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TOTAL MARINE FISHERIES EXTRACTIONS BY COUNTRY IN THE BALTIC SEA: 1950-PRESENT

Fisheries Centre, University of British Columbia, Canada

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Edited by

Peter Rossing, Shawn Booth and Dirk Zeller

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DIRECTOR'S FOREWORD

Illegal, Unreported and Unregulated (IUU) fisheries, which only a few years ago were considered to be mainly a problem for a limited number of regions or fisheries (e.g. Patagonian toothfish), have now been recognized as a substantial global issue of concern. The importance and negative impacts of IUU fisheries catches have gained increasing attention in the world's media, and also by fisheries scientists and managers. To account for IUU, catch reconstructions, such as those being conducted under the guidance of Dr. Dirk Zeller of the *Sea Around Us* Project, and documented in a previous Fisheries Centre Research Report (Vol. 15 (2), 2007) and in numerous peer-reviewed publications, show that fisheries statistics supplied by national, regional and international scientific and management agencies generally underestimate actual catches often by substantial margins. While historically perceived to be largely a developing country problem, the increasing prevalence of vessel apprehension illustrates that IUU catches are also prominent in some of the most developed countries of the world. The countries surrounding the Baltic Sea are predominantly members of the European Union, and have a long history of marine resource use in the Baltic Sea. Yet, as the study presented in this report illustrates, even these highly developed countries with their substantial resources and well established scientific, administrative and management institutions, have so far failed to address the data issues stemming from IUU in a transparent and comprehensive manner. The effort reported in this report, conducted through funding from the Baltic Sea 2020 Foundation (www.balticsea2020.org/), should contribute to more transparent and complete accounting of total catches for Baltic Sea fisheries, and may even serve as a blueprint for all other North-east Atlantic areas.

In general, obtaining a complete accounting of total catches (or removals) from the global ocean is fundamental to our ability to manage marine fishery resources sustainably for the benefits of both current and future generations. The work reported herein continues an effort by the *Sea Around Us* Project, through its catch reconstruction work, to provide such accounting.

Ussif Rashid Sumaila, Director

UBC Fisheries Centre

February 2010

EXECUTIVE SUMMARY

Illegal, Unreported and Unregulated (IUU) catches are a widespread source of underreporting in fisheries, including in the Baltic Sea, where reported landings from commercial fisheries have been the only form of landings officially recorded (although stock assessments try to account for some IUU catches). According to the European Court of Auditors, the incompleteness and unreliability of catch data have prevented the Total Allowable Catch (TAC) and quota system in the Baltic from functioning properly. In addition, the regulatory and institutional frameworks have guaranteed neither the exhaustiveness of data collection, nor the detection of inconsistencies during validation. Consequently, the International Council for the Exploration of the Sea (ICES) advisory processes related to managing Baltic Sea stocks have only partially satisfied the requirements of formal analysis. Policy makers therefore often underestimated the impact of fishing, contributing to the decline seen in some Baltic fisheries, threatening not only important commercial stocks like cod, but also ecosystem functions and the future economic viability of the fishing industry.

This study estimated total fisheries catches by the countries bordering the Baltic Sea using a catch reconstruction approach for the period 1950-2007. There is a need for a better understanding of the impact of fisheries on marine ecosystems, by providing a comprehensive time series of total fisheries catches. This will contribute to more effective collaboration between the fishing industry, scientists, policy makers, NGOs and the general public.

To estimate the total catch (as opposed to reported landings) from 1950 to 2007, four IUU catch components were estimated for the nine coastal Baltic countries (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden): '*adjustments*' to ICES landings statistics (i.e., data source adjustments), '*unreported landings*', *'discards'*, and '*recreational catches*'. ICES landings statistics were used as the '*reported data*' baseline for our reconstruction, since they are the only publicly-available data, covering all taxa, fishing areas and countries in the Baltic Sea back to 1950. Estimated unreported landings and discards were applied to landings data on a taxonomic and country-specific basis. Discard estimates included '*underwater*' discards from actively-fishing trawl gear; '*ghostfishing*' due to lost or abandoned fishing gear; '*boat-based*' discards, generally resulting from fishers' intentional behavior; and '*seal-damaged*' discards representing catch lost because of seal damage. The inclusion of recreational catch estimates for each country allowed estimates of the likely total catch (as opposed to reported landings) to be derived.

