder were higher than usual (378 t in 1995, 1,072 t in 1996, 918 t 1997, and 502 t in 1998), due to a short-term increased demand from Russia (Anon., 2005a). Thus, discarding for these years was assumed to be lower due to the increase in market demand. To derive the discard rate for 1996

and 1997, half of the average discard tonnage for 1995 and 1998 was used and divided by the reported landings for 1996 and 1997. For 2006 and 2007, the very high estimated discard rate in 2005 was not applied, and to remain conservative, the discard for 2004 was used instead (Table 6).

Recreational catches

Swedish national studies from 1977, 1990, 1995, 2000, 2005, and 2007, estimating the extent of recreational fishing, were used to derive anchor points for recreational catches (Anon., 1977a,b; Nilsson, 1991; Nilsson, 1995; Norström *et al.,* 2000; Anon., 2005c; Anon., 2007a). These studies were carried out as questionnaires-based surveys to between 5,000 and 11,000 people at a time, and are known to have their own sets of uncertainties and methodological problems. It is recognized that an individual's interest in fishing increases the willingness to answer the questionnaires, and this can lead to overestimation of results if the fraction of the questionnaires that is not answered is not accounted for differently (Anon., 2005c; Bratt and Jansson, 2007). The 1977 study focused on possession of different gear and fishing effort rather than catch, which was addressed by Anon. (1977b), and is considered to be reliable due to the large sample size (11,000 participants), and a 93% participation rate (Anon., 1977a; A. Paulrud, pers. comm., Swedish Board of Fisheries). Among the 1990-2007 studies, the 2007 study is thought to be most reliable because it adjusts for the variation in willingness to participate based on personal fishing interest (Anon., 2007a). The 2005 study (Anon., 2005c) has been similarly adjusted (A. Paulrud, pers. comm., Swedish Board of Fisheries), and the resultant adjustment factors were used to improve the other studies (Table 8).

The recreational catches in the studies from 2000 and 2005 (Norström *et al*., 2000; Anon., 2005c) were reported as the total Swedish marine recreational catches, hence had to be adjusted for west coast catches. These adjustments were based on Anon. (2005c; 2007a), due to their spatial area reporting, which allowed west coast catches to be excluded and adjustments factors to be derived as follows; for cod, flatfishes, sea trout, and 'other species' individual adjustment factors could be calculated. Mackerel, crab, lobster, mussels, and 'other cod fish' were thought to be entirely caught on the west coast (Anon., 1978; Anon., 2007a). For species without individual adjustment factors, a general adjustment factor was based on the fraction of west coast catches reported in Anon. (2005c) excluding above mentioned species and species categories with specific information (Table 8).

After adjustments, the numbers of country-wide recreational fishers from each study as well as for 1947 (200,000 fishers; Anon., 1978), were used in conjunction with Swedish population numbers (Statistics Sweden, 2008) to derive the percentage of the total population that were recreational fishers for these years. Linear interpolation between derived percentage rates was done to fill missing years, and then the percentage

Table 8. Swedish recreational catches for 2005 (Anon., 2005d), both the originally reported amounts and the amounts adjusted for willingness to participate based on fishing interest. The difference was used to adjust for overestimation of catches in the studies from 1995 and 2000. The west coast adjustment is based on Anon. (2007b), and was used to exclude west coast catches.

Common name	Recreational catch (t)		Adjustment factor	West coast adjustment
	Original	Adjusted		
Atlantic cod	1,730	1,127	1.54	0.78
Herring	3,454	2,043	1.69	0.87
Atlantic mackerel	2,851	1,313	2.17	0.00
Atlantic salmon	569	318	1.79	0.87
Cyprinids nei	380	128	2.97	0.87
Edible crab	1,258	355	3.54	0.00
European eel	388	183	2.12	0.87
European perch	2,360	1,346	1.75	0.87
European whitefish	911	578	1.58	0.87
Flatfish	954	621	1.54	0.81
Lobster	228	189	1.21	0.00
Mussels	76	47	1.62	0.00
Northern pike	2,236	1,294	1.73	0.87
Other cod fish	364	242	1.50	0.00
Sea trout	729	461	1.58	0.72
Other species	896	395	2.27	0.79
Fishers	1,800,000	1,400,000	1.29	n/a
Fishing days	29,000,000	22,000,000	1.32	n/a

for each year was applied to the total population number to derive a complete time series of number of recreational fishers. For example, the number of fishers in 1975 was 2 million, and given a total Swedish population of 8.2 million, the percentage of recreational fishers was 24.4%.

The above recreational surveys were used to derive effort estimates (number of fishing days per fisher per year), and a recreational catch rate per fisher per day. The number of recreational fishing days in 1975 was 25 million, which implies that the average number of fishing days per fisher in 1975 was 12.5. The recreational catch in 1975 was 13,334 t, which gives a catch rate of 0.00053 t·fisher^{-1}·day^{-1}. The 1975 number of fishing days and catch rate per fisher were carried back fixed to 1950. Thus, the recreational catch per year from 1950-2007 was estimated as the product of estimated number of recreational fishers, their average fishing time in days, and daily catch rate. The species specific catch for each study was used to derive a fraction of total recreational catch per species where it was possible. These fractions were then interpolated and applied to the calculated total recreational catch.

RESULTS

The present results represent a first attempt at assumption-based reconstruction of total catch time series for Swedish fisheries in the Baltic Sea, from 1950-2007. Presented are data by species for the major species, followed by examination of recreational catch estimates, and total estimates for Sweden. When considering total reconstructed catch in comparison to official reported landings of species, the reconstructed catch has been compared to the official landings data as defined for the present purposes, namely ICES landings statistics. For time series data of each category by species, see Appendix Tables A1-A9. For results presented by IUU components (rather than by species) see Appendix B.

Cod

ICES landings statistics for Swedish cod landings decreased from approx. 22,000 t·year^{-1} during the 1950s to around 17,000 t·year^{-1} during the 1970s, and thereafter increased substantially to about 51,000 t·year^{-1} during the 1980s with the all time high reported landings by ICES landings statistics in 1984 of almost 66,000 t (Figure 2a). ICES landings statistics for cod declined rapidly in the early 1990s, and in the last five years averaged about 13,000 t·year^{-1} (Figure 2a, Appendix Table A2).

ICES landings statistics were adjusted by around 3%, mainly using adjustments from 1965-1975 from ICES stock assessment working group report data (Figure 2a). The adjustments resulted in raising reported landings to around 23,000 t·year^{-1} during the 1960s and around 18,000 t·year^{-1} during the 1970s (Figure 2a, Appendix Table A2).

Prior to the 1980s, unreported landings of cod were estimated to be relatively small, averaging around 2,000 t·year^{-1} (Figure 2b). From 1980 until the 2000s, estimated unreported landings of between 3,000 and 17,400 t·year^{-1} made up a large proportion of unaccounted catches (Figure 2b). In more recent years, unreported landings of cod for Sweden have declined to around 1,900 t·year^{-1} (Figure 2b; Appendix Table A2).

During the 1950s to 1970s, discards ranged between 1,900 and 3,400 t·year^{-1} (Figure 2b). During the 1980s discards increased to an average of around 7,100 t·year^{-1}, however, discarding behavior remained stable in relation to landings from 1950-1996 due to conservatively assumed fixed discard rate and thereafter varied year to year. In the last five years, the discards were the largest component of the unaccounted catches, with average discards of 2,500 t·year^{-1} (Figure 2b).

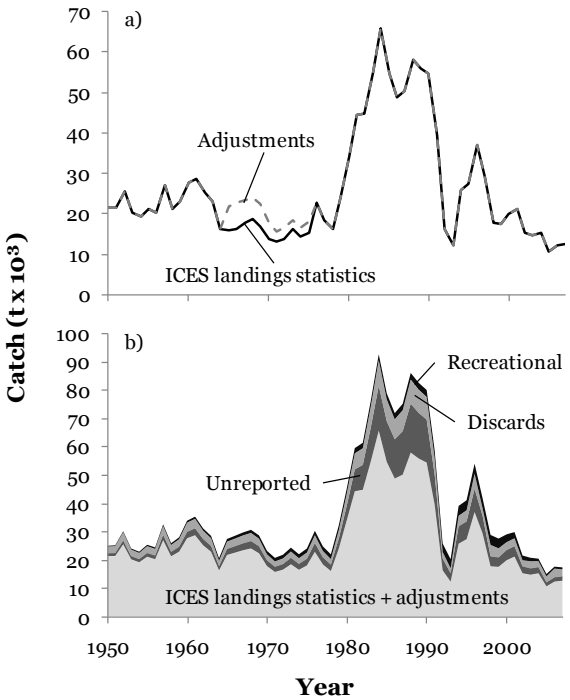

Figure 2. Swedish cod landings in the Baltic Sea: a) ICES landings statistics and adjustments; b) Sweden's reconstructed cod catches in the Baltic Sea.

The recreational catches of cod were relatively low, except possibly during the 1990s when the total estimated decadal recreational catch was around 32,600 t (Appendix Table A2, Appendix Table B5). According to the available information, which does not include the cod-boom 1980's, the historically highest annual recreational catch of cod was around 3,600 t in 1996 (Figure 2b).

Considering total reconstructed catches of cod in contrast to ICES landings statistics, estimated reconstructed catch was 42% larger than ICES landings statistics of cod for 1950-2007. Over the last five years (2003-2007), the reconstructed catches of cod were about 40% higher than ICES landings statistics (Figure 2b, Appendix Table A2).

Herring

Reported landings of herring by Sweden were stable during the 1950s and the 1960s with average landings of around 32,000 t·year^{-1} (Figure 3a; Appendix Table A3). After the mid 1960s, reported landings increased until 1980 and a peak of nearly 93,000 t. During the 1980s, landings declined rapidly to 36,400 tin 1987. Thereafter, landings increased and peaked during the 1990s when around 85,000 t·year^{-1} was reported, and after 2000 landings declined to about 61,000 t·year^{-1} (Figure 3a). The last five years annual reported landings of herring were on average 47,800 t·year^{-1} (Figure 3a; Appendix Table A3).

ICES landings statistics were adjusted from 1990-2007 by ICES stock assessment working group data, resulting in a substantial decrease of reported landings for herring in the 1990s of up to 50% (Figure 3a). This resulted in a substantial data adjustment for the 1990s, and is thought to be due to misreported sprat catches and catches from outside the Baltic Sea.

Prior to 1980, the unreported landings, discards, and recreational catches of herring were relatively small (averaging 3,600, 1,400, and 1,000 t·year^{-1}, respectively, Figure 3b, Appendix Table A2). During the 1980s and the 1990s, unreported landings of between 7,000 and 21,800 t·year^{-1} made up a substantial proportion of the unaccounted herring catches (Figure 3a). In recent years the unreported herring landings were around 6,300 t·year^{-1}.

The underwater discards increased from 1.2% in 1950, to 5.4% reported landings in 2007, due to the increased use of trawl in the herring fishery from 1950 (24% trawl) to 2007 (98% trawl). Prior to 1980, the average underwater discard was 1,400 t·year^{-1}, during the 1980s it was 3,500 t·year^{-1}, and during the 1990s it was 3,800 t·year^{-1} (Figure 3b, Appendix Table A3).

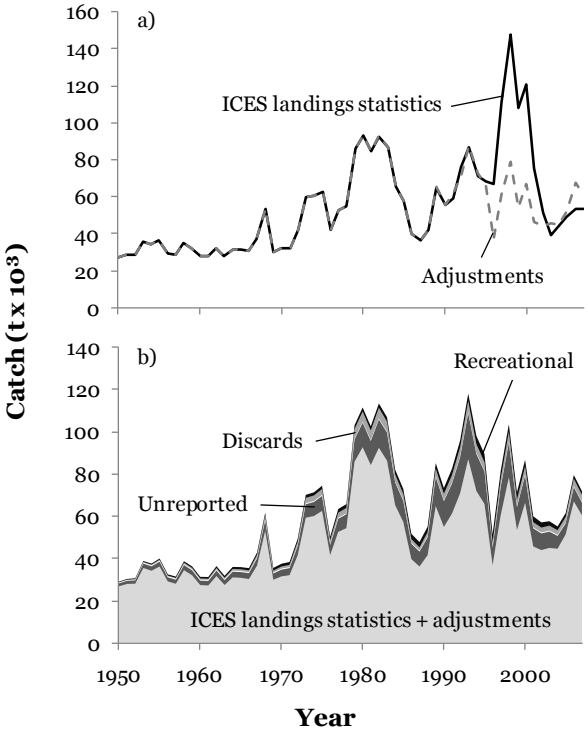

Figure 3. Swedish herring landings in the Baltic Sea 1950-2007: a) ICES landings statistics and adjustments; b) Sweden's reconstructed herring catches in the Baltic Sea.

The estimated recreational catches of herring were small for the whole time period, with peak catches in 1994 of about 3,900 t·year^{-1}. For the most recent period (2000-2007), recreational catches averaged around 2,200 t·year^{-1} (Figure 3b; Appendix Table A3).

The total reconstructed catches of herring were only about 13% larger than ICES landings statistics for 1950-2007 due to large negative adjustments. The total reconstructed herring catches were 23% larger than ICES landings statistics + adjustments for 1950-2007, and for the most recent period (2003-2007), likely total catches were, on average, 36% larger per year (Figure 3; Appendix Table A3).

Sprat

ICES landings statistics of sprat were very low at around 150 t·year^{-1} during the 1950s and the 1960s, but increased to 1,600 t·year^{-1} during the 1970s, and to almost 4,000 t·year^{-1} during the 1980s. After 1990, ICES landings statistics increased extremely rapidly to a peak of around 98,000 t·year^{-1}. Thereafter, ICES landings statistics decreased slightly to 86,000 t·year^{-1} for the last eight years (Figure 4a).

ICES landings statistics were adjusted by Swedish national data in some of the earlier years, and from 1990-2007 by ICES stock assessment working group data. These latter adjustments increased reported landings to a time series peak of approximately 191,000 t in 1998, while lowering reported landings for the most recent period to approx. 80,700 t in 2007 (Figure 4a; Appendix Table A4).

The estimated unreported sprat landings increased substantially with the increased ICES landings + adjustments and averaged 24,600 t·year^{-1} during the 1990s (Figure 4b). The peak unreported sprat landings were around 41,100 t·year^{-1} in 1998, and unreported landings were a substantial part of unaccounted sprat catches (Figure 4b). In recent years, the unreported landings decreased, and the last five year's average was 9,200 t·year^{-1}. The underwater discards were stable in relation to total landings (ICES landings statistics + adjustments + unreported landings) during the entire time period due to exclusive use of trawl gear in the sprat fishery. The discards ranged between 0 t in 1950 and around 11,600 t in 1998, and there were no estimated recreational catches of sprat.

