Examensarbete
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Vad är de uppskattade totala fångsterna av svenskt fiske i Östersjön 1950-2007?

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Photo: Lo Persson

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Keywords: fisheries, Baltic Sea, IUU, discards, recreational, catches, cod

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ABSTRACT

Fisheries around the world have a substantial impact on marine ecosystems through the removal of biomass and modification of habitats, which alters the conditions within food webs. However, our understanding of this impact and consequences for the ecosystems is limited. Despite this limitation and uncertainty, fisheries have been allowed to develop and expand, causing substantial reductions in many fish stocks due to overfishing. The main reason for stock depletion is overcapacity (leading to non-sustainable fishing effort and catches), which has been largely fueled by government subsidies to fisheries. The Baltic Sea is no exception, high fishing pressure combined with unfavorable conditions for the reproduction of Atlantic cod (*Gadus morhua)*, the historically dominant large predatory fish, resulted in a rapidly decrease of annual landings in the late 1980s, from which cod stocks have not recovered. More recently, landings are dominated by small pelagic species, herring (*Clupea harengus*), and sprat (*Sprattus sprattus*), whose high exploitation of the ecosystem can have significant negative consequences for the processes within it. There are several components of fisheries catches that are usually not accounted for and hence not reported, and these are Illegal, Unregulated, and Unreported (IUU) catches. With the hope to contribute to a better understanding of total fisheries impacts and improved management leading to sustainable catch levels, a catch data reconstruction for Swedish fisheries in the Baltic Sea, from 1950-2007, was undertaken. The catch reconstruction estimated IUU catches, including discards, and recreational catches, and added those to a foundation based on the officially reported landings as presented by the International Council for Exploration of the Sea (ICES) on behalf of Swedish government. Data and information on unreported landings were sparse, and much of the estimations had to be based on interpolation between 'anchor points', which in turn were formed using an assumption-based approach previously described in the literature that attempts to maximize the use of all available and suitable data and information. The commonly used standard approach of applying 'zero catch' to situations where no hard data are available was not acceptable here. If a fisheries component was known to exist it had to be estimated for all of Sweden for the entire time period 1950-2007. In order to avoid the potential for substantial over-estimation, a conservative approach was applied throughout. Information was obtained by data and literature searches (including grey and unpublished literature), and interviews with people involved in Swedish fisheries. The total estimated reconstructed Swedish catch in the Baltic Sea for the 1950-2007 period, was 31 % larger than the officially reported landings, and peaked in1998 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 recreational catches.

In recent years, annual unreported catches, discards, and recreational catches of about 17,900 t, 10,700 t, and 7,100 t, respectively, need to be added to reported annual landings of around 154,000 t, to derive the estimated total catch. Discrepancies between reported landings and the total catch of a species can contribute substantial uncertainties to stock assessments, and addressing this bias is one step towards improved assessments. Therefore, better accounting of all catches is required, which in turn does call for more research. Better accounting of catches would be achieved by a 100 % observer coverage of Swedish fisheries, which is a necessity for accurate studies of discards, and 100 % coverage would also minimize

unreported landings. However, improved data and better understanding and stock assessments alone will be pointless as long as politicians continue to ignore scientific advice. So together with better research and data, public insight and transparency has to increase, due to accountability reasons. This is especially important since fisheries policies, with its subsidies, are the main reason and driving force of overexploitation of fish stocks.

INTRODUCTION

Fisheries have a heavy impact on processes within marine ecosystems. The extraction of fish has a direct impact through the removal of biomass itself, and it also indirectly affects the ecosystem by altering conditions within the food web (Botsford *et al*. 1997, Pauly *et al*. 2000). However, ecosystems are complex and it is hard to predict how, and to which extent, a certain impact will affect a system. Marine ecosystems are by their nature difficult to evaluate, and our understanding of the interactions within them are limited (Botsford *et al*. 1997). For management of fisheries, this is a big disadvantage, and one example where it has had a devastating effect is the collapse of the Canadian cod fishery. Overexploitation of cod, mostly due to overestimation of the stock sizes and quotas that were too large, led to a collapse of the population (Walters and Maguire 1996). The former stocks of highly productive benthic fish species, primarily cod that supported a large commercial fishing fleet until the late 1980's, have been replaced by pelagic fish species and macroinvertibrates post 1990. Management actions (i.e., diverted fishing mortality form benthic stocks by banning of directed fishing), in attempt to reverse the trend, have failed and it is not known if the ecosystem change can be reversed (Frank *et al.* 2005). The resulting increased macroinvertebrate fishery (Frank *et al.* 2005) is an example of how fisheries after overexploiting one trophic level increases the exploitation of the next lower trophic level, known as "fishing down the marine food webs" (Pauly *et al*. 1998). Many fished populations show large declines and this impact on marine biodiversity can risk the oceans' capacity of providing food for the human population (Worm *et al*. 2006). The main problem in fisheries is the overcapacity, a consequence of the history of subsidies in fisheries policies (Hildén 1997, Sumaila *et al.* 2007), that hinders the strive towards sustainable fisheries (Pauly *et al.* 2002).

There are several components of fisheries catch that are usually not recorded, but affect fish mortality rates and hence stock assessments for fisheries. These are Illegal, Unregulated and Unreported (IUU, Bray 2000), including discarding and recreational 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). To assume that all IUU components are zero is a statistically highly 'precise' but very 'inaccurate' valuation. In contrast, a clearly described, assumption-based, constructed and if need be conservative estimate of such IUU components is more 'accurate', although possibly less '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 population sizes within safe biological limits. Since 1993, ICES includes an estimate of unallocated catches (here assumed to represent unreported catches), plus discards, to the number they base their recommendation on (Anon. 2007a). The estimates are based on numbers that stock assessment working group members from the different countries present in the stock assessment working group for their

countries' unallocated catches[1,2].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 (Anon. 2008a). Due to current lack of hard data, Sweden has not reported any unallocated catches to the working group[3]. 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[4].

When striving for sustainable catch 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 is reported or not, or even discarded at sea, it will still be dead. Hence, even an approximate estimate for Swedish unallocated catch is better than zero, as it would be more accurate. The purpose of the thesis was to contribute to a better understanding of the fish stocks in the Baltic Sea, by reconstructing Sweden's catches from 1950-2007, and thereby help along to improve management for a sustainable catch. It also aimed to highlight the importance of unaccounted components on the total catch. The catch reconstruction considers and 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 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, (www.ices.dk/fish/statlant.asp), Swedish national catch data, and ICES stock assessment working group reports, formed the foundation for deriving 'nominal landings', 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 catches was available; this component had to be estimated in its entirety, i.e., for all of Sweden back to 1950. The commonly used reason for not doing so, i.e., no hard data, was not acceptable, as it would continue the replacement with an assumed 'zero' catch for this component in catch data.

BACKGROUND INFORMATION

Area description Sweden and the Baltic Sea

Nine countries surround the Baltic Sea, which is the second largest brackish sea in the world[5]. The species richness is low compared to most other seas due to the low salinity. The input of fresh water in the north and saltier water in the south makes for a salinity range between 0.3 % and 1.5 % within the Baltic Sea[6]. Eutrophication, changes in seal populations, and the level

[1] Walther, Y. Personal communication October 2008- February 2009. ICES stock assessment working group. Swedish Board of Fisheries.
[2] Degel, H. Personal communication January and February 2009. Technical University of Denmark. DTU Aqua, National Institute of Aquatic Resources. ICES stock assessment working group. E-mail: hd@aqua.dtu.dk phone: +45-33963386.
[3] Walther, Y. Personal communication October 2008- February 2009. ICES stock assessment working group. Swedish Board of Fisheries.
[4] Walther, Y. Personal communication October 2008- February 2009. ICES stock assessment working group. Swedish Board of Fisheries.
[5] Finnish Institute of Marine Research. The Baltic Sea portal. Available at http://www.fimr.fi/en/info/en_GB/info/ accessed June 11, 2008.
[6] Stockholms Marina Forskningscentrum SMF, Facts about the Baltic Sea, available at http://www.smf.su.se/havet/fakta/livet.html "Fakta om Östersjön" accessed 2009-01-06.

of fishing, all influence fish production (Hanson *et al.* 2007). Eutrophication of the Baltic Sea has contributed to an increased production of biomass, including fish, (Hanson *et al.* 2007), but it has also contributed to oxygen depletion in the deeper waters with devastating effects on the benthic macrofauna (MacKenzie *et al.* 2002, Karlson *et al.* 2002). Cod, reproduction requires salinity above 1.1 %, and oxygen saturation of at least 48 %, for survival and successful fertilization and development of the eggs (Nissling and Westin 1997, Bleil and Oeberst 2000). In the Baltic Sea only the deeper basins, where there is often a lack of oxygen, have a sufficiently high salinity (Hanson *et. al.* 2007, Elmgren 1989). Seals used to be the dominant top predators in the Baltic Sea ecosystem in the beginning of the 1900s (Österblom *et al.* 2007). They declined substantially until the 1950s due to hunting, and the high concentration of toxic pollutants, like Polychlorinated Biphenyl (PCB) kept the seal populations at low levels for several decades thereafter (Elmgren 1989, Olsson 1995, Österblom *et al.* 2007). Due to strong hunting restrictions and international agreements to reduce levels of pollutants, the seal populations have begun recovering (Olsson 1995), and between 1990 and 2006 the average annual increase was 8 % (Karlsson *et al.* 2007). In the absence of mammals, and with enhanced production due to eutrophication, cod became the dominant top predator in the mid century (Österblom *et al.* 2007). It remained that way until the early 1990s, with high biomass levels during the early and mid 1980s, that supported high fishing levels. After the mid 1980s a longer period without inflow of high-salinity, and oxygen rich, water from the North Sea led to poor recruitment of cod. The continued high fishing levels caused a rapid decline of the cod stock in the late 1980s and the beginning of the 1990s. This development favored Clupeids which became the new dominant species in the ecosystem, with both herring, and sprat, reaching their historic peak in the late 1990s (Österblom *et al.* 2007).

Swedish fishing

Commercial fisheries

The commercial fisheries mainly target cod, herring, and sprat (Anon. 2007a). The largest fraction of Swedish landings in the Baltic Sea are caught in the Central Baltic Sea, ICES subdivisions 25-28 (Figure 1), mainly by fishing fleets from the west coast of Sweden (Anon. 2005a). 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 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 its 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 contributes to underreporting of landings (Hultkrantz 1997), and is an underlying driving force of IUU fishing (Sporrong 2007).

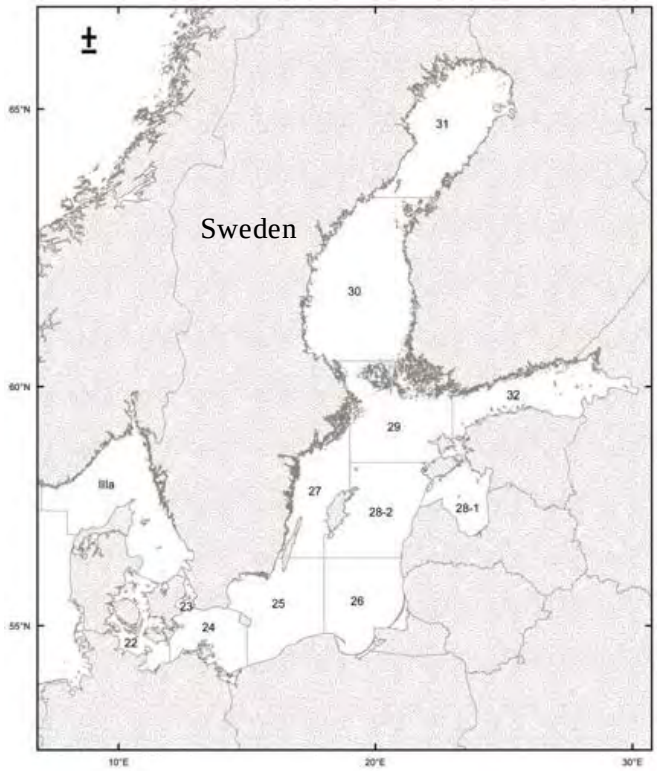

Figure 1. Map of ICES area III. The Baltic Sea = sub division 22 – 32. Source: Ask, L., and H. Westerberg 2008.

Sweden stretches from north to south of the west side of the Baltic Sea (Figure 1), and a diverse small-scale fishery exists along the 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, some smaller trawlers started to show 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 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 for the valuable roe with pair trawlers is, and has been, an important commercial fishing activity (Johansson *et al.* 2005). On the more southern part of the east coast of Sweden, 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 and 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 5200 (Anon. 1978). Reasons for the decrease were the manpower requirement for national industrialization, and increased effectiveness of fisheries enforced by decreased profitability (Johansson *et al*. 2005). The decrease has continued and today 1880 people are registered as

commercial fishers in Sweden. In total there are more people involved in actual fishing since only the skipper on the fishing boat has to be registered[7].

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), but north of Stockholm these inshore waters' fishing rights have been public since the 1950s due to governmental ownership (Neuman and Sandström unpublished[8]). 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[9]. In private waters the 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. 2007b). There are some special cases, for example, salmon and eel. 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. 2007b), and since 2007 a special license is required to fish for eel[10]. Recreational fishing includes house hold 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 the increase in spare time[11]. The number of recreational fishers is believed to have continued at the same level until the 1990s (Nilsson 1991), followed by an increase throughout the 1990s (Norström *et al.* 2000). Subsequently, however, a decline has been documented, and in 2006 the number of recreational fishers was estimated to be 1 million (Anon. 2007b). Recreational catches sometimes form a substantial part of the total catch, e.g., the recreational catches of whitefish, sea trout, pike, and perch are often much bigger than the commercial catches of the same species (Neuman and Sandström unpublished[12], Anon. 2007b).

Unaccounted catch components

Black market sales

Unreported landings are likely the biggest component of IUU catches in the Baltic Sea (Sporrong 2007). There are several indications that landing and selling of fish that is never reported seems to be a well accepted and sometimes common phenomenon (Hultkrantz 1997) [13]. Sometimes, fishers may sell fish to tourists and other people directly from their boats (Anon. 2004a), although this may be a small tonnage overall. In the northern parts of Sweden, the so called 'Midsummer salmon' that is sold without reporting is a well known

[7] Swedish Board of Fisheries. The Swedish commercial fishery. Available at http://www.fiskeriverket.se/vanstermeny/yrkesfiske.4.1e93312510e313daf128000208.html "Det svenska yrkesfisket" accessed 2009-03-20.
[8] Neuman, E., and O. Sandström. Fishing in marine areas worth to preserve. Skärgårdsutveckling Skutab AB. "Fiske I skyddsvärd marin natur". *Unpublished.*
[9] Swedish law of fishing 1993:787. Available at http://www.riksdagen.se/webbnav/index.aspx?nid=3911&bet=1993:787 accessed 2009-01-29.
[10] Swedish Board of Fisheries. Preserved species regulations, available at http://www.fiskeriverket.se/vanstermeny/fiskochskaldjur/arter/allaarter/alanguillaanguilla.4.1490463310f1930632e80005485.html accessed 2009-02-12.
[11] Paulrud, A. Swedish Board of Fisheries. Cell phone: +46-(0)70-6466808. Personal communication January 2009.
[12] Neuman, E., and O. Sandström. Fishing in marine areas worth to preserve. Skärgårdsutveckling Skutab AB. "Fiske I skyddsvärd marin natur". *Unpublished.*
[13] Karlsson, K-E. Personal communication November 2008. Foreign Department, The Swedish Tax Agency. E-mail: karl.erik.karlsson@skatteverket.se, phone: +46 (0)771-778778.

phenomenon[14] (Hultkrantz 1997), and on Gotland smoked flounder is sold to tourists during the summer[15]. One fisher, spoken to during the interviews done in search for information, said that he keeps smoked fish in the boathouse and people take the fish they want and leave money in a jar " I have done that for 40 years"[16]. Expressions about 'under-the-table-sales', such as "the informal economy of coastal communities" and that "this is the normal way for fishers to sell their fish" are comments that also came up during the interviews. These are examples of small-scale selling. However, there are also indications of bigger sales that are never reported (Anon. 2004a). The relationship between fishers and purchasers is often more than just professional (e.g., in 1992 30 % of the purchaser businesses were owned by fishers [Hultkrantz 1997]), and since both parties can benefit from unreported sales it is likely that it occurs (Hultkrantz 1997). There are indications that the unreported sale of cod was at least 10 % in 2003 (Anon. 2004a), and 8 % in 2007 (Anon. 2008c). The Swedish Board of Fisheries, SBF, has to base their statements on detected and officially reported records, since it is a governmental agency[17,18]. However, due to the illegal nature of these activities, there are few detected and reported records, since it is unlikely that someone will report, or is easily detected, while cheating (Hultkrantz 1997). Therefore, it is reasonable to assume that the true unreported catches are bigger than the numbers that the SBF presented for 2003 and 2007 (Anon. 2004a, Anon. 2008c). According to J. Hjelm and stock assessment work, it is unlikely that Sweden's unreported catches of cod are only 8 %[19]. Other species that with a high market value, such as salmon and eel, are expected to have relatively large black markets (Hultkrantz 1997) [20].

Technical 'malfeasances'

Also, there are some technical 'malfeasances' that lead to actually un- or underreported catches. Herring and sprat catches are kept in water tanks for quality reasons, and the fish bodies absorb water while they are in the tanks. During offloading, fishers are allowed to subtract the weight of the water absorbed by the fish. In 2003, the SBF decreased the deductable amount from 20 % to 13 % (Anon. 2004a). Subsequently, and based on studies on how much water the fish bodies actually absorb, the amount was decreased in 2005 even more to 5 %[21]. Therefore, the difference, 15 % (i.e., 20 % - 5 %), has been a legal way of underreporting catches and 'saving' quotas. Even more significantly, some officials and fishery representatives acknowledge that general underreporting of pelagic species may be as high as 50 % (Anon. 2004a). A similar way of un- or underreporting is suspected to occur when fish are landed in boxes. The boxes have room for more fish than what they are supposed to contain. For example cod that is landed in boxes that are supposed to hold 40 kg (+/- a couple of kilos) but can contain more than 50 kg of fish, however, official records would record this as 40 kg (Anon. 2004a).

[14] Steinbash, U. Personal communication November 2008. Swedish coast guard. Phone: +46 (0)611-85522.
[15] Eriksson, Ö. Personal communication October 2008. Swedish Coast Guard surveillance ship KBV 181.
[16] Anonymous(a). Personal communication October 2008. Active commercial fisherman since more than 40 years.
[17] Wallin, B. Personal communication October 2008. Department of Fisheries Control, Swedish Board of Fisheries.
[18] Gustavsson, T. Personal communication October 2008. Swedish Board of Fisheries.
[19] Hjelm, J. Personal communication. October 2008. Head of Institute of Marine Research, Swedish Board of Fisheries. Phone: +46523-18751
[20] Anonymous(b). Personal communication October 2008. Swedish coast guard.
[21] Palmén, L-E. Personal communication October 2008.Pelagic fishing, Department of Fisheries Control, Swedish Board of Fisheries.