Information sources included a wide range of primary and secondary sources, including interviews and collaborations with fisheries experts in Baltic countries, peer-reviewed and grey literature, ICES online databases and publications, and national media sources. The philosophy behind reconstruction is to utilize all available data and information to derive 'anchor points' of IUU catches in time and to use interpolations for time periods between anchor points. To account for some historical differences between countries, we grouped countries into 'western' (Denmark, Finland, West Germany [1950-1990], Germany [after re-unification, 1991-2007] and Sweden) and 'eastern' (former 'eastern bloc': East Germany [1950-1990], Estonia, Latvia, Lithuania, Poland and Russia).

Overall, for the 1950-2007 period, our catch reconstruction estimated that IUU catches added approximately 30% to landings officially reported by ICES landings statistics (Figure 1). When catches peaked in 1997, total catches were likely 43% higher than reported landings, while for the 2000s (2000-2007), total catches were on average 35% (i.e., about 280,000 t·year^{-1}) higher than reported landings. Comprehensive accounting of IUU catches provides an improved baseline for managing fisheries in the Baltic Sea, and aids the transition to ecosystem-based management.

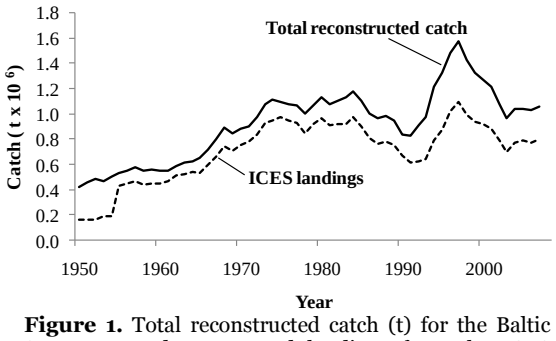

Figure 1. Total reconstructed catch (t) for the Baltic Sea, compared to reported landings from the ICES catch statistics database (1950-2007).

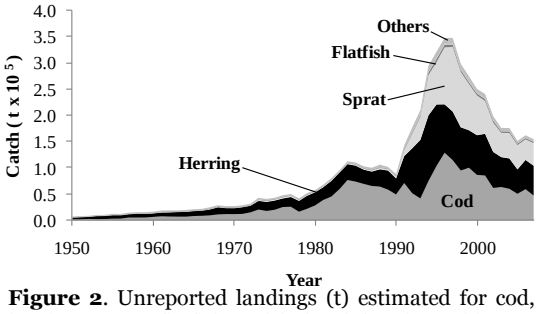

Figure 2. Unreported landings (t) estimated for cod, herring, sprat, flatfish and 'others' for the Baltic Sea from 1950-2007.

Our results indicated that *unreported landings* were the greatest source of IUU catches. This highlighted significant management and enforcement issues, especially as related to unreported landings of cod, herring and sprat taken mainly by Denmark, Poland and Sweden. Unreported landings by all countries added 14% to officiallyreported landings for the entire period, and about 24% per year (i.e., 189,000 t·year^{-1}) since 2000. Unreported landings of cod were the most substantial, representing about 35% of unreported landings of all species since 2000 (Figure 2). A main contributor appears to have been unreported activities in Poland (see below). For 2000-2007, our reconstruction estimated that Poland was accountable for approximately 74% of all unreported landings of cod in the Baltic Sea. Unreported landings of herring by all countries were also significant, more recently (2000-2007) accounting for 33% per year of the unreported landings of all taxa (Figure 2).

Discards were also important. Overall, they added about 10% to reported landings. Denmark was found to be responsible for the majority of discards between 1950-2007, accounting for approximately 31% per year of total discards, while Germany, Poland and Sweden accounted for approximately 13% each. Discards were dominated by cod and herring, accounting for around 36% and 31% of total discards, respectively (1950-2007). More recently (2000-2007) cod accounted on average for 16% of total discards per year. Discards of flatfishes were also of concern as flatfish discards added 36% to the reported landings of flatfishes between 1950-2007. Since 2000, this has increased to 54%.