For the period 1950-2007 the estimated total reconstructed catches of sprat were 34% larger than ICES landings statistics (Figure 4a, Appendix Table A4). From 2000-2007 this difference was 16% (Figure 4b; Appendix Table A4)

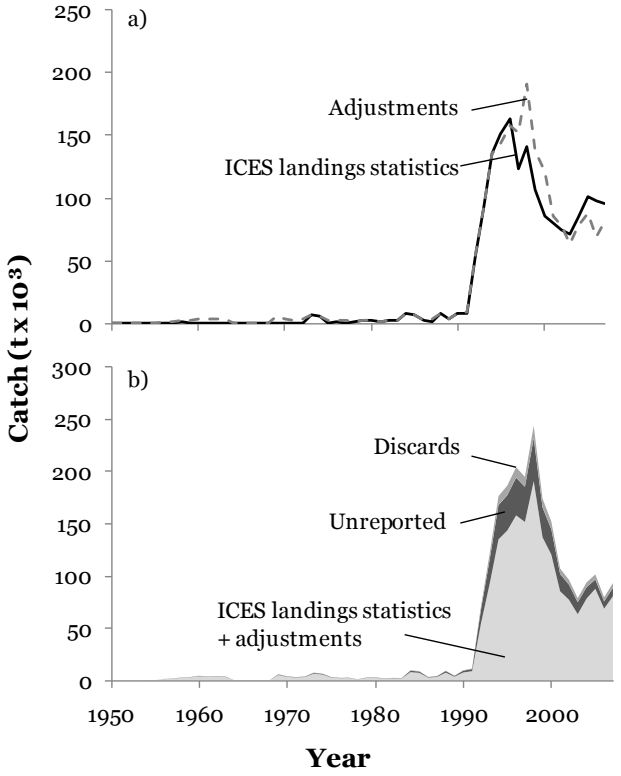

Figure 4. Swedish sprat landings in the Baltic Sea 1950-2007: a) ICES landings statistics and adjustments; b) Sweden's reconstructed sprat catches in the Baltic Sea.

Salmon

ICES landings statistics for salmon were about 500 t·year^{-1} prior to 1980 (Figure 5a). The rather high landings reported for the first few years of the 1950s were unexplained. Landings increased during the 1980s and peaked in 1990 at about 1,200 t, before declining to around 400 t·year^{-1} from 2000-2007 (Figure 5a).

Swedish national landings data were for the most parts identical to ICES landings statistics, and replaced them for the entire period, except for 1978 (Figure 5a). The estimated unreported landings of salmon were relatively small during the

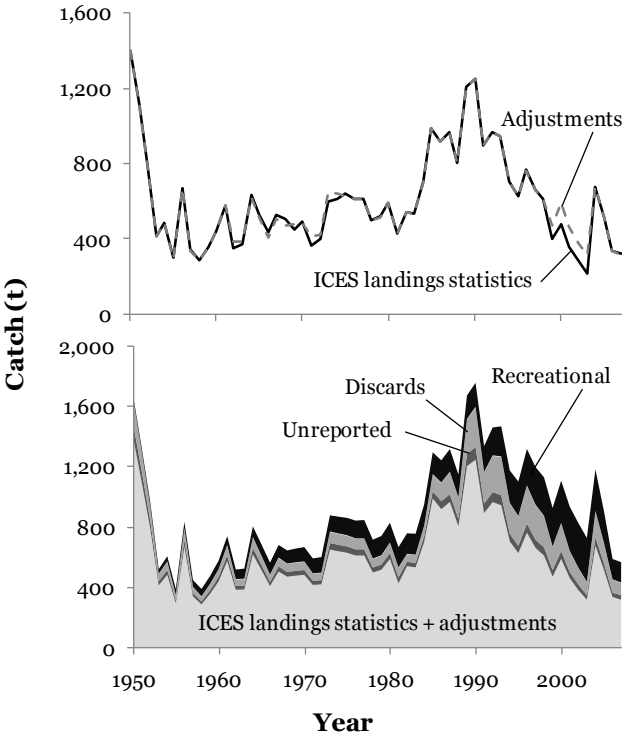

Figure 5. Swedish salmon landings in the Baltic Sea 1950-2007: a) ICES landings statistics and adjustments; b) Sweden's reconstructed salmon catches in the Baltic Sea.

whole time period 1950-2007 and varied between approximately 20 and 95 t·year^{-1} (Figure 5b).

Salmon discards were 60 t·year^{-1} prior to 1980 (Figure 5b). The increase in seal populations after 1980 lead to an increase of salmon discarding, peaking during the 1990s with average discards of around 220 t·year^{-1} (Figure 5b), of which 85% was discarded due to seals. Seal-safe gear, such as 'push-up' traps, contributed to a decline of total discards, averaging 110 t·year^{-1} from 2003-2007.

The estimated recreational catches of salmon increased steadily from 20 t in 1950, to the peak catches of about 300 t in 2002 (Figure 5b). Thereafter, recreational catches declined to about 140 t in 2007.

The total reconstructed catches of salmon were 48% larger than ICES landings statistics 1950-2007. In recent years (2003-2007) the reconstructed catches of salmon were on average 93% larger than ICES landings statistics (Appendix Table A5).

Flatfishes

ICES landings statistics were quite stable during the first two decades with an average of about 1,000 t·year^{-1} (Figure 6a). In the late 1960s, ICES landings statistics started to decrease and reached their lowest reported landings in the 1980s of about 300 t·year^{-1}. From the mid 1980s until the mid 1990s ICES landings statistics were quite stable. Landings then increased three-fold within two years to a peak of 1,500 t by 1996 before decreasing again (Figure 6a). After 2000 the landings were about 400 t·year^{-1} (Figure 6a).

ICES landings statistics were adjusted by ICES stock assessment working group data for flounder, and with Swedish national data for flounder, dab and turbot. Most adjustments were minor, except for the period around 1970 (Figure 6b). Overall, adjustments added 2% to reported landings as per ICES.

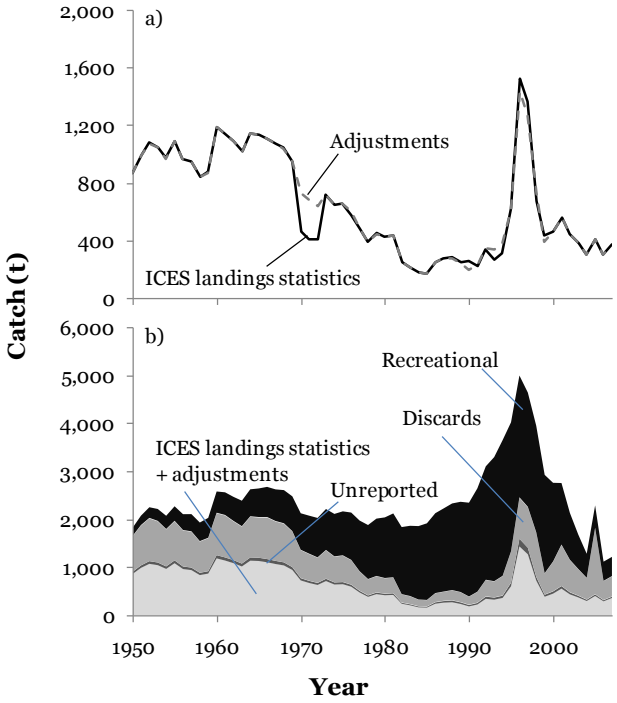

Figure 6. Swedish flatfish landings in the Baltic Sea 1950-2007: a) ICES landings statistics and adjustments; b) Sweden's reconstructed flatfish catches in the Baltic Sea.

Estimated unreported flatfish landings were relatively low during the whole time period 1950-2007, likely reflecting the relatively low market value of these species, and varied between about 20 and 160 t·year^{-1} (Figure 6b). Prior to 1970 the estimated discards averaged 700 t·year^{-1} (Figure 6b). Since the discard rate was kept fixed for most of the time period, discard tonnage decreased to around 200 t·year^{-1} during the 1980s, when landings were small. Thereafter, they increased with increased landings during the 1990s to an average of 500 t·year^{-1}. After 1998 discards were larger than the reported landings and peaked in 2005 at about 1,400 t (Figure 6b), of which 97% was discarded flounder.

Estimated recreational flatfish catches made up a substantial part of the reconstructed likely total catch (Figure 6b). The average recreational catches were 600 t·year^{-1} prior to 1980, 1,600 t·year^{-1} during the 1980s, and 2,400 t·year^{-1} during the 1990s when they peaked. In recent years (2003-2007), the estimated recreational catches were, on average, 500 t·year^{-1} (Figure 6b).

The total estimated reconstructed catches of flatfish were almost 2.7 times larger than ICES landings statistics from 1950-2007. For the more recent years, reconstructed data suggest that likely total catches were about 3.6 times larger then reported landings (Figure 6b, Appendix Table A6).

Sea trout

ICES landings statistics for sea trout and 'trout nei' combined were erratic over time and data were missing for most of the 1960s (Figure 7a). ICES landings statistics peaked in 1993 at 170 t, and thereafter declined to around 40 t·year^{-1} from 2000-2007 (Figure 7a).

Due to missing data ICES landings statistics were replaced for the entire period, except in 1978, by Swedish national landings data (Figure 7a). Overall, the Swedish national data were 20% larger than ICES landings statistics.

The estimated unreported sea trout landings were low and never exceeded 21 t·year^{-1} during the entire period (Figure 7b). The estimated discards were also relatively low and peaked during the 1990s when it ranged between about 20 and 60 t·year^{-1} (Figure 7b).

The estimated total recreational sea trout catches were more than 8 times larger than ICES landings statistics suggested for 1950-2007 (Figure 7b; Appendix Table A7). Estimated recreational catches increased from around 130 t in 1950 to a peak of about 730 t in 1975, before declining during the 1980s (Figure 7b). In the most recent years, recreational catches declined to around 230 t by 2007.

Due to the substantial recreational catches of sea trout, the total estimated reconstructed catches were about 10 times larger than ICES landings statistics from 1950-2007, and almost 12 times larger for the most recent 2003-2007 period (Figure 7).

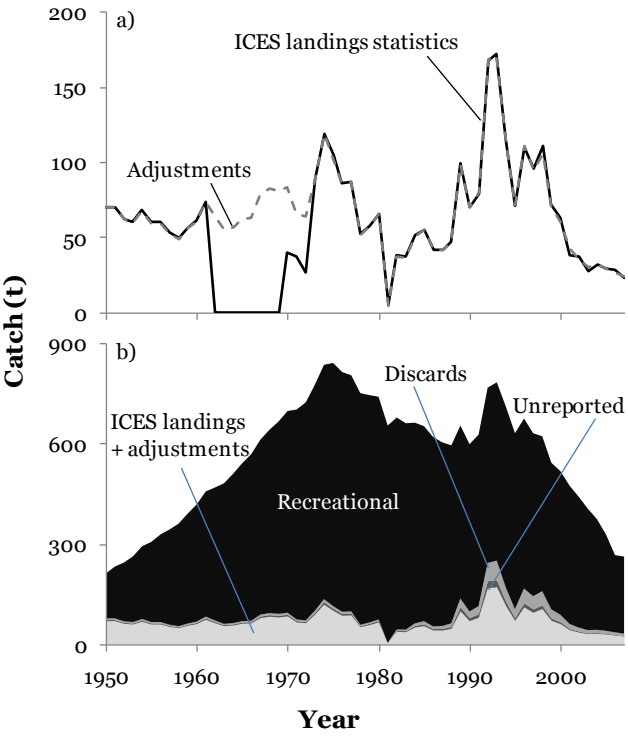

Figure 7. Swedish sea trout landings in the Baltic Sea: a) ICES landings statistics and adjustments; b) Sweden's reconstructed sea trout catches in the Baltic Sea.

<u>Eel</u>

ICES landings statistics for eel declined from, on average, 1,900 t·year^{-1} in the 1950s to an average of 310 t·year^{-1} in the 2000s (Figure 8a, Appendix Table A8). After the introduction of regulation of fishing for eel in 2007, the reported landings rose to 416 t in 2007 (Figure 8a). No adjustments were done to ICES landings statistics for eel. Unreported landings of eel have decreased since the 1950s, from 110 t·year^{-1} to around 60 t·year^{-1} during the 2000s. However, relative to ICES landings statistics, the annual estimated unreported eel landings increased from around 6% during the 1950s, to 18% during the 2000s (Figure 8b, Appendix Table A8).

In the last five years, discards were 17% of ICES landings statistics (Figure 8b), and about 42 % of these discards were due to seal damage. For example in 2004, the estimated discards were about 40 t, of which around 18 t were discarded

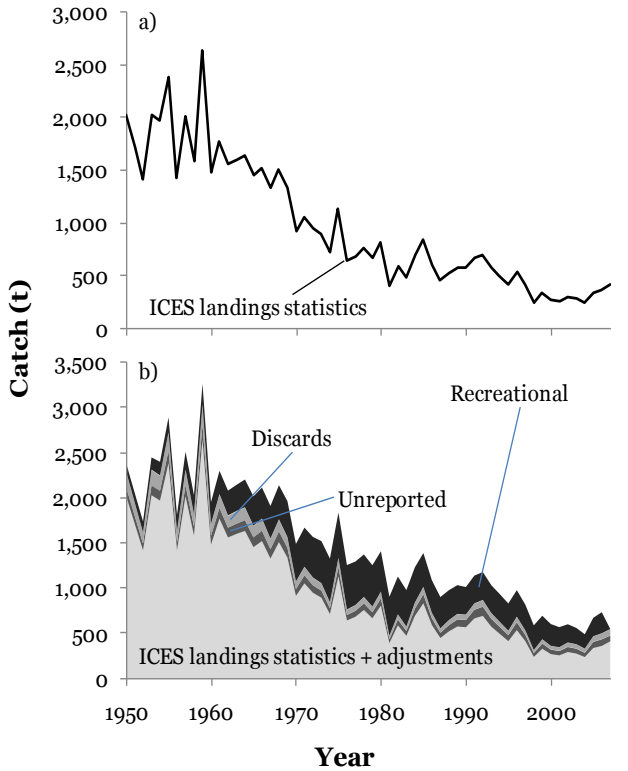

Figure 8. Swedish eel landings in the Baltic Sea 1950-2007: a) ICES landings statistics; b) Sweden's reconstructed eel catches in the Baltic Sea.

due to seal damage.

The estimated recreational catches of eel were larger than both unreported landings and discards combined, and made up a substantial part of IUU catches (Figure 8b). The largest recreational catches were taken during the 1970s with average catches of 460 t·year^{-1} (55% of ICES landings statistics in the 1970s). Between 2000 and 2006, before the regulation of eel fishing in 2007, the recreational catch was on average 210 t·year^{-1}, equaling approximately 70% of reported ICES landings for 2000-2006 (Figure 8b).

The total reconstructed catch of eel was 50% larger than ICES landings statistics from 1950-2007 (Figure 8b). For the most recent years, the total reconstructed catches were on average twice as high as ICES landings statistics.

Whitefish

ICES landings statistics for whitefish (whitefish and 'whitefishes nei' combined) didn't report any landings during the 1950s and 1960s. After the mid 1970s, they ranged between on average 300 – 400 t·year^{-1} until the 2000s, when they declined and were around 200 t·year^{-1} (Figure 9a).