Regular discards

Discards are the part of the catch that is thrown back into the sea during fishing operations. Fishers discard fish that they are not allowed to land due to minimum landing size regulations, and/or quota limitations. They also discard fish due to high grading, i.e., to maximize their profit by discarding fish that have no, or a lower value compared to fish they want to catch (Catchpole *et al.* 2005, Anon. 2007c, Lövgren *et al.* unpublished data[22]). The mortality of fish discarded differs among species and fishing practices but for bottom trawling the mortality of discarded cod is 100 %, and 80-100 % for flatfishes (Jennings and Kaiser 1998). The quantity of fish that is discarded is usually not reported and may become a problem in stock assessments. Since 1995, discard data have been collected in Swedish cod fisheries, but the sampling has covered less than 1 % of the total fishing effort (Anon. 2003a). Observer bias effects are known to skew the data, because observer presence alters fishing behavior that might be practiced to maximize the profit but sometimes can cause a large amount of discard (Babcock and Pikitch 2003, Anon. 2006a, Bremner *et al.* 2009)[23,24]. The amount of by-catch of unwanted fish depends on the size and abundance of the fish in the area, the behavior of the fisher and the gear type. Bottom trawl fisheries have the highest by-catch and therefore often also the highest discard quantities (Anon. 2007c). Information on discard patterns in earlier years is hard to find. In Sweden, a minimum landing size of 30 cm for cod was introduced in 1957 (Otterlind 1974), and this might have caused some discarding of undersized cod (Eero *et al.* 2007). Documented large discarding of cod smaller than 50 cm due to market demands occurred in the late 1940s (Alander 1946).

'Underwater discards'

'Underwater discards' relate to fish that escape deployed fishing gear. This type of fishing mortality is often hard to measure and is quite poorly understood (Anon. 2005b). Some studies have shown that the survival of fish escaping fishing gear differs a lot among species; for example cod, has a relatively high survival rate, whereas the survival rate is substantially lower for small pelagic species (Anon. 2005b). The mortality for herring escaping trawls has been shown to be 77-100 % depending on the size of the fish (Rahikainen *et al.* 2004). When developing selective gear types (i.e., that enables unwanted and undersized fish to escape) the mortality of the escaping fish is important to consider in order for the development to serve its purpose and decrease the fishing mortality of unwanted, and/or undersized, fish (Anon. 2005b).

[22] Lövgren, J. (johan.lovgren@fiskeriverket.se), Ringdahl, K. (katja.ringdahl@fiskeriverket.se), and J. Hjelm (joakim.hjelm@fiskeriverket.se). Swedish Board of Fisheries, phone: +46(0)31-7430300. Unpublished: Patterns of discard and environmental effects of discard in southern Baltic 1996-2003. "Discardmönster och miljöeffekter av discard i södra Östersjön 1996-2003.

[23] Boyes, D. Personal communication February 2009. Halibut fisherman BC, Canada. E-mail: mcboyes@telus.net

[24] Erikson, W. Personal communication February 2009. Wes Erikson is an active fourth generation commercial fisherman. He has fished for halibut, herring, salmon, rockfish, ling cod, skate and sable fish using long line, troll and gill net along the entire British Columbia coastline. Wes has been involved in the fisheries advisory process for over 20 years and has recently been a halibut representative on the Commercial Industry Caucus (CIC) implementing the pilot integrated ground fish strategy.
Along with fishing Wes owned an operated seafood restaurants for the last 15 years. E-mail: erikson.w@gmail.com

Seal caused discards

Seals can cause damages to the catch that can lead to discard of fish, and seals can also entirely consume fish from fishing gear. Depending on the area, this loss can be significant and studies with marked fish have shown a loss of herring of up to 86 % (Königson *et al.* 2005), a loss of cod of 64 % (Sundqvist 2005) and a loss of whitefish of 77 % (Söderlind 2004) after seals had been present. Prior to the 1980s, the seal population in the Baltic Sea was very low, but still some damaged occurred (Olsson 1995)[25].

Ghost fishing

Sometimes fishing gears are lost at sea due to trawling in areas where other gears are used, bad weather etc. (Brown *et al*. 2005). Since fishing gear are made up of synthetic material, they can continue to fish effectively for years (Anon. 2001a). Lost cod gillnets in the Baltic Sea have been found to continue to catch fish for as long as 2 years after they were lost (Tschernij and Larsson 2003). Based on the rate that trawlers retrieve lost gear, a ghost fishing component of cod between 0.1-3.2 % of total reported landings in the same area has been reported(Brown *et al.* 2005).

[25] Olofsson, L. Personal communication October 2008. Commercial fisherman in the county of Umeå. Coastal fishers association. Phone: +46(0)90-149240.

METHODS

Collection of Swedish fishery statistics started early and annual statistics of Swedish commercial fisheries are available from 1913 (Lundgren 2007). The data are presented as catch and landings in tonnes, and since catch data are the weight of fish landed converted into live weight, it has been defined as 'landings' in this study to differentiate it from 'catch' which in this study refers to all catches taken from the Baltic Sea ecosystems, including unreported landings, discards, and recreational catches. It should not be confused with what is called landings in Swedish officially reported statistics, which means what is actually landed i.e., the weight of often gutted fish. 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 (i.e., quantities <50 kg) 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 Baltic Sea ecosystems. The unreported landings, discards, and recreational catches are all components that are missing in the official statistics.

The method used to reconstruct Sweden's catches consists of a five step approach. First, the officially reported ICES catch data, here referred to as landings data, were examined. In step two the landings data were complemented or replaced with landings data from other sources if deemed more reliable or more accurate, resulting in what are referred to here as 'nominal landings' data (Table 1). Step three adds estimated time series unreported landings to nominal landings data. In step four estimated discards were added to the estimated catch data (i.e., nominal landings + unreported landings). As a final step, a country wide time series of estimated recreational marine catches was added. The recreational catches, combined with nominal landings, unreported landings, and discards, represents the total catch reconstruction. To derive estimated time series of the unaccounted components, linear interpolation between assumption- and information-based anchor points was done, and to complete the time series extrapolation was used when anchor points were missing in 1950 or 2007.

Reported landings and nominal landings

The term 'ICES reported landings' is used throughout to refer to ICES catch data by species, area and year, (public available at www.ices.dk/fish/statlant.asp) presented by taxon, statistical reporting area and year[26]. These data were obtained for Sweden by year (1950-2007), species, and ICES statistical area or subdivision. Thus, any references to 'ICES reported landings' are with regards to this data source. These data were adjusted for some years by substitution with data obtained from ICES stock assessment working group reports for cod (Anon. 2008a), for flounder (Anon. 2008a), and for herring and sprat (Anon. 2008a), and by Swedish national landings data (e.g., Anon. 1952, Anon. 1984, Anon. 2003b)[27] for some species. Thus, these modified and improved data, are referred to as 'nominal landings' data throughout this study. These nominal landings data are the foundation on which unreported landings and thereafter discards estimates were built. Explanations for each substitution are given below and the resulting combination of landings data is shown in Table 1.

[26] ICES catch data were obtained from www.ices.dk/fish/statlant.asp December 11th 2008.
[27] As of 1999 available at http://www.fiskeriverket.se/vanstermeny/statistikochdatabaser/fangststatistikyrkesfiske.4.28e4ca7c10e9e5e8f9c80002777.html "Fångst ombord" accessed 2009-03-19.

In 1965-1975 ICES stock assessment working group data were used to replace ICES reported landings because ICES reported landings were suspected to not include catches taken in the Baltic Sea by vessels from the west coast. This conclusion was based on ICES stock assessment working group report from 1974 (Table 2), where the reported catches were almost identical to ICES reported landings 1965-1975, however, states in a table footnote (a), that Swedish catches do not include catches from vessels from the west coast fishing in the Baltic Sea. In ICES stock assessment working group report 2008, the reported catches form 1965-1975 are increased and deemed more reliable for that time period. The replacement for flounder was done during the 1990s due to misreported catches from the cod fishery (Anon. 2008a). Swedish government data were used for dab (*Limanda limanda*) in 1976, and turbot (*Scophthalmus maximus*) from 1962-1969, where ICES reported landings were missing. The term 'flatfishes' refers in this study to brill (*Scophthalmus rhombus*), dab, flounder, plaice (*Pleuronectes platessus*), and turbot, if nothing else is specified.

ICES reported landings data for salmon were for the most parts identical to Swedish national data, however, from 1999-2003 they were about 100 t lower than the Swedish national data which were more inline with catches before and after those years. Hence, Swedish national data replaced ICES reported landings for the entire time period, except 1978 when Swedish national data are incomplete. Due to missing data in ICES reported landings for sea trout, ICES reported landings were replaced by Swedish national data for the entire time period, except 1978. For some species ICES reported landings were missing from 1950-1969 and therefore replaced by Swedish national data for that period. The landings data for sprat varied substantially in the earlier period, which was thought to be partly explained by reporting as 'industrial fish'. Therefore half of the catches reported as 'industrial fish' were added to the reported Swedish national data for sprat for years when it was doable, and for those years Swedish national data replaced ICES reported landings (Table 1). The adjustments made with Swedish national reported landings data where ICES reported landings were missing, have been subtracted from the categories 'Finfishes nei' (Miscellaneous marine fishes), 'Flatfishes nei' (*Pleuronectiformes*), and 'Freshwater fishes nei' (Miscellaneous freshwater fishes), to avoid potential double accounting. Missing data were linear interpolated, for pike-perch the average of the first three years of data was extrapolated back to 1950.

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 reported landings data source, the various additional sources listed above were combined as described to get a complete baseline of landings data (Table 1). The optimal source should have been the catch data from the ICES stock assessment working group reports that are known to attempt adjustment of reported landings data based on additional information. However, data as presented in the working group reports, lack transparency particular with regards for comprehensive and transparent accounting of each catch component (e.g., landings, unallocated, discards, recreational) by country. This lack of country specific transparency makes the use of stock assessment report data very difficult. One example is the herring and sprat data that in the stock assessment working group report are almost 50 % lower for herring, and around 30 % higher for sprat, compared to ICES reported landings from 1996 to 2001. According to Bengt Sjöstrand, who has been the Swedish representative reporting herring and sprat catches to the working group, the differences are due to adjustments for misreporting of catch area and also misreporting of the fraction of the two species[28]. This information about the Swedish data can not be found in the report (Anon. 2008a). Based on Sjöstrand's information ICES reported landings were

[28] Sjöstrand, B. Personal communication March 2009. Swedish Board of Fisheries, ICES working group.

replaced with ICES stock assessment working group data from 1990-2007 for both herring and sprat.

Table 1. 'Nominal landings' data construction by the combination of different official reported landings data for different years 1950-2007.

Common name	ICES reported	ICES stock assessment working group reports	Swedish official reported[a]
Atlantic cod	1950-1964, 1976-2007	1965-1975	
Atlantic herring	1950-1989	1990-2007	
Atlantic salmon	1978		1950-1977, 1979-2007
Brill	1950-2007		
Burbot	1970, 1979-2007		1950-1969
Common dab	1950-1975[b], 1977-2007		1976
European eel	1950-2007		
European flounder	1950-1989[b],	1990-1999	
European perch	1970, 1974-1975,1979-2007		1950-1969
European plaice	1950-2007		
European sprat	1950-1955, 1964-1968,1973-1974, 1978-1986, 1988-1989	1990-2007	1956-1963[c], 1969-1972[c], 1975-1977[c], 1987
European whitefish	1970-1972[d], 1974-2007[d]		1950-1969
Northern pike	1970, 1974-1975, 1979-2007		1950-1969
Pike-perch	1974-1975, 1979-2007		
Sea trout	1978		1950-1977, 1979-2007
Turbot	1950-1961, 1970-2007		1962-1969
Vendace	1970-1972, 1974-2007		1950-1969
Other species	1950-2007		

[a] Data taken from yearbooks of Swedish fisheries statistics 1950-1993, e.g. Anonymous (1952), Anonymous (2003) etc. As of 1999 these data are available at www.fiskeriverket.se accessed 2009-03-19. [b] Switched numbers between common dab and European flounder 1956-1959, and 1972. [c] Half of the industrial fish (not species specific) catches for that year was added to the sprat catch. [d] Merged European whitefish and 'whitefish nei'.

Unreported landings

Unreported landings are assumed 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 (see Appendix 2 Table 1 for all people contacted during the study) and literature (including grey literature[29]). While some anchor points could be found for the period late 1980s to 2007 (Table 2), no information could be found for the pre-1980 period. Thus, a few basic assumptions were made to create anchor points for 1950 and 1980 so that linear interpolation could be done. In 1950, there were fewer incentives to underreport catches due to lack of

[29] This included some access to new media material. However, no detailed news media review was undertaken.

quota limitations (Eero *et al.* 2007), however, there was also less enforcement for reporting catches[30]. Therefore, the unreported landings in 1950 were assumed to be 5 % for all species, except salmon (see below), which is thought to be conservative. To reflect the introduction of quotas starting in the 1970s (Søndergaard 2007), which introduced stronger incentives to underreport catches, 1980 was used as a break point to get a lower fraction of unreported landings prior to 1980. Thus, for 1980, half of the value for the first data anchor point after 1980 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). The average of unreported landings percentages for these species was divided in half since cod, herring, and sprat, are profitable species and therefore assumed to have more unreported landings (Hultkrantz 1997). This estimated unreported landings percentage was applied in 1990. Based on the assumption that unreported landings have decreased in recent years[31,32,33], half of the value for 1990 was used as an anchor point in 2007. Percentage rates were linear interpolated between anchor points (Table 2), and applied to nominal landings to derive a complete time series of estimated unreported landings.

[30] Anonymous. Swedish Board of Fisheries. Personal communication October 2008.
[31] Karlsson, K-E. Personal communication November 2008. Foreign Department, The Swedish Tax Agency. E-mail: karl.erik.karlsson@skatteverket.se, phone: +46 (0)771-778778.
[32] Sjöstrand, B. Personal communication March 2009. Swedish Board of Fisheries, ICES working group.
[33] Löwenadler Davidsson, J. Swedish Board of Fisheries, head of Control Department. E-mail: johan.lowenadler-davidsson@fiskeriverket.se, phone: +46(0)31-7430425.

Table 2. Unreported landings anchor points, see text for details and sources.

Year	Cod	Herring & Sprat	Eel	Vendace	Others[a]	Salmon[b]
1950	5.0%[c]	5.0%[c]	5.0%[c]	5.0%[c]	5.0%[c]	

1980	15.5%[c]	12.5%[c]	9.9%[c]	10.0%[c]	6.8%[c]	6.7%[d]
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					13.5%	6.8%
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%		20.0%		8.7%
2006	13.1%		19.8%			8.5%
2007			15.0%		6.8%	9.4%

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

Cod

Based on information on reported and unreported landings of cod in the harbor of Härnösand in 1987[34], a conservative anchor point for unreported landings was calculated based on the assumption that there were no other unreported landings in Sweden that year (see next

[34] Larsson, P-O. Personal communication February 2009. Former Fishery biologist and fishing method researcher at the Swedish Board of Fisheries, also involved in ICES. Received the Swedish Seafood Award 2006 in the category "Sustainable Fishing" for his work to pursue dialogue with commercial fishermen on nurturing fish stocks and responsible fishing. Highly respected among officials and fishers. E-mail: polarsson@gmail.com phone: +46 (0)70-8648254.

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, Anon. 2007d, Anon. 2008c) were combined to derive an average percentage used as an anchor point for 2006, and also used in 2007 (see next paragraph for details). Linear interpolation was done between the derived anchor points (Table 2) to derive a complete time series of estimated unreported cod landings.

The reported landings of cod in the harbor of Härnösand were 10,000 t in 1987. Based on observations in the harbor and on other information, the total landings of cod in that harbor that year, was estimated to be 30,000 – 40,000 t by Swedish (85 %) and Finnish (15 %) fishers[35]. To stay conservative the lower value (30,000 t) was used to calculate Sweden's unreported landings in the harbor of Härnösand 1987. First the Finnish part of the catch was extracted (30,000 – [30,000 x 0.15] = 25,500), and after that the reported landings was extracted (25,500 – 10,000 = 15,500 t). The harbor in Härnösand was different compared to the harbors in the southern parts of the Baltic Sea, where unreported landings were more complicated to do[36]. 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. That, 31 %, was used as an anchor point in 1987 based on the assumption that there were zero unreported landings in the rest of Sweden that year. This was the first anchor point and therefore half of that (0.5 x 31 % = 15.5 %) was used as an anchor point for 1980, and 5 % was used as an anchor point for 1950 based on the general assumption explained above. In later years, 2004-2007, three different estimations of unreported cod catches have been made. In 2003 the unreported catch was at least 10 % (Anon. 2004a), in 2005-2006 it was 21.4 % (Anon. 2007d), and in 2007 there were indications that it was 8 % (Anon. 2008c). There are reasons to believe that the SBF estimates of unreported landings, (8 % and >10 %), are minimum estimates, since SBF has to base their statements on detected and officially reported records, since they are a governmental agency. The primary reason is that these estimates are derived from comparison of the reported numbers by fishers and the purchaser business, and it is highly unlikely that someone will report their cheating (Hultkrantz 1997). The European Commission's study that estimates the unreported catches to be 21.4 %, has been criticized for its statistical methods[37]. Due to the issues with the separate reported numbers an average of the three, 13.1 %, was used as an anchor point in 2006. The same value was used in 2007.

ICES stock assessment 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 total reported landings. The total landings (reported + unallocated) are divided by the unallocated caches to derive the RF. In the report (Anon. 2008a), the RF is presented as an individual table (in section 2.4.1.2), however, it differs from the RF that can be derived from the total landings, discards, and unallocated catches, presented in Table 2.4.1, later in the report (Table 3). A Swedish Raising Factor (RF) was derived by adding estimated unreported landings to ICES stock assessment reported Swedish

[35] Larsson, P-O. Personal communication February 2009. Former Fishery biologist and fishing method researcher at the Swedish Board of Fisheries, also involved in ICES. Received the Swedish Seafood Award 2006 in the category "Sustainable Fishing" for his work to pursue dialogue with commercial fishermen on nurturing fish stocks and responsible fishing. Highly respected among officials and fishers. E-mail: polarsson@gmail.com phone: +46 (0)70-8648254.

[36] Larsson, P-O. Personal communication February 2009. Former Fishery biologist and fishing method researcher at the Swedish Board of Fisheries, also involved in ICES. Received the Swedish Seafood Award 2006 in the category "Sustainable Fishing" for his work to pursue dialogue with commercial fishermen on nurturing fish stocks and responsible fishing. Highly respected among officials and fishers. E-mail: polarsson@gmail.com phone: +46 (0)70-8648254.

[37] Lundgren, R. Personal communication November 2008. Swedish Board of Fisheries, department of control.

landings, and then dividing that by ICES stock assessment working group reported Swedish landings for each year (Table 3). A total RF factor was also calculated, by adding Sweden's unreported landings to the unallocated catches reported in the ICES stock assessment working group report (2008a).

Table 3. Raising Factors for cod; from ICES stock assessment working group report (Anon. 2008a), reported and calculated based on presented data, calculated Swedish RF factor (see text for information), and total RF including Sweden's estimated unreported cod landings.