Recreational catches totaled approximately 1.5 million tonnes (29,000 t·year^{-1} since 2000) and comprised about 3% of our total catch reconstruction. Of the main commercial species, cod was the most important recreational target, accounting for 29% of all recreational catches since 2000, while generally non-commercial species such as European perch, Northern pike, whitefishes and sea trout accounted for 49% of recreational catches.

Adjustments to the ICES landings statistics, dealing solely with accounting problems and omissions of officially-reported data, added about 3% to ICES reported landings. The majority of these adjustments were country-specific accounting artifacts due to the dissolution of the USSR (see individual reports on Estonia, Latvia, Lithuania and Russia), rather than substantial missing data.

National highlights for 2000-2007:

Denmark: The reconstructed catches were on average 33% higher than reported landings. Cod, herring and sprat accounted for nearly 70% of the difference between reported landings and total catch. Unreported landings and discards were the two biggest IUU components, accounting for 11% and 9% per year. An average discard rate of 43% made flatfishes the most underreported group, relative to flatfish reported landings.

Estonia: The reconstructed catches were 25% higher than reported landings. Herring and sprat dominated Estonia's catches, accounting for 92% of the difference between reported landings and reconstructed total catches. While cod catches were small compared to other countries, cod were still underreported by around 100% relative to ICES reported landing. Herring and sprat accounted for 96% of the estimated total discards. For recent years, Estonia had good publicly-available data regarding discard and recreational catches.

Finland: The reconstructed total of 135,000 t·year^{-1} was 24% higher than the reported landings. Herring and sprat accounted for over 90% of the difference between reported landings and reconstructed total catches, as cod is of minor importance in Finland. Credit must be given to Finland's inclusion of recreational catches in the country's official landings statistics back to 1950.

Germany: The reconstructed catches were 29% higher than reported landings. Cod, sprat and herring made up 81% of the difference between reported landings and reconstructed total catches. While flatfishes only represented around 7% of the total reconstructed catch, they accounted for 28% of total discards. Recreational cod catches were significant, equivalent to 19% of reconstructed cod catches.

Latvia: The reconstructed catches were more than 26% higher than reported landings. Sprat and herring accounted for 74% of the difference between reported landings and total reconstructed catches. Cod were the most underreported taxa, with approximately 88% of cod catches added as IUU catches, mainly due to discarding. Flatfishes were second-highest, with an annual average of 78% of catches added as IUU, mainly due to unreported landings.

Lithuania: The reconstructed catches were on average 44% higher than reported landings. Cod and sprat accounted for 61% and 21% of the total IUU, respectively. Cod represented, on average, 65% of the estimated unreported landings per year.

Poland: The reconstructed catches were about 80% higher than reported landings. Cod, herring and sprat accounted for 93% of the difference between reported landings and reconstructed total catches. Unreported landings of cod, herring, and salmon were estimated to be substantial, on average equivalent to approximately 300%, 100%, and 55% of reported landing per year, respectively.

Russia: The reconstructed catches were over 25% higher than reported landings. On average, sprat, herring and cod accounted for 45%, 18% and 20% of total IUU catches per year. Access to data was generally a problem for Russia.

Sweden: The reconstructed catches were 20% larger than reported landings, despite herring and sprat catches (combined) being overreported by, on average 7% per year. Unreported landings were the largest component, averaging 23,000 $t \cdot year^{-1}$ and accounting for about 12% per year of total catches. Of these, 98% were due to cod, herring, and sprat. Discards and recreational catches averaged 6% and 4% of total catches, respectively. Discarding was substantial for some species, e.g., flounder discards were more than 1.5 times larger than their reported landings.