ICES landings statistics were adjusted with Swedish national landings data from 1950-1969 to account for missing data (Figure 9a). This adjustment added an additional 95% to reported data (Figure 9a; Appendix Table A9). Therefore, ICES landings + adjustments for whitefish declined from a high in the early 1950s of around 860 t in 1951 to around 200 t·year^{-1} in the 2000s (Figure 9a; Appendix Table A9).

Estimated unreported landings were relatively low during the whole time period and never exceeded 70 t·year^{-1} (Figure 9b). Prior to 1980, the estimated discards were relatively low and ranged between 20 and 70 t·year-1. After the increase in the seal population from the 1980s onwards, discards increased considerably. During the 1990s the estimated discards ranged between 130 and 260 t·year^{-1}, but declined during the 2000s with an average discard of 90 t·year^{-1} (Figure 9b).

The estimated recreational whitefish catches were very large compared to reported landings, being about 4.5 times larger than reported landings from 1950-2007. Recreational catches increased from an estimated 300 t in 1950 to a peak of 1,600 t in 1975 (Figure 9b). Thereafter, the recreational catches declined from an average of 1,500 t·year^{-1} in the 1970s to annual catches of around 1,000 t·year^{-1} during the 1990s. The recreational catches declined even more during the 2000s to about 500 t·year^{-1}.

The total reconstructed whitefish catches were 7 times larger than ICES landings statistics from 1950-2007 (Figure 9b). For the most recent years, total reconstructed catches of whitefish were, on average, 3.5 times larger than ICES landings statistics (Figure 9b).

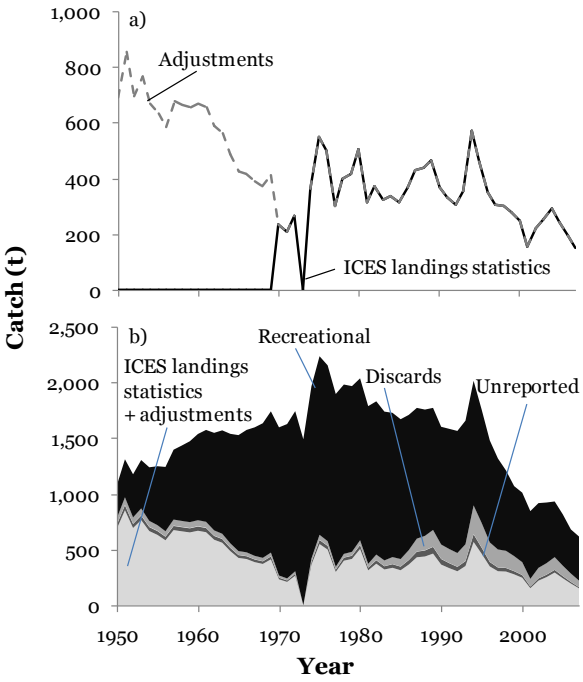

Figure 9. Swedish whitefish landings in the Baltic Sea 1950-2007: a) ICES landings statistics and adjustments; d) Sweden's reconstructed whitefish catches in the Baltic Sea.

Total reconstructed catches

Overall for Sweden, reported ICES landings statistics were about 61,000 t·year^{-1} during the 1950s, increased to about 66,000 t·year^{-1} during the 1960s, and to 78,000 t·year^{-1} during the 1970s. ICES landings statistics thereafter increased substantially to 125,000 t·year^{-1} during the 1980s, and to 216,000 t·year^{-1} during the 1990s (Figure 10a). For the last eight years they declined and were on average 165,000 t·year^{-1} (Figure 10a).

The adjustments to ICES landings statistics resulted in a 2% decrease of reported landings from 1950-2007 (Figure 10a). This difference was exclusively driven by the large tonnage discrepancy in herring landings for the 1990s between ICES landings statistics and stock assessment working group data accounting for taxonomic and spatial misreporting (Figure 3).

The total reconstructed catches were just under 9 million t from 1950-2007 (Figure 10b; Appendix Table A1), and total catches followed the general time-line trend of landings, increasing from on average around 74,000 t·year^{-1} in the 1950s to a peak of about 284,000 t·year^{-1} on average during the 1990s. In recent years total catches were on average 182,000 t·year^{-1} (Figure 10b). The largest IUU component was unreported landings, especially during the 1990s. Cod, herring, and sprat made up around 90% of the total reconstructed catches from 1950-2007.

Overall, the total reconstructed Swedish catches in the Baltic Sea from 1950-2007 were 31% higher than suggested by the reported data as represented by the ICES landings statistics (Figure 10; Appendix Table A1). The difference peaked during the 1990s when it was on average 68,000 t·year^{-1}. In recent years, the difference amounts to about 28,000 t·year^{-1}, thus, reconstructed total catches from 2003-2007 were around 18% higher than reported landings suggest. If herring and sprat were excluded from this comparison, the unaccounted factor increases to 69% of the estimated total catches in recent years.

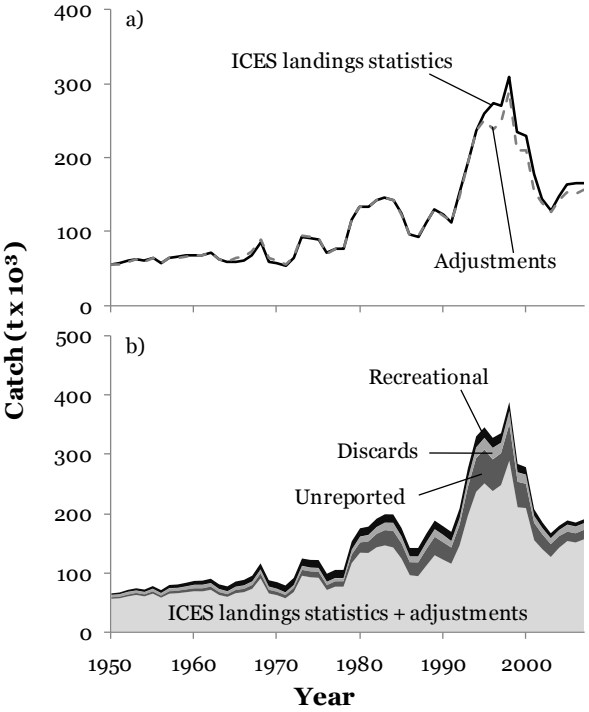

Figure 10. Swedish total landings in the Baltic Sea 1950-2007: a) ICES landings statistics and adjustments; b) Sweden's total reconstructed catches in the Baltic Sea

DISCUSSION

To improve the understanding of fisheries impacts on ecosystems, improvements in the reporting (and verification) of landings and actual catches are urgently required. In this study, an alternative approach has been used to estimate a more comprehensive total catch, including estimates of unreported landings, discards and recreational catches. As long as estimates for unaccounted catches are not substantially overestimated, catch reconstruction will present a likely more accurate (even if not statistically 'precise') picture of total extractions compared to current practices of essentially allocating 'zero catch' to IUU components for which no hard time series data are available.

Sweden submits a yearly landings data set to ICES for integration into its database. As this ICES database is the only publicly accessible data source for all countries, years, areas and taxa, it, by default, represents the officially reported picture of fisheries resource extractions. For the focal period of the present study, 1950-2007, the reported landings by Sweden from the Baltic Sea amounted to a total of over 6,786,000 t. In contrast, Sweden's likely total catch taken from the Baltic Sea from 1950-2007 as reconstructed here was about 8,900,000 t, i.e., 31 % higher than ICES landings statistics suggested. For the more recent years (2000-2007), this difference was 18%. The reconstructed catches peaked during the 1990s with an average of 284,000 t·year^{-1}. Discrepancies between reported landings and total catch of a species can contribute substantial uncertainties to stock assessments (ICES, 2008a) and lead to poor or incorrect management advice.

The difference between ICES landings statistics and reconstructed catches can to a large extent be accounted for by '*unreported*' landings, which were estimated to almost 1.1 million t for the entire period, which was 12% of the estimated total catch. This is supported by Sporrong (2007) who opined that the unreported landings are the largest component of IUU catches in the Baltic Sea.

The estimated Swedish discards for 1950-2007 were just over 0.5 million t, or 6% of the estimated total catches. Discarded fish are a waste, since the resultant mortality rates are often 100%. For ethical, environmental, and economic reasons, discarding is a disgrace (Anon., 2003a), and attempts should be

made to minimize or avoid it. The effects of discarding on the ecosystem are to a large extent unknown and in order to improve the understanding and also stock assessments it is necessary that all discards are reported (Anon., 2003a). Generally, the only way in which actual catches (i.e., reported and unreported landings and discards) can be properly accounted for, is through 100% observer coverage on all vessels of all fleets. Anything less than 100% coverage results in often strong observer bias effects leading to unreliability and high uncertainty in the observer data (Babcock and Pikitch, 2003; Anon., 2006a; Bremner *et al.*, 2009).

The estimated recreational catch was about 0.6 million t from 1950-2007, which was 7% of the estimated total reconstructed catches. Recreational fishing in Sweden is one of the biggest recreational activities and for some species the recreational catch is several times larger than the commercial landings (Anon., 2007a). If one excludes the three major commercial species, cod, herring, and sprat (which account for 94% of reported ICES landings statistics), the recreational catches made up nearly 50% of the remaining total reconstructed catches, none of which is appropriately represented by ICES data. Similar recreational contributions to total catches have been reported in the USA (e.g., Coleman *et al.*, 2004). Even though the recreational part of catches is often substantial, the data on recreational fishing in Sweden are very poor, especially prior to 2006. Hence, better data are needed for recreational fisheries, including species- and area-specific catch and effort data. These could possibly be obtained through well designed, country-wide surveys, conducted at least every 3-5 years, with all data for intervening years being interpolated. Emphasis should also be placed on incorporating these data (surveyed and interpolated) in all annual reports to ICES.

Much of the available information was biased towards the commercially important species, such as cod, herring and sprat. Further, the total reconstructed catches were also largely driven by the three major commercial species that accounted for 94% of the reported ICES landings statistics. These three are also the ecologically dominating species of fish in the Baltic Sea (Hansson and Nissling, www.ecology.su.se/projects/images/WWF1.pdf); hence, fishing is a key factor structuring the Baltic Sea marine ecosystem (Harvey *et al.*, 2003). Consequently, if fishing causes a decline, or even collapse of a fish population in the Baltic Sea, it does not only affect the fisheries (and stock), but it likely also has substantial ecosystem implications (Harvey *et al.* 2003). For example, multi-level trophic cascade effects have recently been reported for the Baltic Sea, driven mainly by overfishing of cod that enabled substantial increases of sprat during the 1990s due to predation release (Casini *et al.*, 2008). This increase in sprat populations in turn led to a decline of zooplankton, the food of sprat, which in turn reduced grazing pressure on phytoplankton, contributing to algal blooms. The potentially harmful algal blooms were previous exclusively ascribed to eutrophication and climate conditions (Casini *et al.*, 2008). Low densities of zooplankton also harm the recruitment of pike and perch (Ljunggren *et al.*, 2008), and problems with recruitment for these two species exist along the Swedish coast of the Central Baltic Sea (Ask and Westerberg, 2008).

Sweden has an extensive tradition of scientific research. Many of the laboratories and research stations that form the national marine research foundation were founded in the 1930s (www.fiskeriverket.se/vanstermeny/omfiskeriverket.4.1e93312510e313daf128000225.html). Yet, there is a lack of data and understanding about fisheries impacts on the Baltic Sea ecosystems beyond the single species stock assessments and the most basic, direct effects of fishing. More ecosystem-level research is needed, and larger safety margins in Total Allowable Catch (TAC) should be applied (Hjerne, 2003). One key requirement is for better accounting of total catches, not only commercial landings data. As suggested, compulsory 100% observer coverage (onboard observer and/or remote video monitored) on all commercial fishing vessels would improve accounting of total catches (Anon., 2005d).

Unreported landings

The estimated unreported landings are thought to be conservative and therefore minimum estimates. Out of a total 1.09 million t unreported landings, more than 66% came from unreported landings during the 1980s and the 1990s. This reflects the limited information available for the present study, but is also a result of the cautious assumptions and conservative methods chosen here for this catch reconstruction. Based on the assumption that the introduction of quotas increased the incentive for un- and underreporting (Søndergaard, 2007), a break point was set to 1980. Further, several sources indicated that unreported landings have declined in recent years (K.-E. Karlsson, pers. comm., Swedish Tax Agency; B. Sjöstrand, J. Löwenadler Davidsson, pers. comm., Swedish Board of Fisheries), hence, the effort to remain conservative when setting anchor points in the 2000s.

The estimated unreported cod landings were about 18% of reported ICES landings statistics, and made up 45% of the total IUU catches of cod. A study on unreported cod fishing in the Baltic Sea suggested that the countries with the largest fraction of the TAC (i.e., Sweden, Denmark and Poland), were the biggest offenders with respect to unreported landings (Sporrong, 2007). According to a Polish fisher the quotas are exceeded in each country, but mainly by Poland and Sweden (M. Sandecki, www.fishsec.org/downloads/1172158401_70868.pdf). However, compared to the average unreported landings of Eastern Cod from 1993-2007, estimated by the ICES stock assessment working group (section 2.4.1.2, ICES, 2008a), Sweden's unreported landings of cod, as estimated here, are relatively small. ICES working group uses a 'Raising Factor' (RF), to estimate total landings. The RF is based on information on unallocated catches (i.e. unreported landings) from various countries, which has been added to the landings reported by the working group. The total landings (reported + unallocated) are divided by the unallocated catches to derive the RF. In ICES (2008a) the RF is different depending on if it is presented as RF (table in section 2.4.1.2; ICES, 2008a), or calculated based on the data presented (Table 2.4.1; ICES, 2008a). This is an example of the lack of transparency that makes stock assessment working group reports very unclear for anyone not part of the working group. Since the RF factor is a Baltic Sea total, and it is not possible to identify which, or how many countries, contributed actual information on unreported landings to derive it, Sweden's unreported landings may be higher than some, and smaller than some of the other individual countries surrounding the Baltic Sea. Since not all countries contribute with information, the RF factor is a minimum estimate (ICES. 2008a), and unreported landings will be more or less underestimated based on which countries that the working group obtain information from. For example; Sweden's unreported landings in 1994 estimated here for the catch reconstruction, equals a RF of 1.24 for Sweden. The unreported landings for Poland are thought to be about 300% (Bale *et al.*, this volume) which equals a RF of 3, hence, if Poland is one of the countries that does not report their unreported landings to the working group, the unallocated catches would be substantially underestimated.

The key message here is that the lack of data transparency evident in all ICES stock assessment working group reports is a problem for open and transparent accounting of resource use and countries' adherence to EU policies. The resources of the Baltic Sea are essentially public property (owned by the people of all Baltic countries), yet the continued non-transparency of fisheries data apparent in ICES reports makes the possibility for public accountability of democratically elected governments of Europe limited.