Year	ICES reported RF[a]	Swe. calc. RF	Total RF	ICES RF calc.[a]
1993	1.42	1.25	1.68	1.60
1994	1.61	1.24	1.86	1.77
1995	1.21	1.23	1.28	1.21
1996	1.08	1.22	1.16	1.10
1997	1.00	1.22	1.06	1.00
1998	1.00	1.21	1.04	1.00
1999	1.00	1.20	1.04	1.00
2000	1.35	1.19	1.39	1.35
2001	1.35	1.18	1.40	1.35
2002	1.35	1.17	1.39	1.35
2003	1.45	1.16	1.51	1.47
2004	1.41	1.15	1.44	1.40
2005	1.38	1.14	1.40	1.37
2006	1.37	1.13	1.40	1.37
2007	1.32	1.13	1.36	1.32

[a] Note the difference in some years between RF presented in section 2.4.1.2 (Anon.2008a), and RF calculated based on table 2.4.1 (Anon. 2008a).

Herring and sprat

Fishing for herring and sprat with trawls is often a mixed fishery, where the catch often contains both species (Anon. 2008a). Therefore they have been treated together with the assumption that the fraction of unreported landings are the same for both species. 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. The last year of data was used for the remaining two years. Linear interpolation was done between the anchor points (Table 2), to derive a complete time series for herring and sprat unreported landings.

In 1993 the water adjustment factor, that fishers are allowed to subtract from the catch as water, was 20 %. In 2003 it was 13 % and in 2005 the adjustment factor was decreased to what was then thought to be the actual weight of the water (5 %) absorbed by the fish bodies. 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 as a part of the estimated unreported landings. Also mentioned before, some officials and fishery representatives acknowledge that underreporting of as much as 50 % occurs (Anon. 2004a). To stay conservative 25 % was used as an anchor point in 1993 (of which 15 % is thought to be due to the technical malfeasances). 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 %, so the unreported landings estimate was reduced with 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 'Midsummer salmon' (sales that are not reported, Hultkrantz 1997), and that fishing with salmon gear occurs during salmon runs when fishing for salmon is not allowed[38], was obtained but could not be used to derive anchor points. Instead, estimated total unreported catches of salmon in the Baltic Sea, including rivers, from 1981 to 2007 that was available from the ICES salmon and trout working group report (Table 2.1.1. in Anon. 2008d), were used. Estimations of recreational catches were included in the Swedish reported catches from 1988 and it was not possible to break them out because the information in the report could not be crossed linked. Sweden's recreational catches for the reconstruction were based on other individual sources. Therefore, in an attempt to avoid double accounting and remain conservative, Sweden's fraction of the total Baltic Sea catch per year was multiplied with the lower end of the 95 % probability interval to derive Sweden's unreported landings per year (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 1981-2007 (Table 2). The average of the first three years of data was used as an anchor point in 1980 (Table 2), and carried back fixed to 1950 (i.e., the same value from 1950-1980) to derive a complete time series of unreported salmon landings.

For example, in 1990 Sweden's landings of salmon (including river catch and estimated recreational catch) was 1468 t, and the total reported catch for the Baltic Sea was 5636 t. The 95 % probability interval of the estimated unreported catch was 324 t – 2512 t. Thus, applying the assumptions outlined above, Sweden's fraction of the total catch (1468 t / 5636 t = 0.26) was multiplied with the lower range value (0.26 x 324 t =84.4 t) to derive unreported salmon landings of 84.4 t for Sweden in 1990. Sweden's reported landings in 1990 was 1,249 t, and based on that the unreported landings were converted into a percentage (84.4 t /1,249 t = 6.8 %), which was used as an anchor point in 1990 (Table 2).

European eel

Eel is a high valuable species and is therefore more likely to have a black market than other less valuable species (Hultkrantz 1997), and today about 15 % of the eel catches are thought to be sold directly to restaurants etc.[39] and are therefore assumed to not be reported, hence, used as an anchor point 2007. A license to fish for eel became required in 2007, and only fishers who were dependent on eel, i.e., caught more than 400 kg in 2003-2005, was supposed to get the license[40]. After the regulation the reporting of catches improved[41], and in the area of Stockholm the number of licensed fishers in the statistics increased from 54 % to 86 % (Anon. 2008b). It was assumed that the difference in reporting, before and after the regulation, was

[38] Steinbash, U. Personal communication November 2008. Swedish coast guard. Phone: +46 (0)611-85522.
[39] Anonymous(b). Personal communication October 2008. Swedish coast guard.
[40] Sweet&Salt 2006-12-28. Swedish Board of Fisheries. Available at http://sottochsalt.fiskeriverket.se/Article.asp?ArticleId=88 "Sött&Salt 2006-12-28" accessed 2009-03-11.
[41] Swedish Board of Fisheries. The catches of eel decreased with about 30 % after new regulations. Available at http://www.fiskeriverket.se/arkiv/nyhetsarkivpressrum/pressinformation/alfangsternaminskademedcirka30procentefternyaregler.5.2cd9c4ad11a113f131a8000585.html "Ålfångsterna minskade med cirka 30 procent efter nya regler" accessed 2009-03-11.

the same for the rest of the country. This was based on the fact that most eel is caught south of Stockholm (Ask and Westerberg 2006) where the fishing regulations are similar to the Stockholm area for the most parts (Anon. 2008f). The difference in reporting was added to the unreported fraction in 2007 to derive an anchor point in 2006 (see next paragraph for details). Anchor points for 1950 and 1980 were derived based on the general assumptions described above, and linear interpolation was done between anchor points (Table 2), to derive a complete time series of unreported eel landings.

In 2007, 15 % was used as an anchor point based on the obtained information. The difference in reporting observed in Stockholm was 32 % units which was added to the 15 % based on the assumptions outlined above (i.e., (86 – 54)x 0.15 = 4.8 → 15 + 4.8 = 19.8 %), to derive an anchor point in 2006. This was the first anchor point and therefore 9.9 % was used in 1980, (0.5 x 19.8 % = 9.9 %) and 5 % was used as an anchor point for 1950 (Table 2).

Vendace

Vendace is a pelagic species mainly caught by trawl, and almost 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), and a rough estimate of 2/3 unreported catches of vendace is not unlikely[42]. To remain conservative, and due to uncertainties about roe conversions to weight of fish, 20 % was used as an anchor point in 2005. Based on the general assumptions explained above, 10 %, (0.5 x 20 % = 10 %), was used as an anchor point in 1980, and 5 % was used in 1950. Linear interpolation was used between anchor points (Table 2), to get a complete time series of estimated unreported vendace landings.

Other species

As indicated above, the average unreported landings percentage for other species, in the late 1980s and the early 1990s was derived as an average of the earliest anchor points of cod, herring and sprat (i.e. [31 +25 +25] / 3 = 27 %). Since cod, herring and sprat are profitable species and therefore assumed to have more unreported landings (Hultkrantz 1997), the average rate of unreported landings was divided in half (27 % / 2 = 13.5 %) to derive an anchor point in 1990 for other species without information on unreported landings. This was treated as the first anchor point and therefore half (0.5 x 13.5 % = 6.8 %) 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. Based on the assumption that the unreported landings have decreased in later years, half of the value for 1990 (0.5 x 13.5 % = 6.8 %) was used as an anchor point in 2007 (Table 2).

Discards

In this study fishing mortality of fish that have been caught but never landed, due to different reasons, have been treated as separate discards components; regular discard, underwater discard, seal caused discard, and ghost fishing (defined in background information). Swedish sampling of regular discards started in 1995-96 and it is mainly the cod fishery that has been studied by Sweden in the Baltic Sea (Anon. 2007c). Due to a lack of information on most other species and fisheries, an extensive Danish study on regular discards in Danish fisheries in 2004 (Anon. 2006b) was used for flatfishes, except flounder, and other species without

[42] Steinbash, U. Personal communication November 2008. Swedish coast guard. Phone: +46(0)611-85522.

information (Table 4). Other discard information existed for cod, salmon and flounder. Herring, sprat, and vendace are assumed to only have underwater discards since the pelagic fishery is considered a 'clean' fishery with little unutilized by-catch[43]. The regular discard percentages from the Danish study were used as anchor points in 2004 for brill, dab, plaice, turbot, and others. The anchor point value was carried back and forth fixed (i.e., the value does not change), due to lack of information on changes of discard patterns over time. The percentage of regular discards for 'other species' has been applied to all species that do not have any other data on regular-, or underwater discarding. Danish trawl studies exist for 1985 to 1988 with higher discards than the study in 2004 (Bagge 1986, 1988, 1989), but due to very small sample size (e.g., sometimes <100 kg landed for a species, and in 1987 only sampled in April), and restriction to cod trawl fishery, the data did not seem as reliable as Anon. (2006b). However, for flounder in 1988, Bagge (1989) was used.

Table 4. Discards (%), based on a Danish study (Anon. 2006b).

Common name	Discard in 2004
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, see text for information. [b] Not used as anchor point for flounder, see text for information.

Seal populations in the Baltic Sea have increased by approximately 8 % year^{-1} 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 damages, was estimated in Swedish Kronor (SEK) to 22 million and 32.9 million (Table 5), respectively (Anon. 2005c, Hemmingsson and Lunneryd 2007). The 2004 data were used to estimate seal-caused 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 6). To derive a discard percentage, the loss in weight was divided by the total reported landings for those species (see next paragraph for example on calculations). Salmon and trout were reported together therefore the loss was divided by the combined reported landings of the two, resulting in the same discard percentage. The derived percentage for each species was used as an anchor point in 2004 (Table 6).

[43] Information centre of the Icelandic Ministry of Fisheries and Agriculture. Pelagic fishes. Available at www.fisheries.is/main-species/pelagic-fishes/ accessed 2009-04-02.

Table 5. Seal caused discard adjustment factor for other fisheries 1997.

	Loss (million SEK)		
Year	Total	Salmon fisheries[a]	Other fisheries[b]
1997	22	14	8
2004	32.9	9.5	23.4
Ratio			0.34[c]

[a] Including salmon, sea trout, and whitefish.
[b] Excluding salmon fisheries, see Table 6 for details. [c] The loss in 1997 was only 34 % of the loss in 2004.

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. The loss in the Baltic Sea (85 t – [85 t x 0.076] = 78.5 t) was divided by the total reported landings of perch from the Baltic Sea (105 t) to derive the seal discard percentage (78.5 t / 105 t = 74.8 %) that 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, targeting salmon, trout, and whitefish (14 million SEK), were available from 1997 (Table 5). 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-caused 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 5). Based on the fraction, and the already calculated values for 2004, a loss in tonnage could be derived for 1997 (Table 6).

Table 6. Seal caused discards in the Baltic Sea[a].

	2004[b]		1997[c]	
Common name	Loss (t)	Salmon fisheries loss (t)	Loss (t)	Salmon fisheries loss (t)
Atlantic cod	896		306	
Atlantic herring	431		147	
Atlantic salmon/Sea trout[d]		157		231
European eel	15		5	
European flounder	3		1	
European perch	79		27	
European whitefish		83		122
Turbot	0.1		0.0	

[a] The West coast + The Sound were excluded based on the economic loss in that area compared to the total loss. Fraction (7.6 %) was used for all species. [b] 2004 based on reported economical loss (Anon. 2005c), see text for information. [c] 1997 based reported total loss and loss in salmon fisheries (Hemmingsson and Lunneryd 2007), and on fractions derived from 2004 for remaining species, see text for information. [d] Separated based on reported landings for each year.

The weight was then converted to percentage as explained above. To remain conservative, and due to lack of information, it was assumed the seal damages prior to 1980 was minimal, and was set as zero. Linear interpolation was done between the three anchor points (1980, 1997, and 2004), and the percentage anchor point in 2004 was used until 2007. The estimated seal-caused discard was added to the regular discard, except for salmon (see below).

Underwater discard is fish that die after escaping deployed fishing gear. The reported underwater discard rate for herring in trawl fishery is 8.85 % (Rahikainen *et al.* 2004). Sprat is likely to have the same, or very similar underwater discard rate[44]. To remain conservative, an underwater discard rate of 5 % was applied to the fraction of catches (nominal landings + unreported landings) caught by trawl for the two species. For vendace, an underwater discard rate of 2.5 % was applied due to lack of other information.

During fishing it happens that the fishing gear is lost but the gear may continue to catch some fish, which is termed ghost-fishing. Brown *et al.* (2005) estimated a ghost-fishing catch of cod of 0.1-3.2 % of catch, 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 catches (nominal landings + unreported landings) of all species.

Cod

Swedish sampling data on regular discards for the years 1997 and 1998 (Anon. 2001b), and 2000 until 2006 were available (Anon. 2007c). The samplings for 1997 and 1998 were incomplete i.e. not all quarters were sampled for both years and the data set lacked mean weights. To fill in the missing data the mean discards for quarters/quarter sampled was applied to quarters without sampling. For example in 1998, in subdivision 24, the sampling for otter trawl was carried out during the 2nd, 3rd, and 4th quarter of the year. The mean discard per age group, derived from the three quarters sampled, was used to fill out the missing data for the first quarter. This method will overestimate discards for some areas and quarters, and underestimate discards for some areas and quarters, but was used with the assumption that the

[44] Rahikainen, personal communication March 2009 (author of Rahikainen *et al.* 2004). This pers. comm. was obtained by Peter Rossing of the *Sea Around Us Project*, UBC, Fisheries Centre.

over- and underestimation will cancel each other out at least to some extent. Mean weights from the Danish data set were used, area and gear type specific when possible, otherwise an average mean weight per age group was used. The discard for 1999 was derived by interpolation between 1998 and 2000. Discard of cod between 2000 and 2006 was reported as a percentage of landings in the cod trawl fishery. In 2006 the rate of discard in cod gillnet fishery (0.02 %), was also reported (Anon. 2007c). The same rate was applied to the gillnet catch for the other years, 2000-2006, without data on discards in the cod gillnet fishery. 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 regular discard was then divided by the total reported landings to derive anchor points in percentage from 2000-2006 (Table 6). The regular discard varied between 4.5 % and 15.6 %. The big variation year to year is partly explained by the effect of big variations in year classes for cod in the Baltic Sea (Anon. 2007c). ICES stock assessment working group extrapolate discards back in time based on the age distribution in landings according to Henrik Degel[45]. This method would have accounted for stronger year classes' larger contribution to discards, usually during ages when they are about to enter the fishery (Anon. 2004b). However, this was not doable for Swedish discards due to lack of data on age distribution. Therefore, the average of the three first years with data was used as an anchor point in 1996 and extrapolated 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, most likely is a minimum value due to observer bias effects[46,47] (Babcock and Pikitch 2003, Anon. 2006a, Bremner *et al.* 2009); the problem with discard pattern changes has been ignored. For 2007 an average of the three last years with data was used. Seal caused discards and the ghost fishing catches were added to the total discards for cod.

[45] Degel, H. Personal communication January and February 2009. Technical University of Denmark. DTU Aqua, National Institute of Aquatic Resources. ICES stock assessment working group. E-mail: hd@aqua.dtu.dk phone: +45-33963386.

[46] Boyes, D. Personal communication February 2009. Halibut fisherman BC, Canada. E-mail: mcboyes@telus.net

[47] Erikson, W. Personal communication February 2009. Wes Erikson is an active fourth generation commercial fisherman. He has fished for halibut, herring, salmon, rockfish, ling cod, skate and sable fish using long line, troll and gill net along the entire British Columbia coastline. Wes has been involved in the fisheries advisory process for over 20 years and has recently been a halibut representative on the Commercial Industry Caucus (CIC) implementing the pilot integrated ground fish strategy.
Along with fishing Wes owned an operated seafood restaurants for the last 15 years. E-mail: erikson.w@gmail.com

Table 7. Regular discards (%), based on individual sources, and for salmon also seal caused discard, see text for information.

Year	Cod	Flounder	Salmon	
			Regular discard	Seal caused discard
1950				

1980			9.0[a]	0.0
1981			12.2	
1982			7.2	
1983			7.6	
1984			7.4[b]	
1985			6.8	
1986			7.7	
1987			7.5	
1988		83.2	8.1	
1989			8.7	
1990			10.0	
1991			9.8	
1992			9.6	
1993			10.2	
1994			9.4	
1995		127.7[c]	10.6	
1996	9.1[d]	56.9[e]	11.0	
1997	4.7	66.4[e]	10.7	30.5
1998	15.6	146.7[c]	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	
2006	14.7		14.0	
2007				

[a] Assumption based anchor point, see text for information. [b] Break point when seal discards replaces regular discards, see text for information. [c] Interpolated between 1988-2004, see text and [e] for information. [d] Assumption based anchor point, see text for information. [e] Adjusted after interpolation for exceptional large landings, see text for information.

Herring and Sprat

The reported underwater discards of herring in subdivision 30 was 8.85 % in the trawl fishery (Rahikainen *et al*. 2004), and to remain conservative, discard of 5 % was applied to the part of the herring and the sprat catches that was caught by trawl. The ratio of trawl versus other gear types for herring was interpolated between anchor points (Table 8). 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 catches (nominal landings + unreported landings).

Table 8. Fraction of catch (%), caught by trawl (e.g., Anon. 1952, Anon. 1984, Anon. 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 continues time series.

Salmon

No Swedish sampling data were available for salmon, therefore, ICES salmon and trout working group report (Anon. 2008d) was used (Table 7). Swedish discards were derived the same way as Swedish unreported landings (see paragraph on unreported salmon landings for explanation). For example, for 1990 Sweden's reported landings of salmon (including river catch and estimated recreational catch) was 1468 t, and the total reported catch for the Baltic Sea was 5636 t. The 95 % probability interval of the estimated unreported catch was 481 t – 1245 t. Thus, applying the assumptions outlined above for unreported landings, Sweden's fraction of the total catch (1468 t / 5636 t = 0.26) was multiplied with the lower range value for discards (0.26 x 481t =125 t), to derive a salmon discard for Sweden in 1990. The discards were then converted into percentages based on reported landings, and the average of the first three years with data, was used as an anchor point in 1980 and extrapolated back to 1950 (Table 7). The calculated discards based on the report were only used in 1981 and 1982. In 1983 the estimated seal caused discard was larger than the calculated total discard from the report, therefore, only the seal caused discards were used for the rest of the time series.

'Flatfishes'

Regular discards of flatfishes are common in the bottom trawl fishery for cod (Anon. 2007c). European flounder is the most abundant flatfish in the Baltic Sea and the discard of this species in the cod fishery is sometimes substantial especially for bottom trawl (Anon. 2008a, Anon. 2001a). Due to lack of data on discards of flatfishes other than flounder, the Danish study in 2004 was used. In the Danish study the discard of dab, flounder and plaice was given and the average discard for those flatfish was applied to brill and turbot (Table 4), with the

assumption of similar discard patterns. The anchor point value was carried back and forth fixed (i.e., the same value was used for the entire time series), due to lack of information on changes of discard patterns over time.

The total discards of flounder in cod fisheries (i.e., otter beam trawl, gillnets, and longlines) in ICES subdivision 24 and 25 (Gårdmark *et al.* 2006), was used as anchor points (Table 7). Despite the uncertainties in the earlier Danish discard studies, the flounder discard reported in 1988 (Bagge 1989), was used as an anchor point and it was carried back fixed to 1950. The discard number in 1988 matched the Swedish discards for 2004 and 2005 better than the Danish study from 2004. In 1996 and 1997 the reported landings of flounder were much higher than usually (378 t in 1995, 1072 t in 1996, 918 t 1997, and 502 t in 1998), due to an increased demand from Russia (Anon. 2005a), and also misreporting of other species as flounder (Anon. 2008a, Ask and Westerberg 2008, Gårdmark *et al.* 2006). The discards for these years were lowered based on the assumption that the discards decreased substantially due to substantial increase of landings. To derive the percentages for 1996 and 1997 half of the average of discards in 1995 and 1998 in t ([483 t + 737 t] / 2 = 610 t → 610 t / 2 = 305 t), was divided by reported landings in 1996 (305 t / 1072 t = 56.9 %) and 1997 (305 t / 918 t = 66.4 %). For 2006 and 2007 the last year of data was not used due to the extraordinary high number, and the discard for 2004 was used instead. Linear interpolation was done between anchor points (Table 7).