The major problem encountered in our reconstruction efforts was a general lack of transparency in published fisheries data from ICES stock assessment working group reports (WGRs). WGRs publish aggregate estimates of IUU (including discards and unreported landings [unallocated catches]). It was not transparent which countries did, or did not contribute to these estimates, and in what proportions. The policy of ICES is to keep these data confidential, in an apparent effort to avoid political problems. We were also not granted access to the relational database '*FishFrame*', which contains Baltic-wide estimates for discards. Such non-transparency reduces accountability of managers, enforcement officers, and fishers, whose IUU catches are thus rarely exposed, and hinders the establishment of public trust.

In 2012, the Common Fisheries Policy (CFP) is set to be renewed, which provides an opportunity to address some of the issues pertaining to accountability and transparency in fisheries data and practices. A high priority should be more accountability for total catches, as opposed to reported landings. For example, Denmark proposed an increase in allowable landings in return for the implementation of mandatory video monitoring to help eliminate discards and high-?grading. One hundred percent observer coverage as onboard and/or video coverage is the only real option to properly account for all catch activities in a transparent manner, as has been demonstrated successfully in other fisheries.

The *Sea Around Us* Project, February 2010

FISHERIES CATCHES FROM THE BALTIC SEA LARGE MARINE ECOSYSTEM: 1950-2007[1]

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ABSTRACT

We estimated the total marine and brackish-water fisheries catches from the Baltic Sea Large Marine Ecosystem, from 1950-2007, taken by Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden. Using the ICES electronic catch database as the 'reported data' baseline, we added several IUU (Illegal, Unreported and Unregulated) catch components: 'adjustments' (data source adjustments to the reported landings), 'unreported' landings (termed 'unallocated' by ICES), estimates of 'discards', and estimates of 'recreational catches'. This 'reconstructed total catch' was 53.5 million tonnes from 1950-2007, which is approximately 30% higher than landings officially reported by ICES for the same period. For the period since 2000 (2000-2007) this difference was 35%. Our reconstruction is likely an underestimate, as we used minimum values based on conservative assumptions. However, a conservative estimate is still preferable to the current default assumption of 'zero catch' in the absence of officially-reported IUU data. Currently, ICES does not disclose countries that do or do not submit estimates of these other fisheries sectors to ICES, and this lack of transparency prevents countries that are either not collecting or not reporting data from being held accountable by the public and other stakeholders on issues of public resource use.

INTRODUCTION

The Baltic Sea, here defined as the Baltic Sea Large Marine Ecosystem (Figure 1; Sherman and Hempel, 2008), is a semi-enclosed sea situated in northern Europe and encompasses a surface area of approximately 394,000 km² (www.seaaroundus.org). Nine coastal countries (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden) surround the Baltic Sea and are involved in national, regional and international agencies to manage the sea and its resources. The Baltic Sea is a water body that consists of brackish water with large inputs of fresh water originating from rivers in the east and inputs of more saline water entering from the Atlantic Ocean through the Kattegat. The Baltic Sea is therefore often thought of as a large semi-enclosed estuary (Graneli *et al.*, 1990). The watersheds' catchment encompasses an area approximately 4 times the surface area of the Baltic Sea (Thulin and Andrushaitis, 2003). The terrestrial landscape surrounding the Baltic Sea has a variety of human impacts that also influence

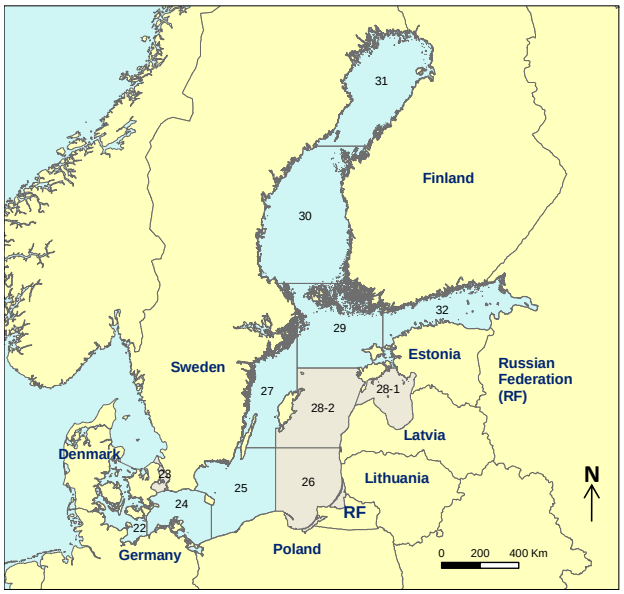

Figure 1. Map of the Baltic Sea with ICES subdivisions and surrounding countries (the Baltic Sea Large Marine Ecosystem consists of all subdivisions indicated).