Discards

Information on Swedish boat-based discards was sparse, except for cod and flounder. Swedish discard studies have mainly focused on cod fisheries, and information found on other species was not detailed enough to be used to derive anchor points. The Swedish sampling of discard data has covered <1% of the fishing effort and the data are highly uncertain (Anon., 2007b). During times with restrictive quotas, discards due to high-grading are more prevalent (ICES, 2008a). A sampling system with limited observer coverage cannot adequately address discarding, particularly discarding due to high-grading, as fishers are known to change their behavior with observers onboard (Anon., 2004b).

The Swedish boat-based discards of cod in 2006 were estimated at about 1,800 t (total estimated discards of cod were around 3,100 t). Most of the discarded cod is undersized, and fishers are not allowed to land them. With large discards of undersized cod there is a large number of sexually immature fish that die, which is a loss of future reproduction capacity as well as catch opportunities (Anon., 2007b). The total cod discards in the Baltic Sea by all countries, as reported in ICES stock assessment working group reports were about 4,650 t in 2006 (ICES, 2008a, Table 2.4.20). Since the estimated Swedish boat-based discards were about 1,800 t in 2006, it would suggest that almost 38% of the total cod discards in the Baltic Sea 2006 was discarded by Swedish fishers. Considering that Sweden's fraction of the total landings of cod was around 20% (ICES, 2008a Table 2.4.1), this boat-based discard rate seemed high. Sweden's relatively high discards might partly be explained by extensive fishing in subdivision 25 where there is a lot of young cod (Y. Walther, K. Ringdahl, pers. comm., Swedish Board of Fisheries). However, it is unlikely that the difference in discards between Sweden and other countries is that big, therefore this discrepancy is more likely an indication of uncertainties in the existing data, and is yet another example of problem with transparency in the ICES stock assessment working group reports.

'Less important' species

Considering all taxa, the total difference between reconstructed catches and ICES landings statistics was 31%. If one excludes the three major commercial species cod, herring and sprat (accounting for 94% of

reported data as per ICES landings statistics), the difference between reconstructed total catches and reported landings was 123 %. This implies that there is a larger fraction of IUU catches for 'less important' species, which is an indication of ICES' focus on the important commercial species, when it comes to enforcement of reporting, and research. While historically potentially justifiable due to the focus on market-based economic development, given the recent and future focus on ecosystem-based management, this focus needs to shift towards comprehensive and inclusive accounting of total catches, including all IUU and non-commercial catches. It is surprising that such a shift in focus of reported data has not become evident in at least the most recent years.

Issues for improvement

The European fisheries in general are economically stressed, to a large extent due to depleted fish stocks (Sissenwine and Symes, 2007). Many of the problems in the Baltic Sea fisheries are caused by the overcapacity that exists in the fishing fleet (Hildén, 1997). Overcapacity is the one of the main reasons for high IUU catches (Sporrong 2007), and it hinders any move for sustainable fisheries (Pauly *et al.* 2002). The build up of overcapacity in fisheries, in the Baltic Sea as well as globally, is heavily influenced by subsidies in fisheries policies (Hildén, 1997; Nyström and Andersson, 2007; Sumaila *et al.*, 2007; ICES, 2009). The attempts to decrease fleet overcapacity by using decommissioning subsidies have had no, or even opposite effects. Subsidies for decommissioning have globally more often caused an increase fishing capacity due to modernization of the fleet (Pauly *et al.*, 2002), and in Sweden the capture efficiency increased by 50% from 1995-2002 (Ackefors, 2008). Thus, a key issue to be addressed urgently by all countries in Europe, and globally, is a substantial reduction of harmful (from an ecosystem and overfishing perspective) subsidies (Sumaila *et al.*, 2007).

Complete (100%) observer cover is required for proper, reliable and comprehensive accounting of catches and discards, due to the often substantial observer bias effects that are known to skew data with less than 100% coverage (Babcock and Pikitch, 2003; Anon., 2006a; Bremner *et al.*, 2009). The success of full observer coverage has been demonstrated, for example, on the West Coast of Canada, through a combination of onboard observer and video-monitoring (W Erikson, pers. comm., halibut representative, Commercial Industry Caucus, http://seafoodchoices.org/seafoodsummit/documents/EricksonW.pdf). Furthermore, 100% observer cover would enable for a complete buy-in by the industry (no-one is being disadvantaged or preferred) and industry self-control. The main counter-argument for a 100% observer cover has been the cost, which should be re-covered from the industry. If cost arguments are seriously raised by the industry, they are likely an indication of economic difficulties, likely due to overcapacity, and the fleet in question needs to be reduced. However, 100% observer cover would save some money for fisheries control, which could be used to help finance the coverage. The cost also has to be contrasted to the cost to society of overfished stocks, lost or reduced ecosystem services, and the cost of trying to rebuild the Baltic Sea ecosystem if politics continues to ignore scientific advice.

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REFERENCES

Ackefors, H. 2008. Is it the politicians or the fisheries that control the fishing? Kungl. Skogs- och Lantbruksakademiens Tidskrift, 2:36-43, 2008. Available at http://www.ksla.se/ "Fiskets kollaps utanför Nordamerika – vad kan Sverige och Europa lära?" accessed 2009-04-05.

Anon. (1952). Year book of fisheries statistics 1951. Statistics Sweden. Stockholm 1952. Anon.. 1951-1993. Fisheries statistics. Statistics Sweden (e.g., Anon. 1952, Anon. 1984, Anon. 2003).

Anon. (1977a). The Swedish people's fishing habits.. Swedish Ministry of Agriculture. Publication series Ds Jo. 1977:3. Stockholm 1978? "Svenskarnas fiskevanor".

Anon. (1977b). The fishery industry in the future, report the fishery committee. Swedish Government Official Report 1977:74. Stockholm 1977. “Fiskerinäringen i framtiden, betänkande fiskerikommittén”.

Anon. (1978). Fish on free time, final report of 1973 year’s fishing waters investigation. Swedish Government Official Reports 1978:75. “Fiska på fritid, slutbetänkande av 1973 års fiskevattenutredning.” Stockholm 1978.

Anon. (1984) Swedish fishery 1982 – an overview. Definite data. Statistics Sweden. Report series J 1984:7. SCB-print Örebro 1984.

Anon. (1993). Swedish fishery year X– an overview. Statistics Sweden. Report series J 55 SM

Anon. (2001). Small scale coastal fishery and inland fishery – an analysis. Swedish Board of Fisheries. No. 101-800-00. “Småskaligt kustfiske och insjöfiske – en analys”.

Anon. (2002) The fishery on the south coast. A study of fishery in Blekinge and Skåne county. County Administrative Board of the southern region. Exakta, Hässleholm 2002. Available at http://www.lansstyrelsen.se/skane/Publikationer/Rapporter_trycksaker/index.htm “Fisket på sydkusten. En studie av fiskerinäringen i Blekinge och Skåne län.” accessed 2009-03-03.

Anon. (2003a) Prerequisite for, and biological and economical consequences of, a discard prohibition from a national perspective as well as an EU perspective. Swedish Board of Fisheries. Partial report 2003-02-27. ”Förutsättningar för och biologiska och ekonomiska konsekvenser av ett dumpningsförbud ur ett nationellt perspektiv såväl som ett EU-perspektiv”.

Anon. (2003b) Swedish fisheries 1994-1999. Swedish Board of Fisheries and Statistics Sweden. Report series JO 55 SM 0201. “Fiske – en översikt”.

Anon. (2004a) Assignment regarding unreported fishing etc. Swedish Board of Fisheries. Report. Dno. 121-3160-02. “Uppdrag angående orapporterat fiske m.m”.

Anon. (2004b) Prerequisite for, and biological and economical consequences of, a discard prohibition from a national perspective as well as an EU perspective. Swedish Board of Fisheries. Partial report 2, 2004-02-26. ”Förutsättningar för och biologiska och ekonomiska konsekvenser av ett dumpningsförbud ur ett nationellt perspektiv såväl som ett EU-perspektiv”.

Anon. (2005a) The future of fishery on the south east coast – development or liquidation? County Administrative Board of the south east region. Printus, Malmö 2005. (Östergötland, Södermanlands län, Gotlands län, Kalmar län, and Stockholms län.) Available at http://www.d.lst.se/sodermanland/Publikationer/2005/rapport_fiskets_framtid_pa_sodra_ostkusten.htm ”Fiskets framtid på södra ostkusten – utveckling eller avveckling?” accessed 2009-03-03.

Anon. (2005b) The situation regarding the work on decreasing damages and by-catches of seals and comorant. Swedish Board of Fisheries. Available at http://www.fiskeriverket.se/download/18.33bca6be10f866e596f8000629/regeringsuppdrag_sal_skarv.pdf “Situationen beträffande arbetet med att minska skador och bifångster av säl och skarv. Strategi för problemens långsiktiga hantering” accessed 2009-03-18.

Anon. (2005c) Fishing 2005, a study on the Swedish people’s fishing interest. Swedish Board of Fisheries and Statistics Sweden. Finfo 2005:10. “Fiske 2005, en undersökning om svenskarnas fritidsfiske”.

Anon. (2005d) Commercial industry caucus pilot integration proposal. Prepared by Diamond Management Consulting Inc. March 2005.

Anon. (2006a) Observer programmes. Best practice, funding options, and North Sea case study. WWF. Available at http://scotland.wwf.org.uk/search_results.cfm?uNewsID=2060 accessed 2009-03-09.

Anon. (2006b) Working paper on discards in Danish fisheries. Ministry of Food, Agriculture and Fisheries. “Arbejdspapir om discard i dansk fiskeri”.

Anon. (2007a) Recreational fishing and recreational fishing dependant business. Swedish Board of Fisheries. Available at http://www.fiskeriverket.se/download/18.323810fc116f29ea95a80001699/Fritidsfiske_web.pdf “Fritidsfiske och fritidsfiskebaserad verksamhet” accessed 2009-01-10.

Anon. (2007b) Actions to enable more precise estimations of fisheries’ by-catches and their effect on threatened species and stands. Swedish Board of Fisheries. Available at http://www.fiskeriverket.se/download/18.36bbe77c11545cd713780003339/bif%C3%A5ngster+reg.uppdrag+070629+dnr101-3108-05.pdf ”Åtgärder för att möjliggöra noggrannare uppskattningar av fiskets bifångster samt deras effekt på hotade arter och bestånd” accessed 2009-01-10.

Anon. (2007c) Evaluation report of catch registration in Baltic-Sea member states 2005-2006. European commission, Directorate-General for Fisheries and Maritme Affairs, Control and Enforcement, Fisheries inspection.

Anon. (2007d) A policy to reduce unwanted by-catches and eliminate discards in European fisheries. Commission of the European communities, communication from the commission to the council and the European parliament, COM(2007) 136 final. Brussels 2007.

Anon. (2008a) Fishing tourism and countryside development . Administrative County Board of Stockholm. Report 2008:30. Available at http://www.ab.lst.se/templates/Publications_____1897.asp ”Fisketurism och landsbygdsutveckling (Rapport 2008:30) – Rapportering av uppdrag 30 i 2008 års regleringsbrev till länsstyrelserna” accessed 2009-03-11.

Anon. (2008b) Annual report 2007. Swedish Board of Fisheries. “Årsredovisning 2007” Intellecta Tryckindustri, Solna 2008. Available at http://www.fiskeriverket.se/arkiv/publikationer/publikationerbroschyrerochinfoblad/arsredovisningfor2007.5.323810fc116f29ea95a80001747.html accessed 2009-03-30.

Anon. (2008c) Council regulation (EC) No 338/2008 of 14 April 2008 providing for the adaptation of cod fishing quotas to be allocated to Poland in the Baltic Sea (Subdivision 25-32, EC Waters) from 2008 to 2011. Official Journal of the European Union, 51: L1 07/1. Available at http://eur-lex.europa.eu/JOHtml.do?uri=OJ:L:2008:107:SOM:en:HTML accessed 2009-04-03.

Anon. (2008d) Statement about the Swedish Board of Fisheries reporting of the government assignment regarding recreational fishing and recreational fishing dependant business (Your Dno. Jo2007/3400). Swedish Ministry of Agriculture. Available at http://www.ksla.se/sv/retrieve_file.asp?n=1600 accessed 2009-03-11.

Ask, L., and Westerberg, H., editors. (2006) Fish populations and environment in sea and fresh water, resources- and environment summary 2006. Swedish Board of Fisheries. "Fiskbestånd och miljö i hav och sötvatten, resurs och miljööversikt 2006".

Ask, L., and Westerberg, H., editors. (2008) Fish populations and environment in sea and fresh water, resources- and environment summary 2008. Swedish Board of Fisheries. "Fiskbestånd och miljö i hav och sötvatten, resurs och miljööversikt 2008".

Babcock, E., and Pikitch, E. (2003) How much observer coverage is enough to adequately estimate by-catch? Report of the Pew Institute for Ocean Science, Rosentiel School of Marine and Atmosheric Science, University of Miami, Miami, FL. Available at http://www.pewcenteronthestates.org/uploadedFiles/wwwpewtrustsorg/Reports/Protecting_ocean_life/oceana_by-catch_110403.pdf accessed 2009-02-20.

Bagge, O. (1989). Danish discard in sub-division 22 in 1988 and in 1978-89 as indicator of strength of year classes. ICES, Baltic Fish commission, CM 1989/J:24.

Bleil, M., and Oeberst, R. (2000). Reproduction areas of the cod stock in the western Baltic Sea. ICES C.M. 2000/N:02.

Botsford, L., Castilla, C., and Peterson, H. (1997). The management of fisheries and marine ecosystems. Science 277:509-515.

Bratt, M. and Jansson, M. (2007). The extent of recreational fishing 2006. Statistics Sweden, Regions and environments, technical report. "Fritidsfiskets omfattning 2006".

Bray, K. (2000) A global review of Illegal, Unreported and Unregulated (IUU) fishing. Food and Agricultural Organization (FAO), AUS:IUU/2000/6, Rome, 53p.

Bremner, G., Johnstone, P., Bateson, T., and Clarke, P. (2009) Unreported by-catch in the New Zealand West Coast South Island hoki fishery. Marine Policy 33:504-512.

Brown, J., Macfadyen, G., Huntington, T., magnus, J., and Tumilty, J. (2005) Ghost fishing by lost fishing gear. Final report to DG fisheries and Maritme Affairs of the European Commission. Fish/2004/20. Institute for European Environmental Policy / Poseidon Aquatic Resource Management Ltd joint report.

Bruckmeier, K., and Höj Larsen, C. (2008) Swedish coastal fisheries – From conflict mitigation to participatory management. Marine Policy 32:201-211.

Casini, M., Lövgren, J., Hjelm, J., Cardinale, M., Molinero, J.-C., and Kornilovs, G. (2008) Multi-level trophic cascades in heavily exploited open marine ecosystem. Proceedings of The Royal Society, doi: 10.1098/rspb.2007.1752. Published online, available at http://www.fiskeriverket.se/arkiv/nyhetsarkivpressrum/ovrigt/minskadtorskkanbidratillalgblomning.5.323810fc116f29ea95a80004622.html "Minskad torsk kan bidra till algblomning" accessed 2009-04-04.