Recreational catches

Recreational catch includes catches for house consumption as well as catches with hand gear for purely recreational purposes. However, it excludes catch that is released or discarded. 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. 2005d, Anon. 2007b). These studies were carried out as questionnaires-based surveys to between 5,000 and 11,000 people at a time. Such survey studies have their own set of uncertainty issues due to the methods used and the information asked for. It is known 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. 2005d, 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) [48]. Among the 1990-2007 studies, the 2007 study is thought to be most reliable because it adjusts for the different willingness to participate based on personal fishing interest (Anon. 2007b). The 2005 study has been similarly adjusted by the SBF[49], and the differences between the original numbers (Anon. 2005d) and the adjusted numbers (Ask and Westerberg 2006) were used to improve the other studies (Table 9).

The catches in the studies from 2000 and 2005, were reported as a total marine recreational catch, hence had to be adjusted for the west coast part of the catch. These adjustment factors were based on the study from 2007 and calculated as follows: catches of cod, flatfishes, sea trout, and 'other species' were reported by different marine areas which enabled individual adjustment factors. Catches of mackerel, crab, lobster, mussels, and 'other cod fish' were

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[49] Paulrud, A. Personal communication October 2008- February 2009. Swedish Board of Fisheries, Fish and Wildlife Department Swedish Agricultural University. Phone: +46(0)70-6466808.

thought to be entirely from the west coast (Anon. 1978, Anon. 2007b). To derive adjustment factors for remaining species the study from 2005 was used; 33 % of the total marine recreational catch in the study from 2005 was caught on the west coast. The species that were thought to be caught exclusively there were subtracted from the west coast part of the catch and also from the total catch. By using the adjustment factor for cod, flatfishes, sea trout and 'other species' based on the study from 2007, the same calculation was made for those species as well. The remaining west coast catch was then divided by the remaining total catch to derive a general fraction. This fraction was subtracted from one to derive the Baltic Sea percentage used for species without individual adjustment factors (Table 9).

Table 9. 2005 recreational catches (t), original and adjusted. The difference was used to adjust for overestimation of catches in the studies from 1995 and 2000. The Baltic Sea adjustment factor is based on the studies from 2007 and 2005, and was used to exclude the west coast catches in the studies from 2000, and 2005, see text for information.

Category	Original	Adjusted	Overestimation	Baltic Sea adjustment
Atlantic cod	1,730	1,127	1.54	0.78
Atlantic 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[a]	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	-----
Fishing days	29,000,000	22,000,000	1.32	-----

[a] Recreational catch of flatfish includes all species of flatfish in the Baltic Sea.

After adjustments, the numbers of country-wide recreational fishers from each study as well as for 1947 (200,000, Anon. 1978), were used in conjunction with total Swedish population numbers[50] to derive the percentage of the total population that were recreational fishers per year. Linear interpolation between these percentage rates was done to fill missing years. To derive total number of recreational fishers over time, these percentages were multiplied by the total population per year.

The above mentioned recreational surveys were then used to derive recreational effort estimates (number of fishing days per fisher per year), and a recreational catch rate per fisher per day. 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 % (2,000,000 / 8,208,442 = 24.4 %). 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 (25,000,000 / 2,000,000 = 12.5). The recreational catch in 1975 was 13,334 t, which gives a catch rate of 0.00053 t fisher^{-1} day^{-1} (13,334 t / 2,000,000 / 12.5 = 0.00053 t fisher^{-1} day^{-1}). Linear interpolation was done for the years between the studies. The 1975 study's number of fishing days per fisher, and catch rate per fisher per day, 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

[50] Statistics Sweden. Sweden's population (in one year classes) 1860-2008. Available at http://www.scb.se/Pages/ProductTables____25795.aspx "Sveriges befolkning (i ettårsklasser) 1860-2008" accessed 2009-03-17.

species where it was possible. These fractions were then interpolated and applied to the calculated total recreational catch.

RESULTS

The results illustrated here represent a first attempt at assumption-based reconstruction of total catch time series for Swedish fisheries in the Baltic Sea, form 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 divided by ICES reported landings. For time series data of each category, see Appendix 1 Table 1-12.

Cod

The landings baseline (herein referred to as 'nominal landings') for the catch reconstruction of cod was mainly formed by ICES reported landings, except in 1965-1975 where ICES stock assessment working group data were used causing the baseline to be 3 % larger than ICES reported landings (Figure 2). Cod landings were relatively stable throughout the first three decades considered here and averaged 21,300 t·year^{-1}. During the 1980s landings increased substantially and averaged 51,000 t·year^{-1} with peak landings of about 65,800 t in 1984. Landings of cod declined dramatically in the early 1990s, and in the last five years average 13,100 t·year^{-1} (Appendix 1 Table 1).

Prior to the 1980s, unreported landings of cod were estimated to be relatively small, averaging 2,100 t·year^{-1}. From 1980 until the 2000s, estimated unreported cod landings of between approximately 3,100 and 17,400 t·year^{-1}, made up a large proportion of unaccounted catches (Figure 2). In more recent years, unreported landings for Sweden have declined to around 1,900 t·year^{-1}.

During the first three decades discards ranged between approximately 1,900 and 3,400 t·year^{-1}. During the 1980s discards tonnage increased to an average of 7,100 t·year^{-1}, however, discards were stable in relation to nominal landings 1950 to 1996 since they were based on a fixed percentage due to lack of data, and thereafter varied year to year. In the last five years the discards were the largest component of the unaccounted catches with an average discard of 2,500 t·year^{-1}, compared to unreported landings with an average of 1,900 t·year^{-1}, and an average recreational catch of 870 t·year^{-1} (Figure 2).

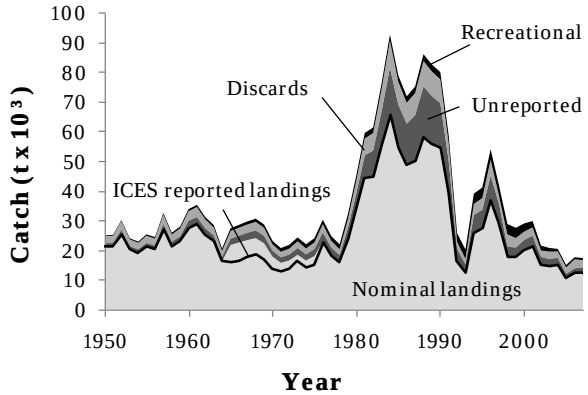

Figure 2. Sweden's total reconstructed cod catches in the Baltic Sea 1950-2007, showing ICES reported landings as a black line.

The recreational catches of cod were relatively low, except possibly during the 1990s when the 1990-1999 total estimated recreational catch of cod was about 32,600 t. According to the

information available, which does not include the 1980s, the historically highest annual recreational catch of cod was around 3,600 t in 1996 (Figure 2).

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

Herring and sprat

ICES reported landings were used as nominal landings until 1989 for herring. ICES stock assessment working group data were used as nominal landings from 1990-2007 causing the baseline to be 20 % smaller then ICES reported landings. Landings of herring were stable for the first 15 years with annual catches of on average 32,700 t·year^{-1}. After the mid 1960s landings increased until 1980 and a top notation of around 92,900 t. During the 1980s landings declined rapidly to 36,400 t in 1987, and thereafter once again increased and averaged about 64,300 t during the 1990s. The last five years annual landings of herring were on average 47,700 t (Figure 3a, Appendix 1 Table 2).

Prior to 1980 the unreported landings, discards, and recreational catches of herring were relatively small (averaging 3,600, 1,400, and 1000 t·year^{-1} respectively). During the 1980s and the 1990s unreported herring landings between approximately 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 % of nominal landings in 1950, to 5.4 % 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}. The underwater discards in the last five years were the highest in terms of proportion of landings, however, since landings declined the annual average underwater discard was lower in tonnage, 2,900 t, than the two previous decades (Figure 3a).

The estimated recreational catches of herring were small for the whole time period with a peak catch in 1994 of about 3,900 t, which was in the magnitude of 6 % of ICES reported landings that year. The total reconstructed catch of herring was about 23 % larger than the nominal landings for 1950-2007, but only 13 % larger than ICES reported landings due to the adjustment for misreported sprat catches and catches from outside the Baltic Sea (Figure 3a).

For sprat the nominal landings were formed by ICES reported landings combined with Swedish national landings data in the earlier years, and ICES stock assessment working group data from 1990-2007 (Table 1). The reported landings of sprat from 1950-1989 were small, averaging 2,400 t·year^{-1}, compared to the reported landing during the 1990s, averaging 108,000 t·year^{-1}. During the last five years the annual landings averaged 75,800 t·year^{-1} (Figure 3b, Appendix 1 Table 3).

The estimated unreported sprat landings increased substantially with the increased nominal landings and averaged 24,600 t·year^{-1} during the 1990s. The peak unreported sprat landing was around 41,100 t in 1998, and the unreported landings were a substantial part of unaccounted sprat catches (Figure 3b). 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 (5 % of the nominal landings) during the entire time period due to exclusive use of trawl in the sprat fishery, and there were no estimated recreational catches of sprat. For the period 1950-2007 the estimated total reconstructed catch of sprat was 34 % larger than ICES reported landings (Figure 3b).

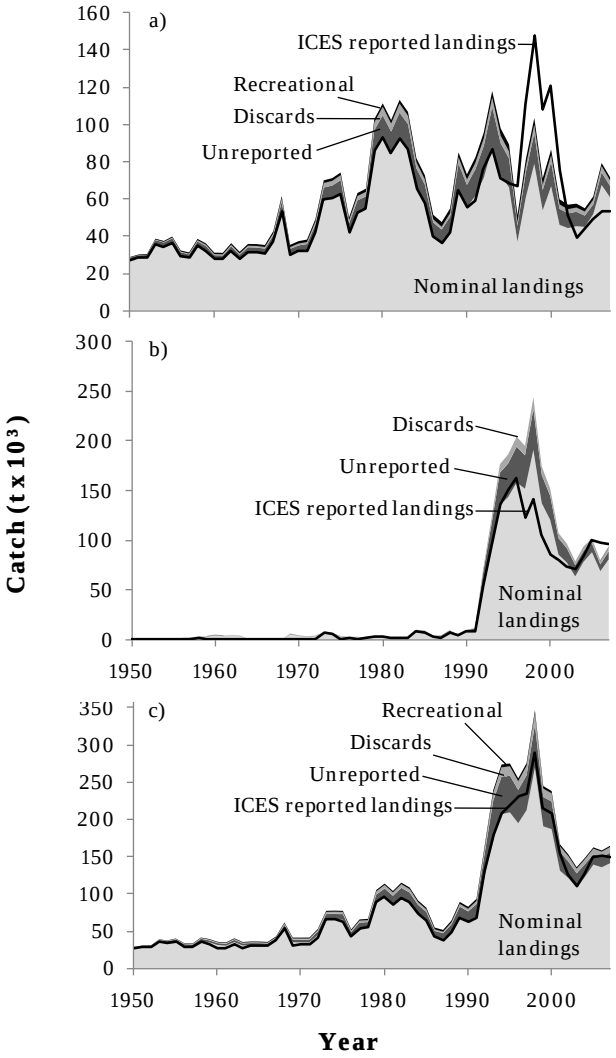

Figure 3. Sweden's total reconstructed catches in the Baltic Sea 1950-2007, for (a) herring, (b) sprat, and (c) herring and sprat combined, showing ICES reported landings as a black line.

The total reported landings of herring and sprat combined were about 4,7 million t from 1950-2007, which was 70 % of total reported landings for Sweden, which was about 6,7 million t for the entire period. The peak landings were approximately 269,700 t in 1998 (Figure 3c, Appendix 1 Table 4).

Salmon

Swedish national landings data made up the nominal landings for salmon except in 1978 where ICES reported landings data were used. Landings of salmon were quite stable prior to 1980, except for a decline from about 1,400 t in 1950 to around 400 t in 1953. After 1980, landings increased from an average annual landing of 500 t·year^{-1} (from 1954-1979), to

approximately 1,200 t in 1990, which was the highest reported landing since 1950. After 1990 landings declined and in the last five years the average annual landing was 400 t (Figure 4, Appendix 1 Table 5). The estimated unreported landings of salmon were relatively small during the whole time period 1950-2007 and varied between approximately 20 and 95 t·year^{-1} (Figure 4).

The discards of salmon were estimated to 60 t·year^{-1} on average prior to 1980. The increase of seals after 1980 caused an increase of discards of salmon that peaked during the 1990s with an average discard of 220 t·year^{-1} (Figure 4). The total discard of salmon in 1997 was around 230 t, whereof about 200 t, 87 %, was discarded due to seal damages. In recent years the total discard decreased and averaged 110 t·year^{-1}.

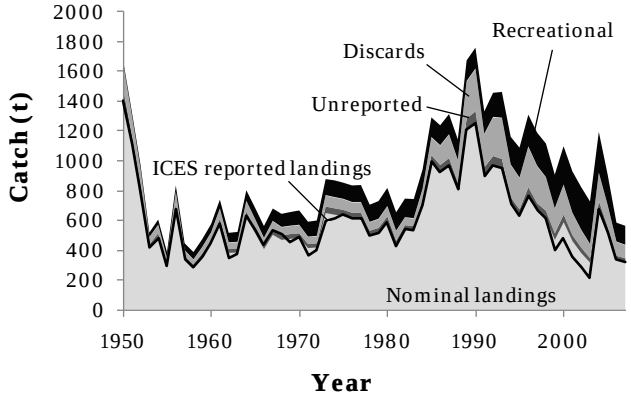

Figure 4. Sweden's total reconstructed salmon catches in the Baltic Sea 1950-2007, showing ICES reported landings as a black line mostly in concurrence with nominal landings.

The estimated recreational catches of salmon increased steadily from 20 t in 1950, to the peak catch of about 300 t in 2002 and thereafter declined to about 140 t in 2007 (Figure 4).

The estimated recreational catches and discards of salmon made up a substantial part of the estimated total salmon catches from 1950-2007. After the unaccounted catches were added to the nominal landings the total reconstructed catch of salmon was 48 % larger than ICES reported landings 1950-2007. In recent years (2003-2007) the reconstructed catch of salmon was on average 93 % larger than ICES reported landings for the same period (Figure 4).

'Flatfishes'

Flatfishes includes brill, dab, flounder, plaice and turbot. The nominal landings for flatfishes were formed by ICES reported landings and ICES stock assessment working group data, and Swedish national landings data (Table 1). The nominal landings for flatfishes were overall 2 % larger than ICES reported landings. For the first two decades, the 1950s and the 1960s, the average landings of flatfishes were about 1,000 t·year^{-1}, whereof around 63 % was flounder. The landings decreased during the 1970s and the early 1980s to the all time low landings of about 170 t in 1985, whereof around 65 % was flounder (Figure 5a, Appendix 1 Table 6 and 7). After 1985 the landings were quite stable until the mid 1990s when the landings more than tripled in two years, from approximately 370 t in 1994, to around 1,400 t in 1996, whereof 74 % was flounder, and thereafter declined to about 400 t again in 1999, and thereafter remained quite stable for the rest of the period (Figure 5a).

Estimated unreported flatfish landings were relatively low during the whole time period 1950-2007 and varied between about 20 and 160 t·year^{-1} (Figure 5a). Prior to 1970 the estimated discards averaged 700 t·year^{-1} (Figure 5a). Since the discards for most of the time period, were based on a percentage they decreased during the 1980s, when the reported landings were small, and averaged 200 t·year^{-1}. Thereafter, they increased with increased landings during the 1990s to an average of 500 t·year^{-1}. After 1998 discards were larger than the nominal landings and peaked in 2005 when nominal landings were 400 t and the discards were about 1,400 t, whereof 97 % was discarded flounder (Figure 5a).

Estimated recreational flatfish catches (might include other flatfish species but are thought to be dominated by the five referred to as 'flatfishes') made up a substantial part of the likely true catch (Figure 5a). The average recreational catch was 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 it peaked. In recent years the estimated recreational catch was 500 t·year^{-1} on average (Figure 5a). The total estimated reconstructed catch of flatfish was almost 3.7 times larger than ICES reported landings from 1950-2007 (Figure 5a).

Sea trout

The nominal landings for sea trout were formed by Swedish national landings data, except in 1978 where ICES reported landings data were used. The total nominal landings was 20 % larger than ICES reported landings due to missing data in ICES reported landings (Figure 5b). Landings of sea trout were quite stable prior to 1980 and averaged 70 t·year^{-1}. After a drop in 1981, when landings of only 5 t were reported, landings increased until the all time high of about 170 t in 1993, and thereafter declined to an average of 30 t·year^{-1} in recent years (Figure 5b, Appendix 1 Table 8).

The estimated unreported sea trout landings were relatively low and never exceeded 41 t·year^{-1} during the entire period (Figure 5b). The estimated discards were also relatively low and peaked during the 1990s when it ranged between approximately 20 to 60 t (Figure 5b).

The total estimated recreational sea trout catch was 8 times larger than ICES reported landings from 1950-2007. Prior to 1980 the average recreational catch was 460 t·year^{-1}, and during the 1980s it was on average 590 t·year^{-1}, which was 12 times larger than ICES reported landings that averaged 48 t·year^{-1} in that period (Figure 5b). During the 1990s the estimated recreational catch was on average 500 t·year^{-1}, which was 5 times larger, compared to ICES reported landings for that period that averaged 106 t·year^{-1} (Figure 5b). Considering the total catches of sea trout (in contrast to reported landings) the total estimated reconstructed catch was about 10 times larger than ICES reported landings from 1950-2007 (Figure 5b).

Eel

ICES reported landings data made up the entire nominal landings for eel. The average annual landings declined from 1,900 t·year^{-1} in the 1950s to 310 t·year^{-1} in the 2000s (Figure 5c, Appendix 1 Table 9). After the regulation of fishing for eel the reported landings in 2007 were 416 t (Figure 5c).

The total estimated unreported eel landings were 9 % of nominal landings from 1950-2007. Unreported landings have decreased in size since the 1950s, when the average unreported

landings were 110 t·year^{-1}, to unreported landings of 60 t·year^{-1} on average during the 2000s. However, relative to the nominal landings the annual estimated unreported eel landings increased from 6 % on average during the 1950s, to 18 % on averages during the 2000s (Figure 5c).

The total estimated discards were also 9 % of the nominal landings from 1950-2007. In the last five years the discards were 17 % of the nominal landings (Figure 5c), and about 42 % of the discards were due to seal damages. In 2004 the estimated discards were about 40 t, whereof around 18 t were discarded due to seal damages.

The estimated recreational catches of eel were larger than both unreported landings and discards combined, and made up a substantial part of the unaccounted eel catches (Figure 5c). The largest recreational catches were taken during the 1970s with an average catch of 460 t·year^{-1} (55 % of ICES reported landings in the 1970s). The relatively largest recreational catches were taken in the 2000s, until the regulation of eel fishing in 2007, with an average catch of 210 t·year^{-1} (70 % of ICES reported landings) for 2000-2006 (Figure 5c). The total reconstructed catch of eel was 50 % larger than ICES reported landings from 1950-2007 (Figure 5c).