Coleman, F., Figueire, W., Ueland, J., and Crowder, L. (2004) The impact of United States recreational fisheries on marine fish populations. Science 305:1958-1960.

Eero, M., Köster, F., Plikshs, M., and Thurow, F. (2007) Eastern Baltic cod (Gadus morhua callarias) stock dynamics: extending the analytical assessment back to the mid-1940s. ICES Journal of Marine Science, 64:1257-1271.

Gårdmark, A., Aho, T., and Florin, A-B. (2004) Coastal fish and fishery – the state of the resources of fish without quotas in 2003. Finfo 2004:5. Available at http://www.fiskeriverket.se/service/publikationer/fiskeriverketinformerar.4.63071b7e10f4d1e2bd3800013712.html#2004 "Kustfisk och fiske – tillståndet hos icke kvotbelagda fiskresurser år 2003" accessed 2009-04-10.

Harvey, C., Cox, S., Essington, T., Hansson, S., and Kitchell, J. (2003) An ecosystem model of food web and fisheries interactions in the Baltic Sea. ICES Journal of Marine Science, 60:939-950.

Hemmingsson, M., and Lunneryd, S.-G. (2007) Push up traps in Sweden, introduction of a new seal secure fishing gear. Swedish Board of Fisheries. Finfo 2007:8. Available at http://www.fiskeriverket.se/service/publikationer/fiskeriverketinformerar/finfo2007/finfo20078.4.36bbe77c11545cd71378000636.html "Pushup-fällor i Sverige, introduktion av ett nytt sälsäkert fiskeredskap" accessed 2009-03-11.

Hildén, M. (1997) Boundary conditions for the sustainable use of major fish stocks in the Baltic Sea. Ecological Economics, 20:209-220.

Hjerne, O. (2003) Fisheries management in an ecological context – examples from the Baltic Sea. Doctoral Dissertation, Department of System Ecology, Stockholm University.

Hultkrantz, L. (1997) Fish and cheating - Objectives, means and power in fishery politics. ESO Ds 1997:81. Chapter 4, p. 9-26. "Fisk och fusk – Mål, medel och makt I fiskeripolitiken".

ICES (1974) Report of the working group on assessment of demersal stocks in the Baltic. ICES, Demersal Fish (Northern) Committee C.M.1974/F:4. Riga, 25 February – 1 March, 1974.

ICES (2001) Report of the study group on discard and by-catch information. ICES, Headquarters 26-29 March 2001, Copenhagen, Denmark. ICES CM 2001/ACFM:13.

ICES (2005) Joint report of the study group on unaccounted fishing mortality (SGUFM) and the workshop on unaccounted fishing mortality (WKUFM), 25-27 September 2005, Aberdeen, UK. ICES CM 2005/B:08. 68p.

ICES (2007a) Report of the Baltic fisheries assessment working group (WGBFAS). ICES Advisory Committee on Fishery Management, ICES CM 2007/ACFM:15.

ICES (2008a) Report of the Baltic fisheries assessment working group (WGBFAS). ICES Advisory Committee, ICES CM 2008\ACOM:06.

ICES (2008b) Report of the Baltic salmon and trout working group (WGBAST). ICES advisory Committee on Fishery Management, ICES CM2008/ACOM:05

ICES (2009) ICES catch statistics database. ICES. *http://www.ices.dk/fish/statlant.asp* [Date accessed: 2009-03-11]

Icelandic Fisheries (2009). Information centre of the Icelandic Ministry of Fisheries and Agriculture. Pelagic fishes. http://www.fisheries.is/main-species/pelagic-fishes/ [Date accessed 2009-04-02]

Jennings, S., and Kaiser, M. (1998) The effect of fishing on marine ecosystems. Advances in Marine Biology, 34:201-352 . In Lövgren, J., Ringdahl, K., and J. Hjelm. Discardmönster och miljöeffekter av discard I södra Östersjön 1996-2003. Unpublished.

Johansson, S. and the County fishery advisers in concerned counties. (2005) The development of the commercial fishery along the northern coast 1990-2004 and suggested actions. County Administrative Board in Uppsala, Gävleborg, Västernorrland, Västerbotten and Norrbotten. Printus, Malmö 2005. "Utvecklingen av fiskerinäringen längs Norrlandskusten 1990-2004 och förslag till åtgärder".

Karlsson, O., Härkönen, T., and Bäcklin, B.-M. (2007) Seals on the rise. The Sea 2007 Swedish Museum of Natural History. Available at http://www.nrm.se/download/18.1877eab11162387461d80001203/S %C3 %A4lar+p %C3 %A5+uppg %C3 %A5ng+Havet2007.pdf "Sälar på uppgång" accessed 2009-03-12.

Königson, S., Fjälling, A., and Lunneryd, S-G. (2005) Impact of grey seals in the herring gillnet fishery along the Swedish Baltic coast. ICES CM, 6p.p.

Ljunggren, L., Sandström, A., and Johansson, G. (2008)Extensive damage on recruitment for the Baltic Sea coastal fish stocks. Swedish Board of Fisheries and Swedish Environmental Protection Agency. Available at http://www.fiskeriverket.se/arkiv/publikationer/publikationerutredningarpmrapporter/rekryteringsskadorpaostersjonskustbestand.5.1e7cbf241100bb6ff0b80001136.html accessed 2009-04-10.

Lundgren, R. (2007). Swedish sea-fisheries during 2006. Definitive data. Swedish Board of Fisheries and Statistics Sweden, report series JO 55 SM 0701. Available at http://www.fiskeriverket.se/vanstermeny/statistikochdatabaser/statistiskameddelanden/sm2007.4.63071b7e10f4d1e2bd3800013208.html accessed 2009-04-06.

Lövin, I. (2007). Silent ocean. The hunt of the last edible fish. "Tyst hav. Jakten på den sista matfisken". Ordfront, Stockholm 2007.

MacKenzie, B., Alheit, J., Conley, D., Holm, P., and Kinze, C.C. (2002) Ecological hypotheses for historical reconstruction of upper trophic level biomass in the Baltic Sea and Skagerrak. Canadian Journal of Fisheries and Aquatic Science 59:173-190.

Nilsson, M. (1991) Recreational fisheries - 1990. Statistics Sweden and Swedish Board of Fisheries, 2nd edition.

Nilsson, M. (1995) National survey on Swedish recreational fisheries 1995. Statistics Sweden and Swedish Board of Fisheries. Report series J56 SM9601. "Sport- och husbehovsfiske 1995. En undersökning av Svenskarnas fiskevanor".

Nordlund, S. (2008) Black fishing for millions. Norrbotten's courier, 2008-01-24. Available at http://www.kuriren.nu/arkiv/2008/01/24/Lule %E5/3090024/Svartfiske-f %F6r-miljoner.aspx "Svartfiske för miljoner" accessed 2009-03-11.

Norström, K., Wahlstedt, G., and Otterskog, L. (2000) Fishing 2000. A study on the Swedish people's sport- and house consumption fishing. Statistics Sweden and Swedsih Board of Fisheries. Finfo 2000:1. Available at http://www.fiskeriverket.se/service/publikationer/fiskeriverketinformerar.4.63071b7e10f4d1e2bd3800013712.html#2000 "Fiske 2000: En undersökning om svenskarnas sport- och husbehovsfiske" accessed 2009-03-20.

Nyström, S., and Andersson, H. (2008) Appendix – workshop in Vaxholm November 2007. Kungl. Skogs- och Lantbruksakademiens Tidskrift, 2:62-64, 2008. Available at http://www.ksla.se/ "Fiskets kollaps utanför Nordamerika – vad kan Sverige och Europa lära?" accessed 2009-04-05.

Pauly, D., Christensen, V., and Walters, C. (2000) Ecopath, Ecosim, and Ecospace as tool for evaluating ecosystem impact of fisheries. ICES Journal of Marine Science 57:697-706.

Pauly, D., Christensen, V., Guénette, S., Pitcher, T.J., Sumaila, U.R., Walters, C.J., Watson, R., and Zeller, D. (2002) Towards sustainability in world fisheries. Nature, 418:689-695.

Rahikainen, M., Peltonen, H., and Pönni, J. 2004. Unaccounted mortality in northern Baltic Sea herring fishery – magnitude and effects on estimates of stock dynamics. Fisheries Research 67, 111-127.

Sissenwine, M., and Symes, D. (2007) Reflections on the common fisheries policy. Report to the General directorate for fisheries and maritime affairs of the European Commission. July 2007. Available at http://www.greenpeace.org/raw/content/denmark/press/rapporter-og-dokumenter/reflections-on-the-common-fish.pdf accessed 2009-04-04.

Sporrong, N., editor. (2007) A report of IUU fishing of Baltic Sea. The Fisheries Secretariat. OH-print, 2007. Available at http://www.fishsec.org/publications.asp accessed 2009-03-13.

Sumaila, R., Khan, A., Watson, R., Munro, G., Zeller, D., Baron, N., and Pauly, D. (2007) The World Trade Organization and global fisheries sustainability. Fisheries Research 88:1-4.

Søndergaard, M. K. (2007) Dansk fiskeri c. 1945-2005 : teknologi, udvikling og forestillinger om kontrol [Danish fisheries, 1945-2005: Technology, development, and perceptions about inspections], PhD thesis, Center for Maritime og Regionale Studier, Fiskeri- og Søfartsmuseet/Syddansk Universitet Esbjerg: 322.

Statistics Sweden (2008). Sweden's population (in one year classes) 1860-2008. http://www.scb.se/Pages/ProductTables_____25795.aspx "Sveriges befolkning (i ettårsklasser) 1860-2008" [Date accessed: 2009-03-17]

Sweet&Salt (2006). Swedish Board of Fisheries. Available at http://sottochsalt.fiskeriverket.se/Article.asp?ArticleId=88 "Sött&Salt 2006-12-28" [Date accessed: 2009-03-11].

Thulin, J., and Andrushaitis, A. (2003) The Baltic Sea: its past, present and future. In print in the proceedings of the Religion, Science & the Environment Symposium V on the Baltic Sea, 2003.

Zeller, D., Booth, S., Craig, P., and Pauly, D. (2006) Reconstruction of coral reef fisheries catches in American Samoa, 1950-2002. Coral Reefs 25:144-152.

Zeller, D., and Pauly, D., editors. (2007) Reconstruction of marine fisheries catches for key countries and regions (1950-2005). Fisheries Centre Research Report, FCRR, 2007, 15(2). Available at http://www.fisheries.ubc.ca/publications/reports/report15_2.php accessed June 12, 2008.

Zeller, D., Booth, S.,Craig, P., and Pauly, D. (2007) Re-estimation of small scale fisheries catches for the U.S. flag-associated island areas in the Western Pacific: The last 50 years. Fishery Bulletin 105.

APPENDIX A

Appendix Table A1. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for Sweden (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	55,488	0	2,799	4,053	2,452	64,791
1951	56,373	0	2,987	4,132	2,833	66,325
1952	59,583	-1	3,320	4,632	3,219	70,753
1953	62,030	-1	3,604	4,206	3,605	73,444
1954	59,631	0	3,622	4,056	3,995	71,305
1955	64,214	-1	4,070	4,487	4,399	77,170
1956	57,399	-1	3,791	4,321	4,802	70,314
1957	64,163	0	4,439	5,210	5,216	79,028
1958	64,940	0	4,629	4,691	5,626	79,886
1959	66,625	-1	4,914	5,146	6,033	82,717
1960	68,303	0	5,241	5,897	6,438	85,878
1961	68,115	0	5,432	5,981	6,860	86,388
1962	70,695	34	5,744	5,831	7,284	89,590
1963	61,933	15	5,223	5,228	7,718	80,117
1964	58,758	-12	4,949	4,774	8,180	76,649
1965	59,052	5,955	5,688	5,513	8,659	84,867
1966	60,414	6,321	5,977	5,777	9,138	87,627
1967	66,913	5,556	6,729	5,992	9,596	94,786
1968	84,646	5,467	8,582	6,814	10,051	115,561
1969	58,847	5,675	6,489	5,429	10,551	86,993
1970	57,159	4,405	6,194	4,921	11,065	83,744
1971	53,262	3,079	5,899	4,399	11,525	78,164
1972	63,848	2,995	7,173	4,927	11,959	90,902
1973	92,300	2,310	10,152	6,696	12,399	123,856
1974	89,842	2,280	10,106	6,358	12,864	121,450
1975	88,308	2,784	10,383	6,383	13,334	121,192
1976	70,390	27	8,547	5,614	13,478	98,057
1977	76,048	0	9,322	5,513	13,616	104,499
1978	76,044	0	9,374	5,356	13,724	104,498
1979	116,195	0	14,755	8,033	13,821	152,803
1980	133,744	0	17,536	9,729	13,908	174,917
1981	133,332	0	19,662	10,728	13,966	177,688
1982	142,969	0	22,853	11,369	14,015	191,206
1983	146,177	0	25,966	12,430	14,054	198,627
1984	142,656	0	28,286	13,335	14,095	198,371
1985	123,652	0	26,089	11,576	14,136	175,454
1986	95,548	0	22,198	9,735	14,182	141,663
1987	91,615	2,273	23,545	9,963	14,233	141,629
1988	111,968	0	27,858	11,780	14,296	165,903
1989	129,486	0	31,303	12,738	14,392	187,918
1990	122,067	-58	29,736	12,303	14,472	178,520
1991	112,322	2,707	27,600	10,773	15,438	168,840
1992	150,327	-4,150	34,942	10,855	16,419	208,393
1993	195,301	1,113	48,591	13,669	17,434	276,108
1994	236,405	825	57,092	17,480	18,509	330,311
1995	260,341	-8,717	57,454	18,931	17,756	345,766
1996	273,562	-35,035	53,646	18,841	16,918	327,932
1997	269,735	-21,086	54,046	17,096	16,017	335,807
1998	309,387	-19,160	61,564	21,660	15,067	388,518
1999	234,304	-23,274	43,148	15,531	14,056	283,766
2000	229,174	-19,570	41,183	14,992	12,544	278,323
2001	178,286	-23,270	29,192	11,768	11,093	207,068
2002	143,211	-3,686	25,264	10,309	9,706	184,804
2003	128,313	-1,773	21,907	9,745	8,385	166,578
2004	146,884	-4,713	19,827	9,979	7,130	179,108
2005	163,850	-10,244	15,943	11,596	7,065	188,211
2006	165,938	-14,779	15,617	11,278	6,548	184,602
2007	164,551	-8,028	16,126	10,933	6,548	190,130

Appendix Table A2. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for cod (*Gadus morhua*) for Sweden (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	21,290	0	1,065	2,405	267	25,027
1951	21,340	0	1,141	2,419	309	25,209
1952	25,475	0	1,451	2,897	351	30,174
1953	20,159	0	1,219	2,300	393	24,071
1954	19,099	0	1,221	2,186	436	22,942
1955	21,068	0	1,420	2,420	480	25,388
1956	20,178	0	1,430	2,325	524	24,458
1957	26,918	0	2,002	3,112	569	32,601
1958	21,224	0	1,652	2,462	613	25,951
1959	22,855	0	1,859	2,659	658	28,031
1960	27,635	0	2,344	3,226	702	33,907
1961	28,701	0	2,534	3,361	748	35,344
1962	25,140	0	2,307	2,953	794	31,195
1963	22,827	0	2,175	2,690	842	28,534
1964	16,222	0	1,602	1,918	892	20,634
1965	15,736	5,969	2,219	2,574	944	27,442
1966	16,182	6,343	2,381	2,680	996	28,582
1967	17,784	5,579	2,551	2,788	1,047	29,749
1968	18,508	5,500	2,705	2,874	1,096	30,683
1969	16,656	5,645	2,590	2,678	1,150	28,720
1970	13,664	4,092	2,124	2,139	1,207	23,226
1971	12,945	2,725	1,929	1,894	1,257	20,750
1972	13,762	2,709	2,085	1,997	1,304	21,857
1973	16,134	2,255	2,392	2,236	1,352	24,369
1974	14,184	2,251	2,195	2,005	1,403	22,038
1975	15,168	2,797	2,462	2,198	1,454	24,079
1976	22,802	0	3,204	2,798	1,526	30,331
1977	18,327	0	2,639	2,256	1,599	24,821
1978	15,996	0	2,359	1,975	1,669	21,999
1979	24,003	0	3,624	2,973	1,739	32,338
1980	34,089	0	5,265	4,235	1,808	45,397
1981	44,300	0	7,820	5,640	1,874	59,634
1982	44,807	0	8,898	5,845	1,940	61,490
1983	54,876	0	12,108	7,331	2,004	76,319
1984	65,788	0	15,967	8,998	2,069	92,822
1985	54,723	0	14,489	7,660	2,134	79,006
1986	48,804	0	13,999	6,989	2,200	71,992
1987	50,186	0	15,502	7,351	2,268	75,307
1988	58,027	0	17,382	8,485	2,338	86,233
1989	55,919	0	16,229	8,162	2,414	82,724
1990	54,473	0	15,300	7,937	2,488	80,198
1991	39,552	0	10,740	5,752	2,719	58,762
1992	16,244	0	4,259	2,357	2,961	25,821
1993	12,201	0	3,085	1,767	3,217	20,270
1994	25,685	0	6,254	3,712	3,493	39,144
1995	27,289	0	6,390	3,934	3,554	41,168
1996	36,931	0	8,303	5,312	3,580	54,126
1997	29,327	0	6,319	2,637	3,572	41,855
1998	17,666	0	3,642	4,036	3,532	28,875
1999	17,476	0	3,439	3,220	3,456	27,591
2000	19,801	0	3,712	2,786	2,777	29,076
2001	21,120	0	3,762	2,818	2,184	29,884
2002	15,203	0	2,566	2,141	1,673	21,583
2003	14,686	0	2,341	2,521	1,240	20,789
2004	15,201	0	2,281	2,109	880	20,472
2005	10,558	0	1,486	2,175	812	15,031
2006	12,252	0	1,610	3,084	697	17,643
2007	12,558	0	1,650	2,480	697	17,385

Appendix Table A3. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for herring (*Clupea harengus*) for Sweden (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	27,071	0	1,354	341	281	29,047
1951	28,184	0	1,480	356	325	30,345
1952	28,289	0	1,556	418	369	30,632
1953	35,741	0	2,055	605	414	38,815
1954	34,435	0	2,066	657	458	37,616
1955	36,430	0	2,277	774	505	39,986
1956	29,386	0	1,910	689	551	32,536
1957	28,258	0	1,907	724	598	31,487
1958	34,684	0	2,428	965	645	38,722
1959	32,284	0	2,341	987	692	36,303
1960	27,639	0	2,073	906	739	31,357
1961	27,455	0	2,128	917	787	31,287
1962	31,930	0	2,554	1,104	836	36,424
1963	27,691	0	2,285	974	886	31,836
1964	31,297	0	2,660	1,138	938	36,033
1965	31,082	0	2,720	1,149	993	35,944
1966	30,511	0	2,746	1,164	1,048	35,469
1967	36,900	0	3,413	1,431	1,101	42,845
1968	53,256	0	5,059	2,129	1,153	61,597
1969	30,167	0	2,941	1,225	1,211	35,544
1970	31,757	0	3,176	1,327	1,270	37,530
1971	32,351	0	3,316	1,373	1,322	38,362
1972	41,721	0	4,381	1,821	1,372	49,295
1973	59,546	0	6,401	2,671	1,423	70,041
1974	60,352	0	6,639	2,747	1,476	71,213
1975	62,791	0	7,064	2,934	1,530	74,319
1976	41,841	0	4,812	1,983	1,615	50,250
1977	52,871	0	6,212	2,570	1,701	63,354
1978	54,629	0	6,555	2,692	1,785	65,662
1979	86,078	0	10,545	4,348	1,868	102,839
1980	92,923	0	11,615	4,757	1,951	111,246
1981	84,500	0	11,375	4,458	2,030	102,363
1982	92,675	0	13,367	4,984	2,109	113,135
1983	86,561	0	13,317	4,594	2,187	106,659
1984	65,519	0	10,710	3,430	2,265	81,924
1985	57,554	0	9,961	2,971	2,344	72,830
1986	39,909	0	7,291	2,006	2,424	51,630
1987	36,446	0	7,009	1,803	2,505	47,763
1988	41,828	0	8,446	2,162	2,590	55,026
1989	65,032	0	13,757	3,545	2,680	85,014
1990	55,174	-12	12,199	3,132	2,769	73,263
1991	59,176	2,324	14,192	3,633	3,033	82,359
1992	75,907	-4,807	17,091	4,145	3,309	95,645
1993	86,497	765	21,816	5,127	3,603	117,807
1994	70,886	1,345	17,480	4,261	3,919	97,891
1995	68,019	-1,976	15,454	3,871	3,905	89,273
1996	67,115	-30,064	8,374	2,158	3,859	51,441
1997	110,465	-49,684	13,250	3,516	3,784	81,332
1998	147,706	-69,105	16,506	4,565	3,683	103,355
1999	108,316	-54,606	10,849	3,099	3,550	71,208
2000	120,887	-54,300	12,918	3,896	3,157	86,558
2001	75,194	-29,230	8,549	2,644	2,783	59,940
2002	51,194	-6,972	7,872	2,527	2,427	57,047
2003	39,350	5,907	7,694	2,542	2,089	57,581
2004	43,922	934	6,056	2,444	1,770	55,125
2005	48,940	2,749	5,169	2,758	1,835	61,451
2006	53,166	14,106	6,727	3,626	1,775	79,400
2007	53,503	7,167	6,067	3,270	1,775	71,782

Appendix Table A4. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for sprat (*Sprattus sprattus*) for Sweden (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	8	0	0	0	0	9
1951	12	0	1	1	0	13
1952	13	0	1	1	0	14
1953	19	0	1	1	0	21
1954	35	0	2	2	0	39
1955	59	0	4	3	0	66
1956	38	1,072	72	59	0	1,241
1957	120	1,547	113	89	0	1,869
1958	839	1,491	163	125	0	2,618
1959	355	2,394	199	147	0	3,096
1960	257	3,581	288	206	0	4,332
1961	76	3,047	242	168	0	3,533
1962	155	3,277	275	185	0	3,892
1963	101	3,020	257	169	0	3,547
1964	58	0	5	3	0	66
1965	46	0	4	3	0	53
1966	38	0	3	2	0	43
1967	55	0	5	3	0	63
1968	112	0	11	6	0	129
1969	134	4,889	490	276	0	5,788
1970	31	3,234	327	180	0	3,771
1971	69	2,567	270	145	0	3,052
1972	102	3,035	329	173	0	3,640
1973	6,310	0	678	349	0	7,338
1974	5,497	0	605	305	0	6,407
1975	31	2,616	298	147	0	3,092
1976	713	1,257	227	110	0	2,306
1977	433	1,718	253	120	0	2,524
1978	807	0	97	45	0	949
1979	2,240	0	274	126	0	2,640
1980	2,388	0	299	134	0	2,821
1981	1,510	0	203	86	0	1,799
1982	1,890	0	273	108	0	2,271
1983	1,747	0	269	101	0	2,117
1984	7,807	0	1,276	454	0	9,537
1985	7,111	0	1,231	417	0	8,759
1986	2,573	0	470	152	0	3,195
1987	870	2,273	604	187	0	3,935
1988	7,307	0	1,475	439	0	9,222
1989	3,453	0	730	209	0	4,393
1990	7,485	15	1,659	458	0	9,617
1991	8,328	372	2,008	535	0	11,243
1992	53,558	642	13,029	3,361	0	70,590
1993	92,416	284	23,175	5,794	0	121,669
1994	135,779	-579	32,854	8,403	0	176,456
1995	150,435	-6,735	33,913	8,881	0	186,494
1996	163,087	-4,887	36,228	9,721	0	204,149
1997	123,208	28,692	33,722	9,281	0	194,903
1998	141,209	49,891	41,087	11,609	0	243,796
1999	106,000	31,300	28,558	8,293	0	174,151
2000	85,981	34,619	24,241	7,242	0	152,083
2001	79,553	5,847	16,568	5,098	0	107,066
2002	74,109	3,191	14,455	4,588	0	96,343
2003	71,188	-7,788	11,412	3,741	0	78,553
2004	83,949	-5,649	10,962	4,463	0	93,725
2005	100,797	-12,997	8,780	4,829	0	101,409
2006	97,584	-28,884	6,870	3,779	0	79,349
2007	95,897	-15,197	8,070	4,439	0	93,209

Appendix Table A5. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for salmon (*Salmo salar*) for Sweden (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	1,400	0	94	159	21	1,674
1951	1,105	0	74	126	24	1,329
1952	796	0	53	90	28	968
1953	414	-1	28	47	31	519
1954	483	0	32	55	34	604
1955	295	0	20	34	38	386
1956	670	0	45	76	41	832
1957	340	0	23	39	45	446
1958	287	0	19	33	49	388
1959	357	0	24	41	52	473
1960	440	0	29	50	56	575
1961	575	0	39	65	59	738
1962	350	34	26	44	63	516
1963	371	15	26	44	67	523
1964	631	-12	41	70	71	802
1965	529	-14	34	59	75	683
1966	431	-22	27	46	79	562
1967	528	-23	34	57	83	679
1968	504	-33	32	54	87	643
1969	448	30	32	54	91	655
1970	488	-5	32	55	95	665
1971	360	56	28	47	99	590
1972	401	19	28	48	103	599
1973	1,924	55	128	188	107	2,402
1974	1,038	29	70	109	111	1,358
1975	639	-9	42	72	115	859
1976	612	0	41	70	118	841
1977	612	0	41	70	122	845
1978	499	0	33	57	125	714
1979	517	0	35	59	128	738
1980	589	0	39	67	131	826
1981	427	0	39	65	134	665
1982	541	0	29	50	136	756
1983	533	0	30	52	139	754
1984	709	0	40	68	141	958
1985	998	0	48	111	144	1,302
1986	932	0	54	122	147	1,255
1987	982	0	53	146	150	1,332
1988	836	0	54	140	152	1,182
1989	1,241	0	84	232	156	1,713
1990	1,274	1	88	264	159	1,786
1991	920	0	67	207	172	1,366
1992	981	0	68	241	185	1,475
1993	966	-1	70	255	199	1,489
1994	714	0	52	203	215	1,184
1995	628	0	49	194	229	1,099
1996	764	0	60	250	241	1,315
1997	664	0	53	231	249	1,197
1998	611	0	55	206	255	1,127
1999	398	73	44	153	256	925
2000	476	113	52	183	280	1,105
2001	354	108	41	138	293	933
2002	285	97	37	110	296	825
2003	213	105	30	87	290	725
2004	676	2	53	174	275	1,180
2005	512	3	45	133	209	902
2006	336	0	28	87	135	586
2007	317	1	30	83	135	565

Appendix Table A6. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for the category 'flatfish' for Sweden (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	870	0	44	740	169	1,822
1951	996	0	50	834	195	2,075
1952	1,081	0	55	895	222	2,253
1953	1,054	0	55	861	248	2,217
1954	977	0	51	773	275	2,076
1955	1,095	0	58	819	303	2,274
1956	973	0	52	752	331	2,108
1957	951	0	51	748	359	2,110
1958	847	0	46	652	388	1,933
1959	878	0	48	689	416	2,031
1960	1,194	0	67	878	444	2,582
1961	1,149	0	65	878	473	2,565
1962	1,095	0	62	811	502	2,470
1963	1,026	0	59	773	532	2,389
1964	1,147	0	67	851	564	2,629
1965	1,140	0	67	842	597	2,646
1966	1,113	0	66	870	630	2,679
1967	1,077	0	64	824	661	2,627
1968	1,047	0	63	808	693	2,611
1969	953	0	58	743	727	2,481
1970	464	274	45	584	763	2,130
1971	415	269	43	558	794	2,078
1972	412	230	40	524	824	2,030
1973	724	0	46	592	855	2,217
1974	653	0	42	535	887	2,116
1975	659	0	43	549	919	2,170
1976	582	27	40	510	989	2,147
1977	484	0	32	399	1,059	1,974
1978	396	0	26	332	1,129	1,883
1979	450	0	30	337	1,198	2,015
1980	427	0	29	318	1,267	2,040
1981	434	0	32	324	1,335	2,125
1982	250	0	19	167	1,402	1,838
1983	217	0	19	161	1,468	1,865
1984	176	0	17	132	1,535	1,860
1985	170	0	17	127	1,602	1,917
1986	251	0	27	180	1,670	2,128
1987	274	0	31	186	1,739	2,230
1988	281	0	34	206	1,811	2,332
1989	246	0	31	204	1,886	2,367
1990	257	-62	26	165	1,961	2,348
1991	224	10	31	222	2,161	2,648
1992	337	15	45	340	2,371	3,108
1993	271	66	41	331	2,595	3,304
1994	314	59	44	404	2,837	3,658
1995	661	-6	75	651	2,697	4,078
1996	1,600	-85	168	864	2,546	5,094
1997	1,382	-93	138	848	2,388	4,663
1998	678	59	76	923	2,225	3,961
1999	439	-40	40	439	2,056	2,933
2000	464	0	44	615	1,645	2,768
2001	567	0	52	857	1,286	2,762
2002	449	0	39	671	978	2,137
2003	383	0	32	548	718	1,681
2004	310	0	25	446	502	1,282
2005	415	0	31	1,383	465	2,294
2006	301	0	21	392	401	1,116
2007	370	0	25	419	401	1,215