Whitefish

The nominal landings data for whitefish was 95 % larger than ICES reported landings 1950-2007 (Figure 5d). It was made up of Swedish national landings data (1950-1969) and ICES reported landings for whitefish and 'whitefishes nei' (*Coregonus*) merged (Table 1). Landings of whitefish declined from 1950 to 2007. Prior to 1980 the average landings were 500 t·year^{-1}, after that they decreased but were quite stable during 1980s and 1990s with average landings of around 380 t·year^{-1}. During the 2000s the average landings decreased again to 220 t·year^{-1} (Figure 5d, Appendix 1 Table 10).

Estimated unreported whitefish landings were relatively low during the whole time period and annually never exceeded 70 t which was the estimated unreported landings in 1994 (Figure 5d). Prior to 1980 the estimated discards were relatively low and ranged between approximately 20 and 70 t·year^{-1}. After the increase of seals, from the 1980s and onwards, the discards increased substantially and made up a larger part of the unaccounted catches of whitefish. During the 1990s the estimated discards ranged between approximately 130 to 260 t·year^{-1}, but declined during the 2000s with an average discard of 90 t·year^{-1} (Figure 5d).

The estimated recreational whitefish catches accounted for a substantial part of the unaccounted catches and were almost 5 times larger than ICES reported landings from 1950-2007. The recreational catches declined from the 1970s and an average of 1,500 t·year^{-1}, to an annual catch of 1,000 t on average during the 1990s. The recreational catches declined even more during the 2000s to an annual catch of about 500 t, but were still on average twice the size of ICES reported landings (Figure 5d). After the unaccounted catches were added to the nominal landings the total reconstructed whitefish catch was 7 times larger than ICES reported landings (Figure 5d).

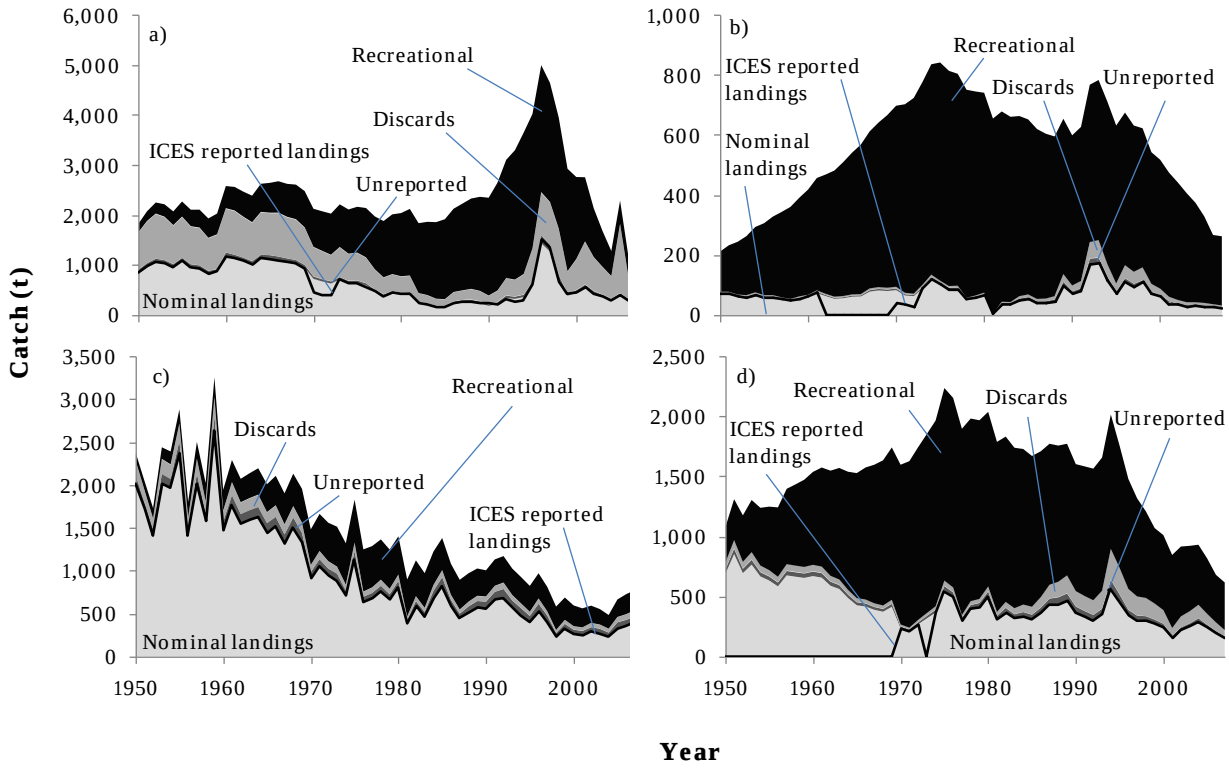

Figure 5. Sweden's total reconstructed catches in the Baltic Sea 1950-2007 for (a) flatfish (b) sea trout (c) eel and (d) whitefish, showing ICES reported landings as a black line mostly in concurrence with nominal landings. Flatfish includes brill, common dab, flounder, plaice, and turbot, except the recreational component which might include catches of other flatfish species but is thought to be of such a small amount and has therefore been ignored. ICES reported landings for sea trout is sea trout and trouts nei merged, and for whitefish it is whitefish and whitefishes nei merged.

Total recreational catches

Estimated recreational catches in Sweden increased from around 2,500 t·year^{-1} in 1950 to about 18,500 t in 1994, but declined rapidly thereafter to around 6,500 t in 2006 (Figure 6, Appendix 1 Table 11). The species composition of the recreational catch differed from the commercial species composition, and also showed changes in preference over time. Species like Northern pike and European perch are two large components of the total recreational catches (Figure 6), compared to the commercial catches where cod, herring, and sprat accounts for 94 % of ICES reported landings.

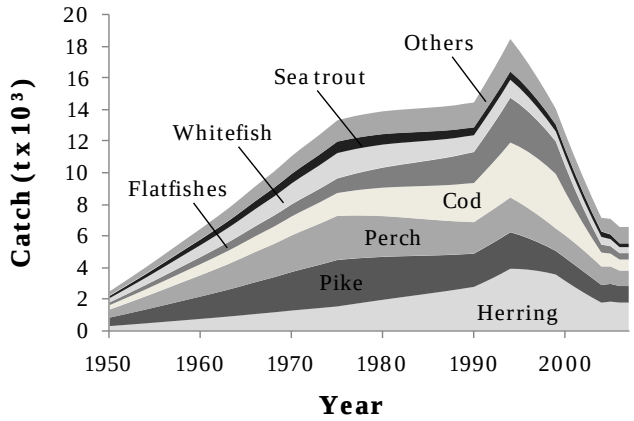

Figure 6. Sweden's total recreational catches in the Baltic Sea 1950-2007. Others includes eel and salmon among other species.

Total reconstructed catch

Total Swedish nominal landings were 2 % smaller then ICES reported landings from 1950-2007 (Figure 7). Prior to 1980, the total nominal landings were quite stable with an annual average of 70,000 t. In the beginning of the 1980s, the landings increased substantially to around 146,000 t in 1983 (Figure 7, Appendix 1 Table 12). The average landings during the 1980s were 125,000 t·year^{-1}, which was 79 % higher than prior to 1980. This was partly explained by the big increase of cod landings during the 1980s (Figure 2). During the 1990s, the catches once again increased substantially, and averaged almost 206,000 t·year^{-1}, with the all time peak landings of approximately 290,000 t in 1998 (Figure 7). This peak was mainly driven by increased landings of sprat (Figure 3b-c). Thereafter, total landings declined and averaged 146,000 t·year^{-1} during the last five years (Figure 7).

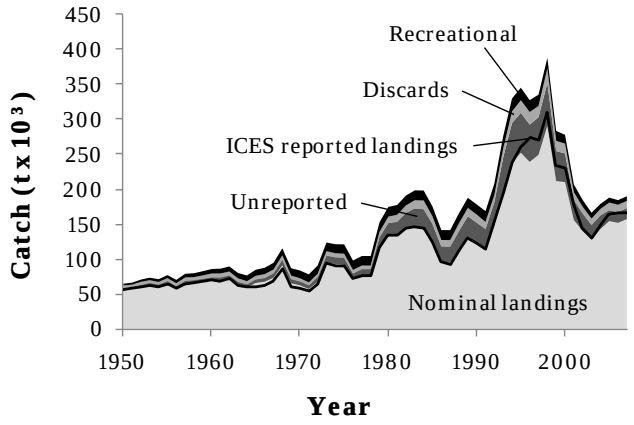

Figure 7. Sweden's total reconstructed catches in the Baltic Sea 1950-2007, showing ICES reported landings as a black line.

Overall, the total estimated reconstructed catch for Sweden was 31 % higher than suggested by officially reported data (ICES reported catch by species, area, and year), for the 1950-2007 time period (Figure 7). The difference peaked during the 1990s and was on average 68,000 t·year^{-1}, which is a substantial tonnage. In recent years, the difference amounts to about 28,000 t·year^{-1}; thus, around 18 % of estimated total catches appear not to be accounted for by officially reported ICES catch data. If herring and sprat were excluded the unaccounted

factors increases to 37 % of the estimated total catches in recent years. Over the entire time period the total estimated unreported landings were 1.09 million t, the total estimated discards were 0.52 million t, and the total estimated recreational catch was 0.63 million t (Figure 7).

DISCUSSION

To improve the understanding of fisheries impacts on the ecosystem, and to decrease uncertainties for stock assessments, 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 holistic total catch including unreported landings, discards and recreational catches. As long as the estimates for unaccounted catches are not overestimated, the catch reconstruction will be more accurate compared to reigning total catch estimates were the use of 'zero catch' for no hard data often is applied. Therefore the effort to remain conservative throughout the study was persistent.

Sweden submits their yearly landings data to ICES who has one of the world's largest databases on fisheries[51]. For the focal period of the catch reconstruction, 1950-2007, the reported landings by Sweden to ICES amount to a total of 6,786,623 t from the Baltic Sea. In contrast, Sweden's total catch taken from the Baltic Sea ecosystems from 1950-2007 as reconstructed here was about 8,900,000 t, i.e., 31 % higher than official reported landings from 1950-2007.

The difference between reported landings and reconstructed catches can to a large extent be accounted for by the unreported landings, which were estimated to about 1.09 million t for the entire period, which was 12 % of the estimated total catch. This is in line with the opinion that the unreported landings are the largest component of IUU catches in the Baltic Sea (Sporrong 2007).

The estimated Swedish discards for 1950-2007 were about 0.52 million t, which was 6 % of the estimated total catch. 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 discards 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). Principally, the only way in which actual catches (i.e., reported and unreported landings and discards) can be appropriately accounted for, is through 100 % observer coverage, due to the observer bias effects introduced with a coverage of less then 100 % (Babcock and Pikitch 2003, Anon. 2006a, Bremner *et al.* 2009)[52,53].

The estimated recreational catch was about 0.63 million t from 1950-2007, which was 7 % of the estimated total catch. Recreational fishing in Sweden is one of the biggest recreational

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[51] ICES and Global Observing Systems Information Center. Available at http://www.gosic.org/goos/ICES-data-access.htm accessed 2009-04-06.

[52] Boyes, D. Personal communication February 2009. Halibut fisherman BC, Canada. E-mail: mcboyes@telus.net

[53] Erikson, W. Personal communication February 2009. Wes Erikson is an active fourth generation commercial fisherman. He has fished for halibut, herring, salmon, rockfish, ling cod, skate and sable fish using long line, troll and gill net along the entire British Columbia coastline. Wes has been involved in the fisheries advisory process for over 20 years and has recently been a halibut representative on the Commercial Industry Caucus (CIC) implementing the pilot integrated ground fish strategy.
Along with fishing Wes owned an operated seafood restaurants for the last 15 years. E-mail: erikson.w@gmail.com

activities and for some species the recreational catch is many times larger than the commercial catch (Anon. 2007b). If one excludes the three major commercial species, cod, herring, and sprat (who accounts for 94 % of total ICES reported landings), the recreational catches made up 49 % of the remaining total catch. Similar recreational fractions of total catches have been reported in the USA. For example, in the Gulf of Mexico the recreational part of the total catch of species of concern (i.e., species that are overfished or experiencing overfishing) was 64 %, on the Pacific coast 59 %, and in the South Atlantic 38 % (Coleman *et al.* 2004). Even though the recreational part of catches is often substantial, the data on recreational fishing in Sweden is very poor, especially prior to 2006. Hence, more studies are needed for the same reasons as for discards and unreported landings; better stock assessments and improved understanding of fisheries impact on the ecosystem. Better data needed for recreational fisheries include 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 intervening years interpolated.

The conservatively estimated unaccounted catches, as reconstructed here, peaked during the 1990s and averaged 68,000 $t \cdot year^{-1}$, which is a substantial tonnage. The unreported landings-, discards-, and recreational component together accounted for most of the unaccounted catches that were added to the reported landings. The choice of nominal landings data made the difference in percentage smaller between ICES reported landings and the reconstructed catch. The unreported landings component was almost about the same size as the other two combined; 1.09 million t of unreported landings compared to 1.15 million t for discards (0.52 million t) and recreational catches (0.63 million t). Discrepancies between reported landings and the total catches of a species, can contribute substantial uncertainties to stock assessments (Anon. 2008a), and lead to poor or incorrect management advices, as it provides for difficulties in determine sustainable catch levels and quotas. This can have devastating effects, and one example mentioned earlier, is the Canadian Atlantic cod stocks of Newfoundland that collapsed during the 1990s, mostly due to overestimation of the stock sizes, and quotas that were too large (Walters and Maguire 1996).

The information that exists and was found during this study, was very biased towards the commercially important species, such as cod. The total reconstructed catch numbers were mainly driven by the three major commercial species cod, herring, and sprat, that accounted for 94 % of the total ICES reported landings. These three are also the ecologically dominating species of fish in the Baltic Sea (Hansson and Nissling unpublished data[54]); hence, fishing is one key factor structuring the Baltic Sea marine ecosystems (Harvey *et al.* 2003). Consequently, if fishing causes a decline, or collapse, of a fish population, it does not only affect the fisheries, but also the ecosystem (Harvey *et al.* 2003). For example, multi-level trophic cascade effects have recently been reported for the Baltic Sea (Casini *et al.* 2008), driven mainly by overfishing of cod that enabled substantial increases of sprat during the 1990s due to predation release. This in turn led to a decline of zooplankton, the food of sprat,

[54] Ecological effects of fishing in the Baltic Sea – analyzes and modeling with main focus on cod ecology and cod fishery. “Ekologiska effekter av fisket i Östersjön – analyser och modelleringar med tyngdpunkt på torskens ekologi och torskfisket”. Available at http://www.ecology.su.se/projects/images/WWF1.pdf accessed 2009-04-04.

which in turn reduced grazing pressure on phytoplankton enabled them to bloom, hence the cascade effect of overfishing. The potentially harmful algal blooms were previous exclusively ascribed to eutrophication and climate conditions (Casini *et al.* 2008). Low densities of zooplankton also harms the recruitment of pike and perch (Ljunggren *et al.* 2008), and problems with recruitment for these two species exists along the Swedish coast of Central Baltic Sea (Ask and Westerberg 2008). Sweden has an extensive tradition of scientific research. Many of the laboratories and research stations that make up the foundation of the national marine research today, were founded around 1930[55]. However, there is a lack of data and understanding about fisheries impact on the Baltic Sea ecosystems beyond the most basic, single species stock assessments and direct effects of fishing. More ecosystem-level research is needed, and larger safety margins in Total Allowable Catch (TAC) due to the uncertainties of the effects on the ecosystems (Hjerne 2003). One of the important needs is for better accounting of total catches, not only commercial landings data. As indicated above, compulsory 100 % mandate observer coverage (physically onboard and/or video monitored and off-ship analyzed) on all commercial fishing vessels improves accounting of total catches (Anon. 2005e).

Unreported landings

The estimated unreported landings for the catch reconstruction are thought to be conservative and therefore minimum estimates. Out of the total 1.09 million t unreported landings that was added to Sweden's total nominal landings, more than 65 % came from unreported landings during the 1980s and the 1990s. This reflects the limited information available, but is also a result of the cautious assumptions and conservative methods chosen to complete the time series of unreported landings based on anchor points (i.e., information- and assumption based anchor points). 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. The general opinion expressed by sources that provided information and knowledge, was that the unreported catches have declined in recent years[56,57,58], hence, the effort to remain conservative when setting anchor points in the 2000s. The 1980s, and the 1990s, was also the time with high reported landings and since the unreported landings component was a percentage, it resulted in a high tonnage of unreported landings.

Cod and ICES stock assessment working group reports

The estimated unreported cod landings were about 18 % of ICES reported landings, and made up 45 % of the total unaccounted cod catches. A study on unreported cod fishing in the Baltic suggested that the countries with the largest fraction of the TAC (i.e., Sweden, Denmark and Poland), are the biggest offenders with respect to unreported landings (Sporrong 2007).

[55] The history of the Swedish Board of Fisheries. Available at http://www.fiskeriverket.se/vanstermeny/omfiskeriverket.4.1e93312510e313daf128000225.html accessed 2009-04-06.
[56] Karlsson, K-E. Personal communication November 2008. Foreign Department, The Swedish Tax Agency. E-mail: karl.erik.karlsson@skatteverket.se, phone: +46 (0)771-778778.
[57] Sjöstrand, B. Personal communication March 2009. Swedish Board of Fisheries, ICES working group.
[58] Löwenadler Davidsson, J. Swedish Board of Fisheries, head of Control Department. E-mail: johan.lowenadler-davidsson@fiskeriverket.se, phone: +46(0)31-7430425.

According to a Polish fisher the quotas are exceeded in each country, but mainly by Poland and Sweden[59]. 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, Anon. 2008a), Sweden's unreported landings of cod, estimated here, are relatively small. As pointed out earlier, the RF factor in the report (Anon. 2008a) is different depending on if it is presented as 'RF', or calculated based on the data presented. This is another example of lack of transparency that makes the stock assessment working group reports very unclear for uninformed people (i.e., anyone outside 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 (Anon. 2008a), and it 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, and increases the total RF by 10 %. The unreported landings for Poland are thought to be about 300 % (Anon. 2008e) which equals a RF of 3, hence, if Poland is one of the countries that does not report any 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 (and other marine areas) are essentially public property (owned by the people of all Baltic countries), yet the continued, apparently purposeful 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 regular discards was sparse, except for cod and possibly flounder. Swedish discard sampling has mainly focused on cod fisheries. The Swedish information found about other species was not detailed enough, and could therefore not be used to derive anchor points. The Swedish sampling has covered <1 % of the fishing effort, and due to high variability the data are uncertain (Anon. 2007c). During times with restrictive quotas, discards due to high grading are more prevalent (Anon. 2008a). The sampling system with observers onboard can not address discards due to high grading, since fishers likely changes their behavior with observers onboard (Anon. 2004b), and due to lack of information that type of discard was not covered in this study. Concerning seal caused discards, another way of estimating them could have been to use the growth rate of the seal population. However, the extent of damage is not entirely related to the population size of seals, due to development of seal safe gears, for example the 'push-up' trap, and the absence of hunting which has

[59] Sandecki, M. Big cod fraud. Polish newspaper article, in Gdańsk 2006-05-04. Available at http://www.fishsec.org/downloads/1172158401_70868.pdf accessed 2009-04-08.

decreased seals' fear of people, which changes the conditions for seal damages over time (Hemmingsson and Lunneryd 2007, Anon. 2005c).