Appendix Table A7. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for sea trout (*Salmo trutta*) for Sweden (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	70	0	4	6	134	213
1951	70	0	4	6	155	234
1952	62	-0.25	3	5	176	246
1953	60	0	3	5	197	265
1954	68	0	4	6	218	295
1955	60	-0.25	3	5	240	308
1956	60	0	3	5	262	330
1957	53	0	3	5	285	345
1958	49	0	3	4	307	363
1959	56	0	3	5	329	393
1960	61	0	3	5	351	421
1961	74	0	4	6	375	459
1962	0	64	4	5	398	471
1963	0	55	3	5	421	484
1964	0	57	3	5	447	512
1965	0	62	4	5	473	544
1966	0	63	4	5	499	571
1967	0	79	5	7	524	614
1968	0	83	5	7	549	644
1969	0	81	5	7	576	669
1970	40	44	5	7	604	700
1971	37	29	4	6	629	705
1972	27	37	4	5	653	727
1973	89	0	6	8	677	779
1974	119	0	8	10	702	839
1975	105	-4	7	9	728	844
1976	86	0	6	7	718	817
1977	87	0	6	7	707	807
1978	52	0	3	4	694	754
1979	58	0	4	5	681	748
1980	66	0	4	6	667	743
1981	5	0	0	1	651	657
1982	38	0	3	5	635	681
1983	37	0	3	5	618	664
1984	51	0	5	9	601	665
1985	55	0	6	10	584	655
1986	42	0	5	9	567	622
1987	42	0	5	10	550	606
1988	47	0	6	12	533	598
1989	99	0	13	27	518	657
1990	70	0	9	21	501	601
1991	79	1	10	25	514	630
1992	168	0	21	56	525	770
1993	172	-1	21	60	534	786
1994	115	0	14	43	542	713
1995	71	0	8	28	527	634
1996	110	1	12	45	509	678
1997	96	-1	10	41	488	634
1998	111	-5.25	11	44	464	625
1999	72	-1	7	28	439	545
2000	63	-2.25	6	23	430	520
2001	38	4.75	4	16	414	477
2002	38	-1.5	3	13	392	444
2003	28	3.25	3	11	364	408
2004	32	0.25	3	10	332	377
2005	29	1	2	10	289	331
2006	28	-1	2	9	231	269
2007	23	1	2	8	231	264

Appendix Table A8. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for eel (*Anguilla anguilla)* for Sweden (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	2,020	0	101	171	92	2,384
1951	1,717	0	89	146	106	2,057
1952	1,418	0	76	121	121	1,735
1953	2,025	0	111	172	135	2,444
1954	1,966	0	111	168	150	2,395
1955	2,379	0	138	203	165	2,886
1956	1,421	0	85	122	180	1,808
1957	2,014	0	124	172	196	2,506
1958	1,580	0	100	136	211	2,026
1959	2,635	0	170	226	226	3,258
1960	1,481	0	98	127	241	1,948
1961	1,766	0	120	152	257	2,295
1962	1,560	0	109	135	273	2,076
1963	1,599	0	114	138	289	2,140
1964	1,632	0	119	141	307	2,199
1965	1,454	0	108	126	325	2,013
1966	1,520	0	116	132	343	2,111
1967	1,328	0	103	115	360	1,907
1968	1,508	0	120	131	377	2,136
1969	1,338	0	108	117	396	1,959
1970	916	0	76	80	415	1,487
1971	1,054	0	89	92	432	1,667
1972	951	0	82	83	448	1,564
1973	896	0	78	79	465	1,518
1974	716	0	64	63	482	1,325
1975	1,131	0	103	100	500	1,833
1976	646	0	60	57	491	1,254
1977	686	0	65	61	481	1,292
1978	761	0	73	67	469	1,370
1979	670	0	65	59	457	1,252
1980	809	0	80	72	445	1,406
1981	396	0	41	36	431	903
1982	592	0	63	54	417	1,126
1983	477	0	53	44	403	977
1984	695	0	79	65	389	1,228
1985	835	0	99	79	374	1,386
1986	596	0	73	57	360	1,085
1987	453	0	57	44	346	900
1988	525	0	68	51	331	975
1989	579	0	77	57	318	1,031
1990	571	0	78	57	304	1,010
1991	668	0	94	67	307	1,137
1992	696	0	101	71	308	1,176
1993	577	0	86	60	308	1,030
1994	497	0	76	52	307	932
1995	418	0	65	44	301	828
1996	539	0	86	58	293	976
1997	418	0	68	45	284	816
1998	245	0	41	28	273	587
1999	334	0	57	42	260	693
2000	275	0	48	37	241	601
2001	261	0	47	37	222	567
2002	298	0	55	45	201	599
2003	281	0	52	45	180	559
2004	243	0	46	41	159	489
2005	342	0	66	58	204	670
2006	365	0	72	62	233	732
2007	416	0	62	68	233	779

Appendix Table A9. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for whitefishes (*Coregonus lavaretus*) for Sweden (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	0	691	35	59	296	1,080
1951	0	857	43	73	342	1,315
1952	0	697	36	59	388	1,180
1953	0	768	40	65	435	1,308
1954	0	669	35	57	482	1,243
1955	0	635	34	54	530	1,253
1956	0	586	31	50	579	1,246
1957	0	678	37	58	629	1,401
1958	0	667	36	57	678	1,438
1959	0	657	36	56	728	1,477
1960	0	672	38	57	776	1,543
1961	0	659	37	56	827	1,579
1962	0	591	34	50	878	1,553
1963	0	564	32	48	931	1,576
1964	0	488	28	42	986	1,544
1965	0	427	25	36	1,044	1,533
1966	0	417	25	36	1,102	1,579
1967	0	389	23	33	1,157	1,603
1968	0	373	23	32	1,212	1,639
1969	0	414	25	35	1,272	1,747
1970	234	0	14	20	1,334	1,602
1971	211	0	13	18	1,390	1,632
1972	267	0	17	23	1,442	1,749
1973	0	0	0	0	1,495	1,495
1974	366	0	23	31	1,551	1,972
1975	552	0	36	47	1,608	2,243
1976	502	0	33	43	1,583	2,161
1977	301	0	20	26	1,556	1,903
1978	402	0	27	35	1,525	1,988
1979	418	0	28	36	1,492	1,974
1980	508	0	34	44	1,458	2,044
1981	315	0	23	35	1,420	1,794
1982	375	0	30	52	1,380	1,837
1983	323	0	28	53	1,340	1,744
1984	338	0	32	65	1,299	1,733
1985	316	0	32	69	1,259	1,676
1986	367	0	40	90	1,218	1,715
1987	433	0	50	118	1,177	1,778
1988	440	0	53	132	1,137	1,763
1989	466	0	60	153	1,099	1,778
1990	367	0	49	131	1,060	1,608
1991	335	0	44	128	1,082	1,589
1992	307	0	39	125	1,099	1,570
1993	354	0	44	153	1,112	1,663
1994	571	0	68	261	1,122	2,022
1995	464	0	53	224	1,020	1,761
1996	350	0	39	177	918	1,484
1997	307	0	33	163	819	1,322
1998	304	0	31	155	723	1,214
1999	279	0	28	137	630	1,073
2000	248	0	24	117	626	1,014
2001	155	0	14	70	610	848
2002	222	0	19	96	583	920
2003	254	0	21	104	546	926
2004	295	0	23	115	501	935
2005	244	0	18	95	462	819
2006	196	0	14	76	397	683
2007	153	0	10	59	397	619

APPENDIX B

The results as presented here are the same data as presented in the report proper, but summarized by IUU components, i.e., in line with the other contributions in this volume. Presented are data by each unaccounted component followed by the total estimates for Sweden. The detailed data of reconstructed catch in comparison to official reported landings of species (defined here as the ICES landings statistics), are presented as time series data of each category in Appendix Tables A1-A9 and Appendix Tables B1).

Reported landings, as per ICES landings statistics, indicated that Sweden's total landings increased steadily from approx. 55,000 t in 1950 to a peak of 309,000 t in 1998, before declining rapidly in the early 2000s to 165,000 t in 2007 (Figure B1).

Table B1. Reported landings (t) summed by decade for the major taxonomic entities of Swedish fisheries in the Baltic Sea, based on ICES landing statistics.

Common name	Reported landings (t)					
	1950s	1960s	1970s	1980s	1990s	2000s[a]
Cod	219,606	205,391	166,985	511,519	276,844	121,379
Herring	314,762	327,928	523,937	662,947	849,261	486,156
Sprat	1,498	1,032	16,233	36,656	981,505	689,058
Flatfishes	9,719	10,941	5,239	2,726	6,164	3,257
Salmons	6,148	4,807	7,090	7,789	7,920	3,169
Others[b]	58,712	107,578	63,911	29,511	42,058	17,187

[a] the 2000s only include data from 2000-2007.
[b] Includes sea trout (Salmo trutta), eel (Anguilla anguilla), whitefishes (Coregonus lavaretus).

Decadal summaries suggest total landings during the 1950s of around 610,000 t, increasing to 658,000 t during the 1960s, 783,000 t in the 1970s, 1,251,000 t in the 1980s, and peaked during the 1990s with total landings of approximately 2,164,000 t (Table B1). Cod, herring, and sprat made up 94% of the ICES landings statistics from 1950-2007. Herring has always accounted for a large part of reported landings, with around 37% during the 2000s, and up to 67% during the 1970s (Table B1). Cod contributed the most during the 'cod boom' in the 1980s with 41% of reported landings, and sprat made up 52% of landings after 2000. For the last eight years, 2000-2007, cod, herring, and sprat made up 98% of the reported landings (Table B1).

Table B2. Adjustments (t) to reported landings (ICES landings statistics) summarized by decade, for the major taxonomic entities of Swedish fisheries in the Baltic Sea.

Common name	Landings adjustments (t)					
	1950s	1960s	1970s	1980s	1990s	2000s[a]
Cod	0	29,036	16,829	0	0	0
Herring	0	0	0	0	-205,820	-59,639
Sprat	6,504	17,814	14,427	2,273	98,995	-26,858
Flatfishes	0	0	800	0	-77	0
Salmons	-2	-25	145	-1	73	429
Others[b]	-6,506	-17,814	-14,321	0	-6	6

[a] the 2000s only include data from 2000-2007.
[b] Includes sea trout (Salmo trutta), eel (Anguilla anguilla), whitefishes (Coregonus lavaretus).

Illegal, Unreported and Unregulated (IUU) catches

IUU is used in this study to refer to all data that are not part of the officially reported data, as represented by the ICES landings statistics, which are the only publicly available data source presenting all countries, taxa, areas and years. Hence '*adjustments*' to ICES landings statistics, '*unreported*' landings, '*discards*', and '*recreational*' catches are all treated as IUU.

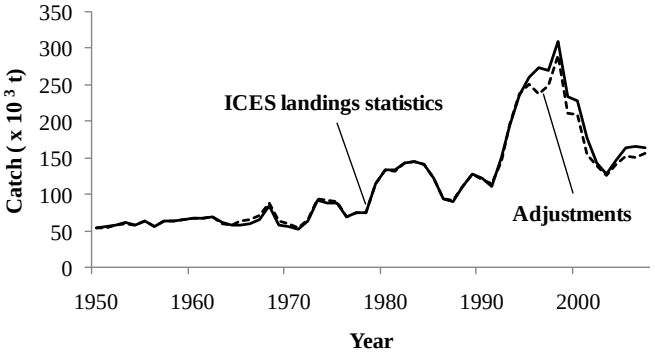

Figure B1. ICES landings statistics and adjustments to ICES landings for Sweden from 1950-2007.

Adjustments to ICES landings statistics

Overall, ICES landings statistics were reduced by about -144,000 t from 1950-2007 (Table B2, see Methods for details). During the

1950s, most adjustments were mainly taxonomic re-allocation of landings tonnage from pooled 'miscellaneous' groups (other taxa) to individual taxa, resulting in virtually no net change in adjustment tonnage (Figure B1, Table B2). During the 1960s and the 1970s the net change in adjustments were approximately 29,000 t and 18,000 t, respectively, and about 98% of that was due to adjusted cod catches (Table B2). The adjustments were small during the 1980s and only accounted for just over 2,000 t for the decade, mainly due to sprat adjustments in 1987 (Table B2). The largest adjustments were done during the 1990s, and nearly all were due to misreported herring and sprat catches (Table B2).

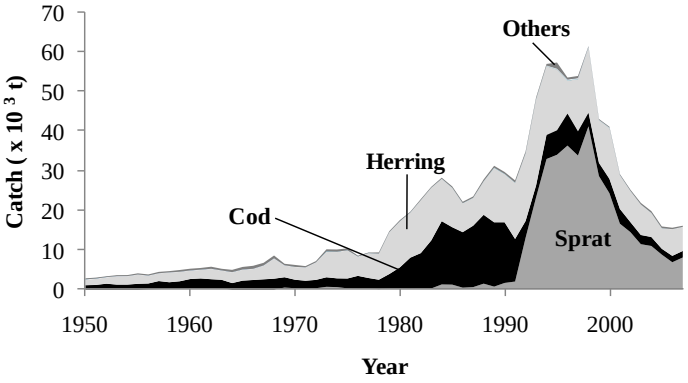

Figure B2. Sweden's unreported landings by taxa for the Baltic Sea from 1950-2007.

The herring catches were adjusted by about -206,000 t and the sprat catches were adjusted by around 99,000 t, resulting in reductions in landings (Figure B1). During the 2000s (2000-2007), the adjustments were about -86,000 t, and were largely due to misreported herring and sprat landings (Table B2).

Unreported landings

Unreported landings were estimated and added to ICES landings statistics + adjustments to generate estimates of total commercial landings (in contrast to total catches). Sweden's' unreported landings were very low in 1950 (3,800 t·year^{-1}) and increased slowly to the end of the 1970s (Figure B2). They increased more rapidly during the 1980s to, on average, 25,000 t·year^{-1}, and rose sharply in the early 1990s to a peak of 62,000 t in 1998 (Figure B2). Unreported landings fell rapidly in the early 2000s to 16,000 t by 2007. Decadal totals for unreported landings by main taxonomic entities are presented in Table (B3). The total unreported landings were estimated at about 1.1 million t from 1950-2007, of which 97% was unreported landings of the three major commercial species cod, herring and sprat (Figure B2, Table B3). Cod and herring dominated unreported landings until the 1990s, after which unreported sprat landings dominated total unreported landings (Figure B2, Table B3).

Table B3. Estimated unreported landings (t) summed by decade for the major taxonomic entities of Swedish fisheries in the Baltic Sea.

Common name	Unreported landings (t)					
	1950s	1960s	1970s	1980s	1990s	2000s[a]
Cod	14,460	23,408	25,014	127,659	67,731	19,408
Herring	19,373	28,579	59,100	106,848	147,212	61,051
Sprat	556	1,580	3,357	6,830	246,231	101,357
Flatfishes	511	637	386	256	684	269
Salmons	411	320	478	471	605	317
Others[b]	2,864	5,531	3,570	3,231	5,357	2,656

[a] the 2000s only include data from 2000-2007.
[b] Includes sea trout (Salmo trutta), eel (Anguilla anguilla), whitefishes (Coregonus lavaretus).

Discards

Discards were comprised of four components (see Methods for details) and were estimated and applied to total landings (i.e., ICES landings statistics + adjustments + unreported landings). The total estimated discards were about 0.5 million t for the entire period (Figure B3, Table B4). Discards were relatively low from the 1950s until the late 1970s,

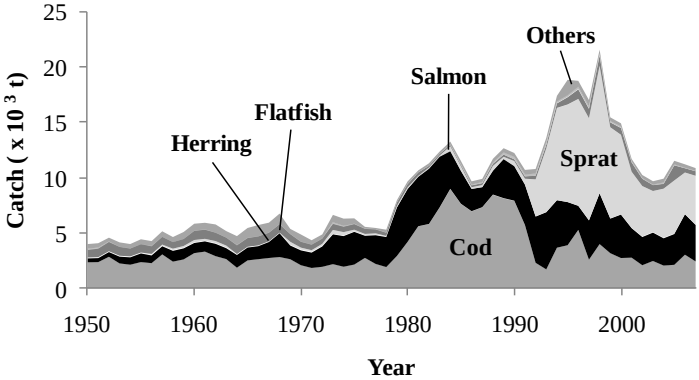

Figure B3. Sweden's discards by taxa 1950-2007.

averaging 5,300 t·year^{-1} (ranging from a total of 45,000 t per decade in the 1950s to 58,000 t per decade in the 1970s, Table B4), before increasing to around 11,000 t·year^{-1} during the 1980s (Figure B3). This increase was mainly driven by increased discarding of cod. While discarding of cod decreased in the early 1990s, discarding of sprat increased substantially in that period, leading to the all-time peak in estimated discards of 21,700 t in 1998 (Figure B3), before declining to the levels of the mid- late- 1980s of around 11,000 t·year^{-1} by 2007 (Figure B3, Table B4)

Prior to 1980, the average discards of cod were about 2,500 t·year^{-1} and then increased to around 7,100 t·year^{-1} during the 1980s. During the 1990s, cod discards declined to an average of approximately 4,100 t·year^{-1}, and 2,500 t·year^{-1} from 2000-2007 (Figure B3).

Discards of herring during the 1950s were on average 650 t·year^{-1} and increased steadily to around 3,800 t·year^{-1} during the 1990s, and thereafter declined to an average of 3,000 t·year^{-1} after 2000 (Figure B3).

During the first four decades of the time series, sprat discards were very small, but increased substantially after 1990 to an estimated 6,600 t·year^{-1} between 1990-1999. Discards of sprat decreased after 2000 and were on average about 4,800 t·year^{-1} for the last eight years (Figure B3).

Table B4. Estimates of decadal total discards (t) for the major taxonomic entities of Swedish fisheries in the Baltic Sea.

Common name	Discards (t)					
	1950s	1960s	1970s	1980s	1990s	2000s[a]
Cod	25,186	27,744	22,470	70,697	40,664	20,115
Herring	6,515	12,136	24,466	34,711	37,508	23,705
Sprat	428	1,021	1,701	2,288	66,337	38,178
Flatfishes	7,763	8,276	4,918	2,004	5,184	5,332
Salmons	698	543	773	1,053	2,205	994
Others[b]	4,344	7,516	3,870	2,630	5,242	2,278

[a] the 2000s only include data from 2000-2007.
[b] Includes sea trout (Salmo trutta), eel (Anguilla anguilla), whitefishes (Coregonus lavaretus).

Flatfishes had the highest proportion of discards due to large by-catches in bottom trawling. The estimated discards were about 780 t·year^{-1} during the 1950s, and 830 t·year^{-1} during the 1960s. Discards of flatfishes apparently decreased to about 490 t·year^{-1} during the 1970s, and to the all time low of 200 t·year^{-1} during the 1980s. After 1990 the discards were estimated to 520 t·year^{-1}. Prior to 2000, flatfish discards were equal to about 80% of reported flatfish landings, and for the last years, 2000-2007, discards were 670 t·year^{-1}, which was equal to about 160% of reported flatfish landings for the same period (Figure B3). Decadal total discards of salmon ranged between 500 t and 700 t prior to 1980 (Table B4). After 1980 the seal population increased and contributed to increased discards of salmon which were estimated to about 100 t·year^{-1}. The discards of salmon peaked with an annual average of 220 t·year^{-1} during the 1990s, mainly due to the seal-based discards. After 2000, salmon discards decreased to an annual average of 120 t·year^{-1}, much due to the development of the push-up trap that decreased seal-based discards (Table B4).

Discards of other species fluctuated, and were a minor component of total discards (Figure B3). These discards ranged between the peak of around 750 t·year^{-1} during the 1960s and the lowest annual average of 260 t·year^{-1} during the 1980s (Figure B3).

Recreational catches

The recreational catches increased rapidly and steadily from about 2,500 t in 1950 to about 13,300 t in 1975, after which they remained quite stable until the 1990s when the recreational catches peaked at 18,500 tin 1994 (Figure B4). Thereafter, they rapidly decreased and were estimated to around 6,300 t in 2007 (Figure B4). The species composition of the recreational catches differed from the commercial landings composition (where cod, herring, and sprat made up 94% of reported landings), and also showed some changes in

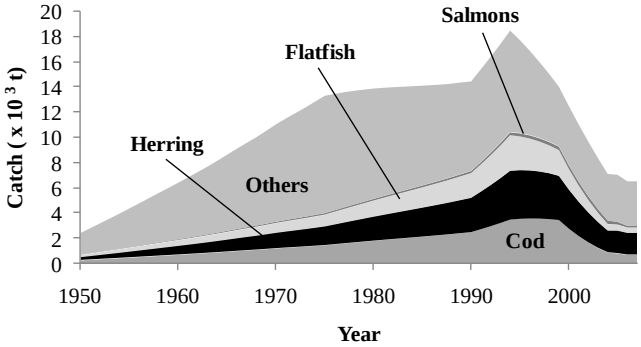

Figure B4. Sweden's recreational catches in the Baltic Sea, 1950-2007.

preferences over time (Figure B4). Overall 'other' species made up 57% of the total recreational catches between 1950-2007 (Figure B4, Table B5). The recreational catches of cod increased from about 460 t·year^{-1} during the 1950s to approximately 3,300 t·year^{-1} during the 1990s when recreational catches of cod peaked (Figure B4). No information was available on recreational fishing when the 'cod boom' occurred during the 1980s. Thus, the present recreational data may underestimate cod catches during that period. After 2000, the recreational catches decreased and were on average about 1,400 t·year^{-1} during the last eight years (Figure B4).

Compared to commercial landings, recreational catches of herring were never big, increasing from about 280 t in 1950 to the peak of around 3,900 t in 1994, and thereafter declined to around 1,800 t by 2007 (Figure B4). There were no recreational catches of sprat.

Table B5. Total recreational catch (t) of Sweden by decade for each of the taxonomic entities considered.

Common name	Decade					
	1950s	1960s	1970s	1980s	1990s	2000s[a]
Cod	4,600	9,211	14,510	21,049	32,572	10,960
Herring	4,838	9,692	15,362	23,085	35,414	17,611
Flatfishes	2,906	5,823	9,417	15,715	23,837	6,396
Salmons	363	731	1,123	1,430	2,160	1,913
Others[b]	29,473	59,018	87,373	79,998	68,103	32,139

[a] the 2000s only include data from 2000-2007.
[b] Includes sea trout (Salmo trutta), eel (Anguilla anguilla), whitefishes (Coregonus lavaretus).

Recreational catches of flatfishes were a large component of total recreational catches, and were estimated to about 290 t·year^{-1} during the 1950s and 2,400 t·year^{-1} during the 1990s (Figure B4). Recreational flatfish catches declined substantially to approx. 400 t by 2007 (Figure B4).

During the 1950s the recreational catches of salmon were estimated to 400 t for the decade (Table B5). The recreational catch component, although small in total tonnage compared to the other taxa (Table B5), increased steadily and by the 1990s was around 220 t·year^{-1}. During the last eight years (2000-2007), the recreational salmon catches were highest and estimated to about 240 t·year^{-1} (Figure B4).

Species like European perch, northern pike, sea trout, and whitefish have recreational catches many times larger than reported commercial landings (Appendix Tables A7-A9, B1).

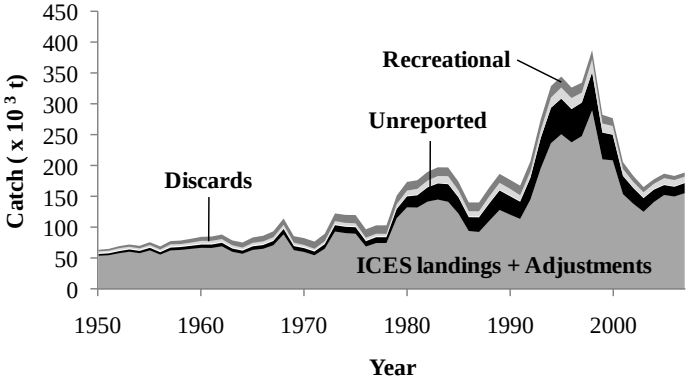

Figure B5. Sweden's total reconstructed catch by component from 1950-2007.

Total reconstructed catch

The total reconstructed catches were just under 9 million t from 1950-2007 (Figure B5, Table B6), and total catches followed the general time-line trend of landings, increasing from on around 74,000 t·year^{-1} in the 1950s to a peak of about 284,000 t·year^{-1} during the 1990s. From 2003-2007 the total catches were approximately 182,000 t·year^{-1} (Figure B5). Besides landings, the next largest component of total catches was unreported landings, especially during the 1990s.

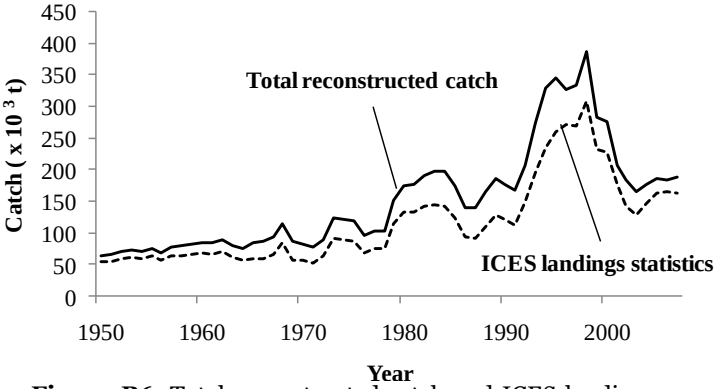

Figure B6. Total reconstructed catch and ICES landings statistics for Sweden from 1950-2007.

Comparing the reconstructed estimates of total catches with the officially reported data, as presented by the ICES landings statistics, illustrated that the reported data underestimate likely total catches by about 31% over the entire 1950-2007 time period (Figure B6). The discrepancies ranged from just under 13,000 t·year^{-1} during the 1950s to about 68,000 t·year^{-1} during the 1990s. For the most recent years, the officially reported data underestimated likely total catches by around 20% (Figure B6).

Table B6. Total catch (t) of Sweden in the Baltic Sea by decade for each of the taxonomic entities considered.

Common name	Total catch (t)					
	1950s	1960s	1970s	1980s	1990s	2000s[a]
Cod	263,852	306,841	249,172	730,924	417,810	171,863
Herring	345,488	378,336	622,865	827,591	863,575	528,884
Sprat	8,986	21,447	35,718	48,047	1,393,068	801,735
Flatfishes	20,899	25,677	20,761	20,700	35,760	15,254
Salmons	7,619	6,376	9,609	10,742	12,963	6,822
Others[33]	88,888	161,829	144,403	115,371	120,784	54,265

[a] the 2000s only include data from 2000-2007.
[b] Includes sea trout (Salmo trutta), eel (Anguilla anguilla), whitefishes (Coregonus lavaretus).

Appendix Table B1. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for the category 'others' for Sweden (t). Includes sea trout (*Salmo trutta*), eel (*Anguilla anguilla*), whitefishes (*Coregonus lavaretus*).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	4,849	0	242	407	1,714	7,213
1951	4,736	0	241	397	1,980	7,355
1952	3,929	0	204	331	2,249	6,712
1953	4,643	0	247	392	2,519	7,801
1954	4,602	0	250	384	2,792	8,027
1955	5,267	0	292	438	3,073	9,070
1956	6,155	-1,072	282	420	3,355	9,139
1957	7,576	-1,547	343	498	3,645	10,515
1958	7,060	-1,491	321	455	3,931	10,275
1959	9,897	-2,394	442	623	4,215	12,782
1960	11,138	-3,581	440	631	4,497	13,125
1961	10,159	-3,047	425	591	4,793	12,921
1962	12,025	-3,277	521	735	5,089	15,093
1963	9,917	-3,020	422	578	5,391	13,288
1964	9,403	0	574	793	5,715	16,485
1965	10,519	0	644	887	6,050	18,100
1966	12,139	0	753	1,015	6,385	20,292
1967	10,569	0	662	888	6,704	18,823
1968	11,219	0	713	944	7,022	19,898
1969	10,489	-4,889	378	454	7,372	13,804
1970	10,755	-3,190	490	637	7,730	16,422
1971	7,122	-2,538	313	382	8,053	13,332
1972	7,450	-2,998	309	364	8,356	13,482
1973	7,662	0	507	659	8,662	17,490
1974	8,118	0	556	657	8,987	18,317
1975	9,020	-2,620	474	484	9,316	16,674
1976	3,840	-1,257	224	144	9,230	12,181
1977	3,321	-1,718	146	98	9,135	10,981
1978	3,717	0	303	255	9,016	13,291
1979	2,907	0	248	191	8,888	12,233
1980	3,328	0	289	219	8,751	12,586
1981	2,161	0	193	156	8,593	11,103
1982	2,806	0	268	214	8,428	11,716
1983	2,243	0	223	191	8,256	10,914
1984	2,656	0	276	253	8,085	11,270
1985	3,096	0	343	290	7,912	11,641
1986	3,079	0	357	285	7,741	11,463
1987	2,857	0	345	289	7,571	11,062
1988	3,689	0	466	349	7,405	11,908
1989	3,595	0	471	385	7,256	11,708
1990	3,404	0	464	347	7,095	11,309
1991	4,122	1	563	423	7,353	12,462
1992	3,300	0	450	410	7,593	11,754
1993	2,950	-1	405	396	7,820	11,570
1994	3,027	0	408	497	8,045	11,977
1995	13,309	0	1,573	1,401	7,371	23,653
1996	4,065	1	513	535	6,692	11,807
1997	4,689	-1	564	583	6,024	11,858
1998	1,518	-5	198	321	5,372	7,404
1999	1,675	-1	218	327	4,738	6,957
2000	1,565	-2	216	270	4,685	6,734
2001	1,498	5	220	213	4,547	6,483
2002	1,971	-2	295	273	4,332	6,869
2003	2,493	3	398	306	4,048	7,249
2004	2,826	0	451	343	3,703	7,323
2005	2,628	1	432	319	3,744	7,124
2006	2,299	-1	360	311	3,540	6,509
2007	1,906	1	284	243	3,540	5,974