The estimated Swedish regular discards of cod in 2006 were about 1,800 t (total estimated discards of cod were around 3,100 t). Most of cod discarded is undersized cod that fishers are not allowed to land. With large discards of undersized cod there is a large number of sexually immature fish that dies, which is a loss of future reproduction capacity as well as catch opportunities (Anon. 2007e). The cod discards in the Baltic Sea reported in ICES stock assessment working group report were about 4,650 t in 2006 (Anon. 2008a, Table 2.4.20). Since the estimated Swedish regular discards were about 1,800 t in 2006, it implies that almost 38 % of the total cod discards in the Baltic Sea 2006 were discarded by Swedish fishers. Compared to Sweden's fraction of the total landings of cod which is around 20 % (Anon. 2008a Table 2.4.1), that seems unreasonably high. Sweden's relatively high discard might partly be explained by extensive fishing in subdivision 25 where there is a lot of young cod[60]. However, it is unlikely that the difference in discards is that big between Sweden and the other countries, therefore this is an indication of lack of data, and uncertainties in the existing data. It is also another example of problems with lack of transparency in the ICES stock assessment working group reports that if transparent enough, possibly could explain why Sweden seems to have an unreasonable high proportion of discards.

Discards of flounder is sometimes substantial in the bottom trawl fishery for cod, and in 2005 the estimated discard of flounder was about 1,300 t, which is about four times the reported landings of flounder of 295 t. Due to large variation in discard patterns of flounder, the total discard is difficult to estimate based on sampling (Anon. 2007f). However, if discards of flounder occurs that are of the magnitude suggested in the source information (Gårdmark *et al.* 2006, Anon. 2007f), further research, development of selective gear, and/or identification of alternative usage, is needed to reduce the waste of biomass. In general, more research is needed for all types of discards (i.e., regular discards, 'underwater discards', and discards due to high grading and seal damages) since the information available often is based on small samples and the accuracy is highly uncertain (Anon. 2005b).

'Less important' species

ICES reported landings and nominal landings

The total difference between the reconstructed catch and ICES reported landings was 31 %, including all species. If excluding the three major commercial species cod, herring and sprat (accounting for 94 % of ICES reported landings), the difference was 223 %. This means that there is a larger fraction of unaccounted catches for 'less important' species, which is an indication of the focus on the important commercial species, when it comes to enforcement of reporting, and research. The difference between ICES reported landings and the nominal landings was 9 %, even though ICES reported landings were used as nominal landings for most of these species.

[60] Walther, Y. (yvonne.walther@fiskeriverket.se) and K. Ringdahl (katja.ringdahl@fiskeriverket.se). Personal communication February 2009. Swedish Board of Fisheries.

Recreational catch

The largest component of the unaccounted catches for 'less important' species was the recreational, which constituted 88 % of the difference between reconstructed catch and ICES reported landings. Recreational fishing is to a large extent unregulated and it is one of the biggest recreational activities in Sweden (Anon. 2007b). Even though the interest is big and catches for some species are larger than the commercial catches, the data on recreational fishing are very poor, partly due to the unregulated nature of recreational fishing in Sweden and lack of requirements for reporting of catches. However, due to socioeconomic (the economic revenue is many times higher per kilo for the recreational fishing compared to commercial fishing[61]), and ecological reasons, more studies on recreational fishing and its catches are needed. For example, the status of the sea trout populations, an important recreational species, is highly uncertain, and many smaller populations are depleted. One identified threat is that small sea trout get caught as by-catch in the gillnet fishery for whitefish (Anon. 2007g). The recreational catches of sea trout were overall 8 times larger then ICES reported landings, and this is substantial for stock assessment. Since 1985 catches in trap nets by non commercial fishers are included in the stock assessment data for Sweden, however, from 2000-2006 the data ranged between 19 and 60 $t \cdot year^{-1}$ in subdivision 24-32 (Table 7.1.2 in Anon. 2007g), whereas the same numbers (subdivision 22-32) in this catch reconstruction (i.e., nominal landings + recreational catches) ranged between about 230 to 330 $t \cdot year^{-1}$ during the same period.

Discards and unreported landings

Only 14 % of the total unaccounted catches were due to discards, which most likely is an underestimate, since species without commercial value regularly are discarded by fishers (Anon. 2003a). Based on data on discards in cod trawl fishery in ICES subdivisions 25-28, the total discards in the area were around 20,500 t from 1996-2003, whereof 7,500 t were cod. Consequently, the discards of other species were about 13,000 t (Lövgren *et al.* unpublished data[62]), compared to 9,900 t which was the conservative estimated discards of other species (excluding herring and sprat) added for the catch reconstruction for that period, i.e., underestimated by at least 3,000 t. The data from the cod trawl fishery in subdivision 25-28 were not used for the catch reconstruction due to lack of detailed information.

About 29,000 t, or 6 % of the unaccounted catches, was made up of the unreported landings component. 7,300 t of that were unreported landings of the relatively low volume but high value species salmon and eel. These species were thought to have a larger unreported landings component (Hultkrantz 1997), however, less information was found on salmon compared to the three major commercial species' unreported landings and this was constraining for the

[61] Anton Paulrud in "Higher value of recreational fishing than commercial fishing" newspaper article in Swedish paper Dagens Nyheter. Available at http://www.dn.se/nyheter/sverige/fritidsfisket-varderas-hogre-an-yrkesfisket-1.679071 "Fritidsfisket värderas högre än yrkesfisket" accessed 2009-04-05.

[62] Lövgren, J. (johan.lovgren@fiskeriverket.se), Ringdahl, K. (katja.ringdahl@fiskeriverket.se), and J. Hjelm (joakim.hjelm@fiskeriverket.se). Swedish Board of Fisheries, phone: +46(0)31-7430300. Unpublished: Patterns of discard and environmental effects of discard in southern Baltic 1996-2003. "Discardmönster och miljöeffekter av discard i södra Östersjön 1996-2003.

creation of anchor points. Due to lack of information, the ICES stock assessment working group report (Anon. 2008d) was used which resulted in very low values and an overall percentage of 7 % of unreported salmon landings.

Issues and suggestions for improvement

The European fisheries in general are economically stressed, due to depleting fish stocks among other things (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). The overcapacity is the main reason for IUU catches (Sporrong 2007), and it also hinders the strive for sustainable fisheries (Pauly *et al.* 2002). The build up of overcapacity in fisheries, in the Baltic Sea as well as globally, is mostly caused by the history of subsidies in fisheries policies (Hildén 1997, Sumaila *et al.* 2007), and it is a well known problem (Hildén 1997, Pauly *et al.* 2002, Anon. 2004a, Nyström and Andersson 2007, Sumaila *et al.* 2007, Anon. 2009). The attempts to decrease the fleet overcapacity by subsidies for decommissioning have had no, or opposite effect. 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).

A 100 % observer cover is needed for accurate studies on regular discards and correct accounting of catch, due to the observer bias effects that are known to skew data with less than 100 % coverage (Babcock and Pikitch 2003, Anon. 2006a, Bremner *et al.* 2009)[63,64]. Further more, a 100 % observer cover would also minimize unreported landings, and should allow 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 covered by the industry. If arguments are raised from the industry, it is an indication of economic difficulties, likely due to overcapacity and the fleet in question needs to be reduced. However, a 100 % observer cover would save money for fisheries control, and scientific surveys, which could be used to help financing the coverage. The cost should also be contrasted to the potential cost of lost ecosystem services, loss of a source of protein, and the cost of trying to rebuild the Baltic Sea ecosystem if politics continues to ignore scientific advice. A 100 % observer coverage, physically onboard and/or video monitored and off-ship analyzed, has been very successful elsewhere. For example, the Canadian Pacific ground fish fisheries in British Columbia have had 100 % observer coverage since 2005. This make up a good foundation for environmentally sustainable fisheries due to reporting of total catch, including discards, combined with individual accountability for fish mortality (Anon. 2005e). The 4th generation halibut fisher W. Erikson witnesses about benefits derived from 100 % observer coverage in combination with Individual Quotas (IQ) in

[63] Boyes, D. Personal communication February 2009. Halibut fisherman BC, Canada. E-mail: mcboyes@telus.net

[64] Erikson, W. Personal communication February 2009. Wes Erikson is an active fourth generation commercial fisherman. He has fished for halibut, herring, salmon, rockfish, ling cod, skate and sable fish using long line, troll and gill net along the entire British Columbia coastline. Wes has been involved in the fisheries advisory process for over 20 years and has recently been a halibut representative on the Commercial Industry Caucus (CIC) implementing the pilot integrated ground fish strategy.
Along with fishing Wes owned an operated seafood restaurants for the last 15 years. E-mail: erikson.w@gmail.com

his presentation 'A Fisherman's Perspective'[65]. The benefits are environmental, social and economic; such as staying within sustainable catch levels, greatly reduced discards, increased selectivity and safer fishing practices, as well as market benefits.

The need of more research and better catch data is substantial. Even with the poor understanding of fisheries impact on the marine ecosystem, fisheries have been allowed to develop and globally cause serious reductions of many fish stocks due to overfishing (Hjerne and Hansson 2002). As Hjerne (2003) states; the obvious result of lack of knowledge should be larger safety margins in TAC.

A more accurate and transparent input to stock assessments should be prioritized, if only to highlight, and get an idea about the magnitude, of the unaccounted components of the total catch; the extent of cheating and unreported landings, how much is being wasted through discards, and the impact of recreational fishing on the fish stocks. However, even with better input for stock assessment, and a better understanding of fisheries impact on the Baltic Sea ecosystem, it is pointless with more research unless the advice from scientists and the stock assessment working group is implemented in the management of the Baltic Sea fisheries. Lövin (2007) asks the question of what the point of spending money on research and stock assessment work is, when the results, so far to a large extent has been ignored in the management of the Baltic Sea fisheries? This is a reason for the public and Non Governmental Organizations (NGO:s), to put pressure on governments and demand total transparency in fisheries management, hence, make politicians accountable for depleting stocks and unsustainable fisheries.

Source of error

The method of reconstructing catch data based on assumptions and estimates is surrounded by uncertainties and possible sources of error. However, as argued before, this way of estimating the total catch is a more accurate way compared to traditional use of 'zero catch' when no hard data are available. There were hardly any data on unreported catches, therefore, those estimates were based mainly on personal communication. The fact that the purpose of doing a catch reconstruction increases with the difference between reported landings and the final reconstructed catch, increases the risk of being biased during the validation of different sources of information. The studies on recreational fishing in Sweden have been adjusted to a large extent to reduce confirmed overestimations, and allocate catch to the Baltic Sea. Uncertainties increases with increased amount of adjustments, but despite many adjustments, the derived numbers are believed to be more reliable then original reported numbers. Large sets of data and data entering are sources of potential errors and mistakes.

Conclusion

The main observation during this study is the lack of information about many components, and the uncertainties in existing data, of fisheries catches. For the time period 1950-2007, the

[65] Erikson, W. (see footnote above) Presentation about British Columbia's groundfish fisheries: 'A fisherman's perspective', available at http://seafoodchoices.org/seafoodsummit/documents/Erickson W.pdf accessed 2009-04-10.

overall total difference between the officially reported landings and the reconstructed estimated catch was 32 % which shows that a quite large part is missing in the official statistics. The unaccounted components' different impact on the total catch differs among species. For major commercial species, such as cod, the unreported catch is the main contributor to missing data. For the 'less important species' the recreational component dominates the missing data. For some species, for example sea trout, the recreational catches are many times larger than the official reported landings. The discards, especially of flatfishes, make up a substantial waste of biomass. As a step towards better understanding of fisheries impact on the Baltic Sea ecosystems, the magnitude of these unaccounted components of catches needs to be noted and better accounted for. The implementation of a 100 % observer cover is suggested to get accurate data on discards and also minimize the unreported landings. Well designed, national surveys on recreational fishing should be carried out regularly to assess the recreational catch component. The other observation during this study is the lack of transparency in ICES stock assessment working group reports, due to discretion constraints (Anon. 2008a), enforced by political concerns. Public insight and transparency is necessary for accountability reasons[66] and is particularly important since fisheries policies, with its subsidies, are the main reason and drive for overexploitation of fish stocks (Sumaila *et al.* 2007).

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APPENDIX 1: TIME SERIES DATA

Appendix 1 Table 1. Sweden's reconstructed cod catches (t) in the Baltic Sea.

Year	ICES	Nominal	Unreported	Discard	Recreational	Total reconstructed
1950	21,290	21,290	1,065	2,405	267	25,027
1951	21,340	21,340	1,141	2,419	309	25,209
1952	25,475	25,475	1,451	2,897	351	30,174
1953	20,159	20,159	1,219	2,300	393	24,071
1954	19,099	19,099	1,221	2,186	436	22,942
1955	21,068	21,068	1,420	2,420	480	25,388
1956	20,178	20,178	1,430	2,325	524	24,458
1957	26,918	26,918	2,002	3,112	569	32,601
1958	21,224	21,224	1,652	2,462	613	25,951
1959	22,855	22,855	1,859	2,659	658	28,031
1960	27,635	27,635	2,344	3,226	702	33,907
1961	28,701	28,701	2,534	3,361	748	35,344
1962	25,140	25,140	2,307	2,953	794	31,195
1963	22,827	22,827	2,175	2,690	842	28,534
1964	16,222	16,222	1,602	1,918	892	20,634
1965	15,736	21,705	2,219	2,574	944	27,442
1966	16,182	22,525	2,381	2,680	996	28,582
1967	17,784	23,363	2,551	2,788	1,047	29,749
1968	18,508	24,008	2,705	2,874	1,096	30,683
1969	16,656	22,301	2,590	2,678	1,150	28,720
1970	13,664	17,756	2,124	2,139	1,207	23,226
1971	12,945	15,670	1,929	1,894	1,257	20,750
1972	13,762	16,471	2,085	1,997	1,304	21,857
1973	16,134	18,389	2,392	2,236	1,352	24,369
1974	14,184	16,435	2,195	2,005	1,403	22,038
1975	15,168	17,965	2,462	2,198	1,454	24,079
1976	22,802	22,802	3,204	2,798	1,526	30,331
1977	18,327	18,327	2,639	2,256	1,599	24,821
1978	15,996	15,996	2,359	1,975	1,669	21,999
1979	24,003	24,003	3,624	2,973	1,739	32,338
1980	34,089	34,089	5,265	4,235	1,808	45,397
1981	44,300	44,300	7,820	5,640	1,874	59,634
1982	44,807	44,807	8,898	5,845	1,940	61,490
1983	54,876	54,876	12,108	7,331	2,004	76,319
1984	65,788	65,788	15,967	8,998	2,069	92,822
1985	54,723	54,723	14,489	7,660	2,134	79,006
1986	48,804	48,804	13,999	6,989	2,200	71,992
1987	50,186	50,186	15,502	7,351	2,268	75,307
1988	58,027	58,027	17,382	8,485	2,338	86,232

Appendix 1 Table 1. (cont'd)

Year	ICES	Nominal	Unreported	Discard	Recreational	Total reconstructed
1989	55,919	55,919	16,229	8,162	2,414	82,724
1990	54,473	54,473	15,300	7,937	2,488	80,198
1991	39,552	39,552	10,740	5,752	2,719	58,762
1992	16,244	16,244	4,259	2,357	2,961	25,821
1993	12,201	12,201	3,085	1,767	3,217	20,270
1994	25,685	25,685	6,254	3,712	3,493	39,144
1995	27,289	27,289	6,390	3,934	3,554	41,168
1996	36,931	36,931	8,303	5,312	3,580	54,126
1997	29,327	29,327	6,319	2,637	3,572	41,855
1998	17,666	17,666	3,642	4,036	3,532	28,876
1999	17,476	17,476	3,439	3,220	3,456	27,591
2000	19,801	19,801	3,712	2,786	2,777	29,075
2001	21,120	21,120	3,762	2,818	2,184	29,884
2002	15,203	15,203	2,566	2,141	1,673	21,583
2003	14,686	14,686	2,341	2,521	1,240	20,789
2004	15,201	15,201	2,281	2,109	880	20,472
2005	10,558	10,558	1,486	2,175	812	15,031
2006	12,252	12,252	1,610	3,084	697	17,643
2007	12,558	12,558	1,650	2,480	697	17,385

Appendix 1 Table 2. Sweden's reconstructed herring catches (t) in the Baltic Sea.

Year	ICES	Nominal	Unreported	Discard	Recreational	Total reconstructed
1950	27,071	27,071	1,354	341	281	29,047
1951	28,184	28,184	1,480	356	325	30,345
1952	28,289	28,289	1,556	418	369	30,632
1953	35,741	35,741	2,055	605	414	38,815
1954	34,435	34,435	2,066	657	458	37,616
1955	36,430	36,430	2,277	774	505	39,986
1956	29,386	29,386	1,910	689	551	32,536
1957	28,258	28,258	1,907	724	598	31,487
1958	34,684	34,684	2,428	965	645	38,722
1959	32,284	32,284	2,341	987	692	36,303
1960	27,639	27,639	2,073	906	739	31,357
1961	27,455	27,455	2,128	917	787	31,287
1962	31,930	31,930	2,554	1,104	836	36,424
1963	27,691	27,691	2,285	974	886	31,836
1964	31,297	31,297	2,660	1,138	938	36,033
1965	31,082	31,082	2,720	1,149	993	35,944
1966	30,511	30,511	2,746	1,164	1,048	35,469
1967	36,900	36,900	3,413	1,431	1,101	42,845

Appendix 1 Table 2. (cont'd)

Year	ICES	Nominal	Unreported	Discard	Recreational	Total reconstructed
1968	53,256	53,256	5,059	2,129	1,153	61,597
1969	30,167	30,167	2,941	1,225	1,211	35,544
1970	31,757	31,757	3,176	1,327	1,270	37,530
1971	32,351	32,351	3,316	1,373	1,322	38,362
1972	41,721	41,721	4,381	1,821	1,372	49,295
1973	59,546	59,546	6,401	2,671	1,423	70,041
1974	60,352	60,352	6,639	2,747	1,476	71,213
1975	62,791	62,791	7,064	2,934	1,530	74,319
1976	41,841	41,841	4,812	1,983	1,615	50,250
1977	52,871	52,871	6,212	2,570	1,701	63,354
1978	54,629	54,629	6,555	2,692	1,785	65,662
1979	86,078	86,078	10,545	4,348	1,868	102,839
1980	92,923	92,923	11,615	4,756	1,951	111,246
1981	84,500	84,500	11,375	4,458	2,030	102,363
1982	92,675	92,675	13,367	4,984	2,109	113,135
1983	86,561	86,561	13,317	4,594	2,187	106,659
1984	65,519	65,519	10,710	3,430	2,265	81,924
1985	57,554	57,554	9,961	2,971	2,344	72,830
1986	39,909	39,909	7,291	2,006	2,424	51,630
1987	36,446	36,446	7,009	1,803	2,505	47,763
1988	41,828	41,828	8,446	2,162	2,590	55,026
1989	65,032	65,032	13,757	3,545	2,680	85,014
1990	55,174	55,162	12,199	3,132	2,769	73,263
1991	59,176	61,500	14,192	3,633	3,033	82,359
1992	75,907	71,100	17,091	4,145	3,309	95,645
1993	86,497	87,262	21,816	5,127	3,603	117,807
1994	70,886	72,231	17,480	4,261	3,919	97,891
1995	68,019	66,043	15,454	3,871	3,905	89,273
1996	67,115	37,051	8,374	2,158	3,859	51,441
1997	110,465	60,781	13,250	3,516	3,784	81,332
1998	147,706	78,601	16,506	4,565	3,683	103,355
1999	108,316	53,710	10,849	3,099	3,550	71,208
2000	120,887	66,587	12,918	3,896	3,157	86,558
2001	75,194	45,964	8,549	2,644	2,783	59,940
2002	51,194	44,222	7,872	2,527	2,427	57,047
2003	39,350	45,257	7,694	2,542	2,089	57,581
2004	43,922	44,856	6,056	2,444	1,770	55,125
2005	48,940	51,689	5,169	2,758	1,835	61,451
2006	53,166	67,272	6,727	3,626	1,775	79,400
2007	53,503	60,670	6,067	3,270	1,775	71,782

Appendix 1 Table 3. Sweden's total reconstructed sprat catches (t) in the Baltic Sea.

Year	ICES	Nominal	Unreported	Discard	Recreational	Total reconstructed
1950	8	8	0	0		9
1951	12	12	1	1		13
1952	13	13	1	1		14
1953	19	19	1	1		21
1954	35	35	2	2		39
1955	59	59	4	3		66
1956	38	1,110	72	59		1,241
1957	120	1,667	112	89		1,868
1958	839	2,330	163	125		2,618
1959	355	2,749	199	147		3,096
1960	257	3,838	288	206		4,332
1961	76	3,123	242	168		3,533
1962	155	3,432	275	185		3,891
1963	101	3,121	257	169		3,547
1964	58	58	5	3		66
1965	46	46	4	3		53
1966	38	38	3	2		43
1967	55	55	5	3		63
1968	112	112	11	6		129
1969	134	5,023	490	276		5,788
1970	31	3,265	327	180		3,771
1971	69	2,636	270	145		3,051
1972	102	3,137	329	173		3,639
1973	6,310	6,310	678	349		7,338
1974	5,497	5,497	605	305		6,407
1975	31	2,647	298	147		3,092
1976	713	1,970	226	110		2,306
1977	433	2,151	253	120		2,524
1978	807	807	97	45		949
1979	2,240	2,240	274	126		2,640
1980	2,388	2,388	299	134		2,821
1981	1,510	1,510	203	86		1,799
1982	1,890	1,890	273	108		2,271
1983	1,747	1,747	269	101		2,117
1984	7,807	7,807	1,276	454		9,537
1985	7,111	7,111	1,231	417		8,759
1986	2,573	2,573	470	152		3,195
1987	870	3,143	604	187		3,935
1988	7,307	7,307	1,475	439		9,222
1989	3,453	3,453	730	209		4,393
1990	7,485	7,500	1,659	458		9,617

Appendix 1 Table 3. (cont'd)

Year	ICES	Nominal	Unreported	Discard	Recreational	Total reconstructed
1991	8,328	8,700	2,008	535		11,243
1992	53,558	54,200	13,029	3,361		70,590
1993	92,416	92,700	23,175	5,794		121,669
1994	135,779	135,200	32,854	8,403		176,456
1995	150,435	143,700	33,913	8,881		186,494
1996	163,087	158,200	36,228	9,721		204,149
1997	123,208	151,900	33,722	9,281		194,903
1998	141,209	191,100	41,087	11,609		243,796
1999	106,000	137,300	28,558	8,293		174,151
2000	85,981	120,600	24,241	7,242		152,083
2001	79,553	85,400	16,568	5,098		107,066
2002	74,109	77,300	14,455	4,588		96,343
2003	71,188	63,400	11,412	3,741		78,553
2004	83,949	78,300	10,962	4,463		93,725
2005	100,797	87,800	8,780	4,829		101,409
2006	97,584	68,700	6,870	3,779		79,349
2007	95,897	80,700	8,070	4,439		93,209

Appendix 1 Table 4. Sweden's reconstructed herring and sprat catches (t) in the Baltic Sea.

Year	ICES	Nominal	Unreported	Discard	Recreational	Total reconstructed
1950	27,079	27,079	1,354	342	281	29,055
1951	28,196	28,196	1,480	357	325	30,358
1952	28,302	28,302	1,557	419	369	30,646
1953	35,760	35,760	2,056	606	414	38,836
1954	34,470	34,470	2,068	659	458	37,655
1955	36,489	36,489	2,281	777	505	40,052
1956	29,424	30,496	1,982	748	551	33,777
1957	28,378	29,925	2,020	813	598	33,355
1958	35,523	37,014	2,591	1,090	645	41,340
1959	32,639	35,033	2,540	1,134	692	39,399
1960	27,896	31,477	2,361	1,112	739	35,689
1961	27,531	30,578	2,370	1,085	787	34,820
1962	32,085	35,362	2,829	1,289	836	40,315
1963	27,792	30,812	2,542	1,143	886	35,383
1964	31,355	31,355	2,665	1,141	938	36,099
1965	31,128	31,128	2,724	1,152	993	35,996
1966	30,549	30,549	2,749	1,166	1,048	35,512
1967	36,955	36,955	3,418	1,434	1,101	42,908
1968	53,368	53,368	5,070	2,135	1,153	61,726
1969	30,301	35,190	3,431	1,501	1,211	41,333

Appendix 1 Table 4. (cont'd)

Year	ICES	Nominal	Unreported	Discard	Recreational	Total reconstructed
1970	31,788	35,022	3,502	1,507	1,270	41,301
1971	32,420	34,987	3,586	1,518	1,322	41,414
1972	41,823	44,858	4,710	1,994	1,372	52,934
1973	65,856	65,856	7,080	3,020	1,423	77,379
1974	65,849	65,849	7,243	3,052	1,476	77,620
1975	62,822	65,438	7,362	3,081	1,530	77,411
1976	42,554	43,811	5,038	2,093	1,615	52,556
1977	53,304	55,022	6,465	2,690	1,701	65,878
1978	55,436	55,436	6,652	2,737	1,785	66,611
1979	88,318	88,318	10,819	4,474	1,868	105,479
1980	95,311	95,311	11,914	4,891	1,951	114,067
1981	86,010	86,010	11,578	4,544	2,030	104,162
1982	94,565	94,565	13,639	5,092	2,109	115,405
1983	88,308	88,308	13,586	4,695	2,187	108,776
1984	73,326	73,326	11,986	3,884	2,265	91,461
1985	64,665	64,665	11,192	3,388	2,344	81,589
1986	42,482	42,482	7,761	2,158	2,424	54,825
1987	37,316	39,589	7,613	1,991	2,505	51,698
1988	49,135	49,135	9,921	2,601	2,590	64,247
1989	68,485	68,485	14,487	3,755	2,680	89,407
1990	62,659	62,662	13,858	3,590	2,769	82,879
1991	67,504	70,200	16,200	4,168	3,033	93,602
1992	129,465	125,300	30,120	7,506	3,309	166,236
1993	178,913	179,962	44,991	10,921	3,603	239,476
1994	206,665	207,431	50,334	12,664	3,919	274,347
1995	218,454	209,743	49,367	12,752	3,905	275,767
1996	230,202	195,251	44,602	11,879	3,859	255,590
1997	233,673	212,681	46,972	12,797	3,784	276,235
1998	288,915	269,701	57,593	16,174	3,683	347,151
1999	214,316	191,010	39,407	11,392	3,550	245,360
2000	206,868	187,187	37,159	11,138	3,157	238,640
2001	154,747	131,364	25,117	7,742	2,783	167,006
2002	125,303	121,522	22,327	7,115	2,427	153,390
2003	110,538	108,657	19,106	6,283	2,089	136,134
2004	127,871	123,156	17,018	6,907	1,770	148,850
2005	149,737	139,489	13,949	7,587	1,835	162,860
2006	150,750	135,972	13,597	7,405	1,775	158,749
2007	149,400	141,370	14,137	7,709	1,775	164,991

Appendix 1 Table 5. Sweden's reconstructed salmon catches (t) in the Baltic Sea.

Year	ICES	Nominal	Unreported	Discard	Recreational	Total reconstructed
1950	1,400	1,400	94	159	21	1,674
1951	1,105	1,105	74	126	24	1,329
1952	796	796	53	90	28	968
1953	414	413	28	47	31	519
1954	483	483	32	55	34	604
1955	295	295	20	34	38	386
1956	670	670	45	76	41	832
1957	340	340	23	39	45	446
1958	287	287	19	33	49	388
1959	357	357	24	41	52	473
1960	440	440	29	50	56	575
1961	575	575	38	65	59	738
1962	350	384	26	44	63	516
1963	371	386	26	44	67	523
1964	631	619	41	70	71	802
1965	529	515	34	59	75	683
1966	431	409	27	46	79	562
1967	528	505	34	57	83	679
1968	504	471	32	54	87	643
1969	448	478	32	54	91	655
1970	488	483	32	55	95	665
1971	360	416	28	47	99	590
1972	401	420	28	48	103	599
1973	596	651	44	74	107	876
1974	611	640	43	73	111	867
1975	639	630	42	72	115	859
1976	612	612	41	70	118	841
1977	612	612	41	70	122	845
1978	499	499	33	57	125	714
1979	517	517	35	59	128	738
1980	589	589	39	67	131	826
1981	427	427	39	65	134	665
1982	541	541	29	50	136	756
1983	533	533	30	52	139	754
1984	701	701	39	67	141	948
1985	991	991	48	110	144	1,293
1986	920	920	53	121	147	1,241
1987	968	968	52	145	150	1,315
1988	806	806	51	137	152	1,146
1989	1,206	1,206	79	229	156	1,670
1990	1,248	1,249	84	262	159	1,754

Appendix 1 Table 5. (cont'd)

Year	ICES	Nominal	Unreported	Discard	Recreational	Total reconstructed
1991	894	894	63	205	172	1,334
1992	967	967	66	240	185	1,458
1993	947	946	67	253	199	1,466
1994	705	705	51	202	215	1,173
1995	628	628	49	194	229	1,099
1996	764	764	60	250	241	1,315
1997	663	663	53	231	249	1,196
1998	611	611	55	206	255	1,127
1999	398	471	44	153	256	925
2000	476	589	52	183	280	1,105
2001	354	462	41	138	293	933
2002	285	382	37	110	296	825
2003	213	318	30	87	290	725
2004	676	678	53	174	275	1,180
2005	512	515	45	133	209	902
2006	336	336	28	87	135	586
2007	317	318	30	83	135	565

Appendix 1 Table 6. Sweden's reconstructed 'flatfish' catches (t) in the Baltic Sea. 'Flatfish' refers to brill, dab, flounder, plaice, and turbot.

Year	ICES	Nominal	Unreported	Discard	Recreational[a]	Total reconstructed
1950	869	869	43	739	169	1,821
1951	996	996	50	834	195	2,075
1952	1,080	1,080	55	895	222	2,252
1953	1,053	1,053	54	861	248	2,216
1954	975	975	51	773	275	2,074
1955	1,094	1,094	58	818	303	2,273
1956	972	972	52	752	331	2,108
1957	950	950	51	748	359	2,109
1958	846	846	46	652	388	1,933
1959	877	877	48	689	416	2,031
1960	1,194	1,194	67	878	444	2,582
1961	1,149	1,149	65	878	473	2,565
1962	1,095	1,095	62	811	502	2,470
1963	1,026	1,026	59	773	532	2,389
1964	1,146	1,146	67	851	564	2,628
1965	1,140	1,140	67	842	597	2,646
1966	1,113	1,113	66	870	630	2,679
1967	1,077	1,077	64	824	661	2,627
1968	1,047	1,047	63	808	693	2,611

Appendix 1 Table 6. (cont'd)

Year	ICES	Nominal	Unreported	Discard	Recreational[a]	Total reconstructed
1969	953	953	58	743	727	2,481
1970	461	735	45	583	763	2,127
1971	413	682	42	558	794	2,076
1972	411	641	40	524	824	2,029
1973	722	722	46	592	855	2,215
1974	650	650	42	534	887	2,113
1975	657	657	42	549	919	2,167
1976	582	605	39	508	989	2,142
1977	484	484	32	399	1,059	1,974
1978	394	394	26	332	1,129	1,881
1979	450	450	30	337	1,198	2,015
1980	427	427	29	318	1,267	2,040
1981	433	433	32	324	1,335	2,123
1982	250	250	19	167	1,402	1,838
1983	217	217	19	161	1,468	1,865
1984	175	175	17	132	1,535	1,858
1985	170	170	17	127	1,602	1,917
1986	251	251	27	180	1,670	2,128
1987	273	273	31	186	1,739	2,229
1988	281	281	34	206	1,811	2,332
1989	246	246	31	204	1,886	2,367
1990	257	195	26	165	1,961	2,348
1991	224	234	31	222	2,161	2,648
1992	337	352	45	340	2,371	3,108
1993	269	335	41	330	2,595	3,302
1994	312	371	44	404	2,837	3,656
1995	620	614	71	647	2,697	4,029
1996	1,528	1,443	160	858	2,546	5,007
1997	1,372	1,279	137	847	2,388	4,650
1998	673	732	75	922	2,225	3,955
1999	436	396	39	438	2,056	2,930
2000	460	460	44	615	1,645	2,764
2001	565	565	51	857	1,286	2,759
2002	446	446	39	671	978	2,133
2003	382	382	32	548	718	1,680
2004	307	307	24	446	502	1,279
2005	412	412	31	1,383	465	2,291
2006	300	300	21	392	401	1,115
2007	370	370	25	419	401	1,215

[a] Includes all species of flatfish, but is thought to be dominated by species referred to as 'flatfish'.

Appendix 1 Table 7. Sweden's reconstructed flounder catches (t) in the Baltic Sea.

Year	ICES	Nominal	Unreported	Discard	Recreational[a]	Total reconstructed
1950	801	801	40	714		1,555
1951	891	891	45	794		1,730
1952	947	947	48	845		1,840
1953	900	900	47	803		1,750
1954	785	785	41	701		1,527
1955	786	786	42	702		1,530
1956	0[b]	746	40	667		1,453
1957	0[b]	754	41	674		1,469
1958	0[b]	643	35	575		1,254
1959	0[b]	691	38	619		1,348
1960	823	823	46	737		1,606
1961	856	856	48	767		1,672
1962	770	770	44	691		1,504
1963	746	746	43	669		1,458
1964	804	804	47	722		1,573
1965	791	791	46	711		1,548
1966	860	860	51	773		1,684
1967	802	802	48	721		1,571
1968	793	793	48	714		1,554
1969	733	733	45	660		1,438
1970	310	584	36	526		1,146
1971	304	573	36	516		1,125
1972	23[b]	537	34	484		1,055
1973	609	609	39	549		1,197
1974	550	550	35	497		1,082
1975	572	572	37	517		1,126
1976	531	531	35	480		1,045
1977	410	410	27	371		808
1978	346	346	23	313		682
1979	315	315	21	285		621
1980	295	295	20	267		582
1981	300	300	22	273		596
1982	143	143	12	131		286
1983	145	145	13	134		292
1984	117	117	11	109		237
1985	111	111	11	104		226
1986	148	148	16	139		303
1987	139	139	16	132		286
1988	166	166	20	158		344
1989	165	165	21	170		356
1990	182	120	16	133		269

Appendix 1 Table 7. (cont'd)

Year	ICES	Nominal	Unreported	Discard	Recreational[a]	Total reconstructed
1991	153	163	21	192		376
1992	217	232	29	288		550
1993	144	210	26	275		511
1994	198	257	31	354		641
1995	384	378	43	545		967
1996	1,157	1,072	119	698		1,889
1997	1,011	918	98	693		1,709
1998	443	502	52	824		1,377
1999	250	210	21	358		589
2000	311	311	30	552		893
2001	438	438	40	805		1,283
2002	327	327	29	623		979
2003	253	253	21	497		770
2004	198	198	16	403		617
2005	295	295	22	1,336		1,653
2006	169	169	12	341		522
2007	170	170	11	342		523

[a] Recreational catches are reported as a total flatfish catch (Appendix Table 6). [b] Mixed catches with common dab (Table 1).

Appendix 1 Table 8. Sweden's reconstructed sea trout catches (t) in the Baltic Sea.

Year	ICES	Nominal	Unreported	Discard	Recreational	Total reconstructed
1950	70	70	4	6	134	213
1951	70	70	4	6	155	234
1952	62	62	3	5	176	246
1953	60	60	3	5	197	265
1954	68	68	4	6	218	295
1955	60	60	3	5	240	308
1956	60	60	3	5	262	330
1957	53	53	3	5	285	345
1958	49	49	3	4	307	363
1959	56	56	3	5	329	393
1960	61	61	3	5	351	421
1961	74	74	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

Appendix 1 Table 8. (cont'd)

Year	ICES	Nominal	Unreported	Discard	Recreational	Total reconstructed
1968	0	83	5	7	549	644
1969	0	81	5	7	576	669
1970	40	84	5	7	604	700
1971	37	66	4	6	629	705
1972	27	64	4	5	653	727
1973	89	89	6	8	677	779
1974	0	119	8	10	702	839
1975	0	101	7	9	728	844
1976	86	86	6	7	718	817
1977	87	87	6	7	707	807
1978	52	52	3	4	694	754
1979	58	58	4	5	681	748
1980	66	66	4	6	667	743
1981	5	5	0	1	651	657
1982	0	38	3	5	635	681
1983	0	37	3	5	618	664
1984	0	51	5	9	601	665
1985	0	55	6	10	584	655
1986	0	42	5	9	567	622
1987	0	42	5	10	550	606
1988	0	47	6	12	533	598
1989	0	99	13	27	518	657
1990	0	70	9	21	501	601
1991	0	80	10	25	514	630
1992	0	168	21	56	525	770
1993	0	171	21	60	534	786
1994	0	115	14	43	542	713
1995	0	71	8	28	527	634
1996	110	111	12	45	509	678
1997	96	95	10	41	488	634
1998	105	106	11	44	464	625
1999	0	71	7	28	439	545
2000	59	61	6	23	430	520
2001	36	43	4	16	414	477
2002	35	36	3	13	392	444
2003	27	31	3	11	364	408
2004	31	32	3	10	332	377
2005	29	30	2	10	289	331
2006	28	27	2	9	231	269
2007	23	24	2	8	231	264

Appendix 1 Table 9. Sweden's reconstructed eel catches (t) in the Baltic Sea.

Year	ICES	Nominal	Unreported	Discard	Recreational	Total reconstructed
1950	2,020	2,020	101	171	92	2,384
1951	1,717	1,717	89	146	106	2,057
1952	1,418	1,418	76	121	121	1,735
1953	2,025	2,025	111	172	135	2,444
1954	1,966	1,966	111	168	150	2,395
1955	2,379	2,379	138	203	165	2,886
1956	1,421	1,421	85	122	180	1,807
1957	2,014	2,014	124	172	196	2,506
1958	1,580	1,580	100	136	211	2,026
1959	2,635	2,635	170	226	226	3,258
1960	1,481	1,481	98	127	241	1,948
1961	1,766	1,766	120	152	257	2,295
1962	1,560	1,560	109	135	273	2,076
1963	1,599	1,599	114	138	289	2,140
1964	1,632	1,632	119	141	307	2,199
1965	1,454	1,454	108	126	325	2,013
1966	1,520	1,520	116	132	343	2,111
1967	1,328	1,328	103	115	360	1,907
1968	1,508	1,508	120	131	377	2,136
1969	1,338	1,338	108	117	396	1,959
1970	916	916	76	80	415	1,487
1971	1,054	1,054	89	92	432	1,667
1972	951	951	82	83	448	1,564
1973	896	896	78	79	465	1,518
1974	716	716	64	63	482	1,325
1975	1,131	1,131	103	100	500	1,833
1976	646	646	60	57	491	1,254
1977	686	686	65	61	481	1,292
1978	761	761	73	67	469	1,370
1979	670	670	65	59	457	1,252
1980	809	809	80	72	445	1,406
1981	396	396	41	36	431	903
1982	592	592	63	54	417	1,126
1983	477	477	53	44	403	977
1984	695	695	79	65	389	1,228
1985	835	835	99	79	374	1,386
1986	596	596	73	57	360	1,085
1987	453	453	57	44	346	900
1988	525	525	68	51	331	975
1989	579	579	77	57	318	1,031
1990	571	571	78	57	304	1,010

Appendix 1 Table 9. (cont'd)

Year	ICES	Nominal	Unreported	Discard	Recreational	Total reconstructed
1991	668	668	94	67	307	1,137
1992	696	696	101	71	308	1,176
1993	577	577	86	60	308	1,030
1994	497	497	76	52	307	932
1995	418	418	65	44	301	828
1996	539	539	86	58	293	976
1997	418	418	68	45	284	816
1998	245	245	41	29	273	588
1999	334	334	57	42	260	693
2000	275	275	48	37	241	601
2001	261	261	47	37	222	567
2002	298	298	54	45	201	598
2003	281	281	52	45	180	558
2004	243	243	46	41	159	489
2005	342	342	66	58	204	670
2006	365	365	72	62	233	732
2007	416	416	62	68	233	779

Appendix 1 Table 10. Sweden's reconstructed whitefish catches (t) in the Baltic Sea.

Year	ICES	Nominal	Unreported	Discard	Recreational	Total reconstructed
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	37	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

Appendix 1 Table 10. (cont'd)

Year	ICES	Nominal	Unreported	Discard	Recreational	Total reconstructed
1970	234	234	14	20	1,334	1,602
1971	211	211	13	18	1,390	1,632
1972	267	267	17	23	1,442	1,749
1973	0	317	20	27	1,495	1,859
1974	366	366	23	31	1,551	1,972
1975	552	552	36	47	1,608	2,243
1976	502	502	33	43	1,583	2,161
1977	301	301	20	26	1,556	1,903
1978	402	402	27	35	1,525	1,988
1979	418	418	28	36	1,492	1,974
1980	508	508	34	44	1,458	2,044
1981	315	315	23	35	1,420	1,794
1982	375	375	30	52	1,380	1,837
1983	323	323	28	53	1,340	1,744
1984	338	338	32	65	1,299	1,733
1985	316	316	32	69	1,259	1,676
1986	367	367	40	90	1,218	1,715
1987	433	433	50	118	1,177	1,778
1988	440	440	53	132	1,137	1,763
1989	466	466	60	153	1,099	1,778
1990	367	367	49	131	1,060	1,608
1991	335	335	44	128	1,082	1,589
1992	307	307	39	125	1,099	1,570
1993	354	354	44	153	1,112	1,663
1994	571	571	68	261	1,122	2,022
1995	464	464	53	224	1,020	1,761
1996	350	350	39	177	918	1,484
1997	307	307	33	163	819	1,322
1998	304	304	31	155	723	1,213
1999	279	279	28	137	630	1,073
2000	248	248	24	117	626	1,014
2001	155	155	14	70	610	849
2002	222	222	19	95	583	920
2003	254	254	21	104	546	925
2004	295	295	23	115	501	935
2005	244	244	18	95	462	819
2006	196	196	14	76	397	683
2007	153	153	10	59	397	619

Appendix 1 Table 11. Sweden's recreational catches (t) in the Baltic Sea.

Year	Herring	Pike	Perch	Cod	Flatfishes[a]	Whitefish	Sea trout	Others[b]
1950	281	541	513	267	169	296	134	251
1951	325	625	593	309	195	342	155	290
1952	369	710	673	351	222	388	176	329
1953	414	796	754	393	248	435	197	368
1954	458	882	836	436	275	482	218	408
1955	505	971	920	480	303	530	240	450
1956	551	1,060	1,005	524	331	579	262	491
1957	598	1,151	1,091	569	359	629	285	533
1958	645	1,242	1,177	613	388	678	307	575
1959	692	1,332	1,262	658	416	728	329	617
1960	739	1,421	1,347	702	444	776	351	658
1961	787	1,514	1,435	748	473	827	375	701
1962	836	1,608	1,523	794	502	878	398	744
1963	886	1,703	1,614	842	532	931	421	789
1964	938	1,805	1,711	892	564	986	447	836
1965	993	1,911	1,811	944	597	1,044	473	885
1966	1,048	2,017	1,911	996	630	1,102	499	934
1967	1,101	2,118	2,007	1,047	661	1,157	524	981
1968	1,153	2,218	2,102	1,096	693	1,212	549	1,027
1969	1,211	2,329	2,207	1,150	727	1,272	576	1,078
1970	1,270	2,442	2,314	1,207	763	1,334	604	1,131
1971	1,322	2,544	2,411	1,257	794	1,390	629	1,178
1972	1,372	2,640	2,502	1,304	824	1,442	653	1,223
1973	1,423	2,736	2,593	1,352	855	1,495	677	1,267
1974	1,476	2,839	2,691	1,403	887	1,551	702	1,315
1975	1,530	2,943	2,789	1,454	919	1,608	728	1,363
1976	1,615	2,907	2,755	1,526	989	1,583	718	1,385
1977	1,701	2,868	2,718	1,599	1,059	1,556	707	1,407
1978	1,785	2,822	2,674	1,669	1,129	1,525	694	1,426
1979	1,868	2,772	2,627	1,739	1,198	1,492	681	1,444
1980	1,951	2,719	2,577	1,808	1,267	1,458	667	1,460
1981	2,030	2,661	2,521	1,874	1,335	1,420	651	1,474
1982	2,109	2,599	2,463	1,940	1,402	1,380	635	1,487
1983	2,187	2,535	2,403	2,004	1,468	1,340	618	1,499
1984	2,265	2,472	2,343	2,069	1,535	1,299	601	1,512
1985	2,344	2,408	2,282	2,134	1,602	1,259	584	1,524
1986	2,424	2,344	2,222	2,200	1,670	1,218	567	1,537
1987	2,505	2,281	2,162	2,268	1,739	1,177	550	1,550
1988	2,590	2,220	2,103	2,338	1,811	1,137	533	1,565
1989	2,680	2,162	2,049	2,414	1,886	1,099	518	1,584
1990	2,769	2,101	1,991	2,488	1,961	1,060	501	1,600

Appendix 1 Table 11. (cont'd)

Year	Herring	Pike	Perch	Cod	Flatfishes[a]	Whitefish	Sea trout	Others[b]
1991	3,033	2,163	2,050	2,719	2,161	1,082	514	1,716
1992	3,309	2,218	2,102	2,961	2,371	1,099	525	1,834
1993	3,603	2,267	2,149	3,217	2,595	1,112	534	1,957
1994	3,919	2,314	2,193	3,493	2,837	1,122	542	2,088
1995	3,905	2,153	2,041	3,554	2,697	1,020	527	1,859
1996	3,859	1,988	1,884	3,580	2,546	918	509	1,634
1997	3,784	1,822	1,727	3,572	2,388	819	488	1,417
1998	3,683	1,658	1,571	3,532	2,225	723	464	1,211
1999	3,550	1,494	1,416	3,456	2,056	630	439	1,015
2000	3,157	1,461	1,421	2,777	1,645	626	430	1,027
2001	2,783	1,405	1,396	2,184	1,286	610	414	1,015
2002	2,427	1,328	1,344	1,673	978	583	392	981
2003	2,089	1,233	1,266	1,240	718	546	364	929
2004	1,770	1,121	1,166	880	502	501	332	858
2005	1,835	1,120	1,104	812	465	462	289	978
2006	1,775	1,047	975	697	401	397	231	1,025
2007	1,775	1,047	975	697	401	397	231	1,025

[a] Recreational catches of flatfish includes all species of flatfish in the Baltic Sea. [b] Others includes eel and salmon among other species.

Appendix 1 Table 12. Sweden's total reconstructed catches (t) in the Baltic Sea.

Year	ICES	Nominal	Unreported	Discards	Recreational	Total reconstructed
1950	55,488	55,488	2,798	4,053	2,452	64,791
1951	56,373	56,373	2,987	4,132	2,833	66,326
1952	59,583	59,582	3,320	4,632	3,219	70,754
1953	62,030	62,029	3,604	4,206	3,605	73,444
1954	59,631	59,631	3,622	4,057	3,995	71,305
1955	64,214	64,213	4,070	4,487	4,399	77,170
1956	57,399	57,399	3,792	4,321	4,802	70,314
1957	64,163	64,163	4,439	5,210	5,216	79,028
1958	64,940	64,940	4,629	4,691	5,626	79,886
1959	66,625	66,625	4,913	5,146	6,033	82,717
1960	68,303	68,303	5,241	5,896	6,438	85,878
1961	68,115	68,115	5,432	5,981	6,860	86,388
1962	70,695	70,729	5,745	5,832	7,284	89,590
1963	61,933	61,948	5,223	5,228	7,718	80,117
1964	58,758	58,746	4,949	4,773	8,180	76,648
1965	59,052	65,007	5,688	5,513	8,659	84,867
1966	60,414	66,735	5,977	5,777	9,138	87,627
1967	66,913	72,469	6,729	5,992	9,596	94,787

Appendix 1 Table 12. (cont'd)

Year	ICES	Nominal	Unreported	Discards	Recreational	Total reconstructed
1968	84,646	90,113	8,582	6,815	10,051	115,561
1969	58,847	64,522	6,490	5,429	10,551	86,992
1970	57,159	61,564	6,194	4,922	11,065	83,745
1971	53,262	56,341	5,899	4,399	11,525	78,164
1972	63,848	66,843	7,173	4,927	11,959	90,902
1973	92,300	94,610	10,152	6,696	12,399	123,857
1974	89,842	92,122	10,106	6,357	12,864	121,449
1975	88,308	91,092	10,383	6,383	13,334	121,192
1976	70,390	70,413	8,547	5,613	13,478	98,050
1977	76,048	76,048	9,323	5,513	13,616	104,499
1978	76,044	76,044	9,375	5,356	13,724	104,498
1979	116,195	116,195	14,755	8,033	13,821	152,803
1980	133,744	133,744	17,536	9,729	13,908	174,917
1981	133,332	133,332	19,661	10,728	13,966	177,688
1982	142,969	142,969	22,853	11,368	14,015	191,205
1983	146,177	146,177	25,966	12,430	14,054	198,627
1984	142,656	142,656	28,286	13,335	14,095	198,371
1985	123,652	123,652	26,089	11,576	14,136	175,454
1986	95,548	95,548	22,198	9,735	14,182	141,663
1987	91,615	93,888	23,546	9,963	14,233	141,629
1988	111,968	111,968	27,858	11,780	14,296	165,903
1989	129,486	129,486	31,302	12,738	14,392	187,918
1990	122,067	122,009	29,736	12,303	14,472	178,519
1991	112,322	115,029	27,600	10,773	15,438	168,840
1992	150,327	146,177	34,942	10,855	16,419	208,394
1993	195,301	196,414	48,591	13,669	17,434	276,108
1994	236,405	237,230	57,092	17,479	18,509	330,311
1995	260,341	251,624	57,455	18,931	17,756	345,766
1996	273,562	238,527	53,646	18,841	16,918	327,932
1997	269,735	248,649	54,047	17,096	16,017	335,808
1998	309,387	290,227	61,563	21,661	15,067	388,518
1999	234,304	211,030	43,149	15,531	14,056	283,766
2000	229,174	209,604	41,182	14,992	12,544	278,322
2001	178,286	155,016	29,191	11,768	11,093	207,068
2002	143,211	139,525	25,264	10,309	9,706	184,804
2003	128,313	126,540	21,907	9,745	8,385	166,578
2004	146,884	142,171	19,827	9,979	7,130	179,108
2005	163,850	153,606	15,943	11,596	7,065	188,210
2006	165,938	151,159	15,617	11,279	6,548	184,602
2007	164,551	156,523	16,126	10,934	6,548	190,131

APPENDIX 2: PEOPLE CONTACTED DURING THE STUDY

Appendix 2 Table 1. People contacted during the study.

Name	Scope of practice	Contact information
	Swedish Board of Fisheries	
Anders Bogelius	Department of Fisheries Control	031-7430323
Anna Gårdmark	Institute of Coastal Research Öregrund	0173-46466
Ann-Britt Florin	Institute of Coastal Research Öregrund	ann-britt.florin@fiskeriverket.se
Antonia Fonfeka	Department of Fisheries Control	031-7430357
Bengt Kåmark	Head of Resource Management Department	031-7430311
Bengt Sjöstrand	Institute of Marine Research Lysekil	0523-21665
Berth Nyman	Institute of Coastal Research Öregrund	berth.nyman@fiskeriverket.se
Bo Wallin	Department of Fisheries Control	031-7430383
Daniel Valentinsson	Institute of Marine Research Lysekil	daniel.valentinsson@fiskeriverket.se
Fredrik Arrhenius	Head of the Institute of Marine Research Lysekil	0523-18700
Frida Lenberg	Archivist	031-7430447
Håkan Westerberg	Assistant branch head at the Research and Development Department	031-7430333
Henrik Svedäng	Institute of Marine Research Lysekil	0523-18723
Jarl Enqvist	Department of Fisheries Control	031-7430386
Jens Olsson	Institute of Coastal Research Öregrund	0173-46486
Joakim Hjelm	Branch head at the Institute of Marine Research Lysekil	070-3693004
Johan Lövenadler-Davidsson	Head of the Department of Fisheries Control	031-7430425
Johan Lövgren	Institute of Marine Research Lysekil	0523-08759, 070-6143728
Johan Modin	Institute of Coastal Research Öregrund	0731-109880
Katja Ringdahl	Institute of Marine Research Lysekil	0523-18753, 070-8619286
Lars Karlsson	Institute of Freshwater Research	076-82503
Lars-Erik Palmén	Fisheries Competence Centre	031-696282, 070-5330426
Magnus Appelberg	Head of the Institute of Coastal Research Öregrund	0173-46460
Mats Börje	Department of Fisheries Control	031-7430312
Max Cardinale	Institute of Marine Research Lysekil	073-0342209
Peter Funegård	Resource Management Department	031-7430325
P-O Larsson	Institute of Marine Research Lysekil	0523-18707, 070-8648254
Robin Lundgren	Department of Fisheries Control	031-7430393
Stig Thörnqvist	Resource Management Department	031-7430408
Teija Aho	Institute of Coastal Research Öregrund	teija.aho@fiskeriverket.se
Thomas Hasselborg	Fisheries Investigation Office Luleå	070-6513641
Tore Gustavsson	Resource Management Department	031-7430309
Yvonne Walther	Institute of Marine Research Karlskrona	0455-20119
	County Administrative Board	
Anders Kjellberg	Kalmar	0480-82989

Appendix 2 Table 1. (cont'd)

Name	Scope of practice	Contact information
	County Administrative Board	
Christer Örn	Gävleborg	026-171113
Dan Blomkvist	Norrbotten	0920-96094, 070-3096094
Henrik C Andersson	Stockholm	08-7855078, 070-6730671
Ivar Hägglund	Uppsala	018-195295
Ivar Sundvinsson	Västernorrland	0611-349029
Johan Wagnström	Skåne	040-252036, 070-3797766
Karl Gullberg	Gävleborg	026-171112
Lars Lundahl	Blekinge	0455-87074
Per-Erik Larsson	Östergötland	013-196377, 070-6296377
Rolf Gydemo	Gotland	0498-292006, 073-7195422
Sören Johansson	Västerbotten (retired)	090-30412
Sten Nilsson	Södermanland	0155-264127
Thomas Hederyd	Norrbotten	0920-96278
Ulf Carlsson	Västerbotten	090-108298, 070-5158298
	Swedish Coast Guard	
Anders Litzén	Local manager Competence Centre	031-696271
Helene Hasselgren	Assistant chief-of-staff Southern region	0455-353513
Ola Vesterlund	Administrator Western region	031-699015, 0768-716720
Örjan Eriksson	Coastal Station Slite	0498-200960
Ulf Steinbach	Region Inspector Northern region	0611-85522
Ulrik Sörehall	Coastal Station Furusund	0176-80001, 070-3106564
	ICES	
Hans Lassen	Head of Advisory Program	hans@ices.dk
Henrik Degel	Working Group, discards assessment	0045-33963386
Jan Thulin	Working Group	0523-16345, 070-8458601
	Others	
Anton Paulrud	Swedish Agricultural University, Swedish Board of Fisheries	070-6466808
Bertil Bodlund	Chairman of Coastal Fishers Organization in Norrbotten	bertil.bodlund@telia.com
Björn Aronsson	Coastal Fishers Organization Östergötland	0125-91004, 070-5371228
Björn Lindblad	Sweden Pelagic Organization	031-694483
Björn Sundqvist	Sundqvist AB, former Swedish Board of Fisheries	031-922990
Christer Olburs	Author and biologist	olburs@hotmail.com
Henrik Österblom	University of Stockholm	08-6747664, 070-711928
Isabella Lövin	Author of 'Silent Ocean'	isabella.lovin@telia.com
Jan Ljunggren	Simrishamn Trolling	070-8165881
Karl Landfors	Commercial fisher Uppland	0294-23110, 070-5513958
Karl-Erik Karlsson	Tax Agency Foreign Department	010-5757167, 070-6593467
Kenneth Awebro	University of Luleå	kenneth.awebro@sh.se

Appendix 2 Table 1. (cont'd)

Name	Scope of practice	Contact information
	Others	
Kenneth Olsson	Agricultural Society	060-558422
Lars Berglund	Commercial fisher Gävle	026-99375
Lennart Olofsson	Coastal Fishers Organisation Västerbotten	090-149240, 070-5737606
Mats Andersson	Agricultural Society Västerbotten	090-171864, 070-3405117
Olle Hjerne	University of Stockholm	08-161353
Olle Sandström	Skutab AB	0173-46460, 0173-50033
Ottilia Toresson	WWF Sweden	08-6247400
Per Wramner	Former head of Swedish Board of Fisheries	08-6084167
Reine Johansson	Chairman of the BSRAC	070-8124591
Rune Lundström	Commercial fisher Västerbotten	070-2644007
Sigvard Möller	Chairman of SKIFO	sigvard_moller@hotmail.com
Staffan Danielsson	Greenpeace	08-7027087, 070-3536585
Sture Hansson	University of Stockholm	08-164248