[1] Cite as: Zeller, D., Booth, S., Bale, S., Rossing, P., Harper, S., and Pauly, D. (2010) Fisheries catches from the Baltic Sea Large Marine Ecosystem: 1950-2007. pp. 7-38. *In:* Rossing, P., Booth, S., and Zeller, D. (eds.), *Total marine fisheries extractions by country in the Baltic Sea: 1950-present*. Fisheries Centre Research Reports 18 (1). Fisheries Centre, University of British Columbia, Canada [ISSN 1198-6727].

the physical and biological components of the sea. Currently, the human population inhabiting the drainage area of the Baltic Sea is approximately 85 million (this includes estimates from non-coastal states that are within the drainage area of the Baltic Sea) and it is estimated that 27 million people live within 50 km of the coastline (Hannerz and Destouni, 2006). Human activity has influenced the productivity of the Baltic Sea, with excessive inputs of nutrients contributing to eutrophication and algal blooms that cause large hypoxic/anoxic areas affecting the biological communities. Inputs of toxins from both point and non-point sources affect water quality, and there are ongoing studies detailing levels of pollutants in the sea's organisms (HELCOM, 2003).

The amount of salt- and fresh-water, and hence the salinity gradient, in part, determines the species composition of the aquatic ecosystem, which comprises marine, fresh water and diadromous species. The western portion near Denmark has the highest number of fish species (~100) while the north-eastern portion in the Gulf of Finland has only 20 fish species (Voipio, 1981); see Appendix Table A1 for a listing of taxa considered in this report.

From a fisheries perspective, salinity levels heavily impact whether the system is an Atlantic cod (*Gadus morhua*) or herring (*Clupea harengus*)/sprat (*Sprattus sprattus*) dominated system. Higher biomass and larger catches of cod from both the eastern and western stock have traditionally been considered to occur under more saline conditions, whereas herring and sprat biomass and catches increase during less saline conditions (HELCOM, 2003). Increasing salinity levels are associated with increased fluxes of saltwater entering through the Kattegat, which also results in increased oxygen levels. Higher salinity levels and the associated increased dissolved oxygen concentrations in the deep basins where cod spawn increases the survivorship of cod eggs (Nissling and Westin, 1991). Increased inflow of saltwater to the Baltic also leads to high population levels of marine copepods, the dominant food of pre-adult cod (Hammer *et al.*, 2008). The International Council for the Exploration of the Sea (ICES) reports 153 taxa (including fish, mollusks, bivalves and crustaceans) being landed in fisheries, but cod, herring and sprat are the commercially most important species, accounting for over 90 per cent of reported landings. Fisheries catches and analysis have been previously documented for the Baltic Sea Large Marine Ecosystem (Heileman and Thulin, 2008) using analysis techniques documented in Pauly *et al.* (2008).

Fishing is known to also impact heavily on the resources and state of the Baltic Sea. Currently, sprat, Gulf of Riga herring, and cod are considered to be overfished in relation to fishing mortality and long-term yield (ICES, 2008a; 2009b), and this affects ecosystem functions and services. The decline in cod biomass since the 1980s (due to both decreases in habitat and excessive fishing mortality) has led to altered trophic relationships that affect the ecosystem. Declining abundance of cod and the increase in biomass of sprat and herring has led to an increase in hypoxic events due to trophic cascades (Österblom *et al.*, 2007). Increased sprat and herring biomass result in increases predation on zooplankton, leaving less zooplankton biomass. Less zooplankton can cause an increase in phytoplankton/algae biomass, resulting in increased levels of eutrophication and hypoxia (Casini *et al.*, 2008).

Information on total catches (in contrast to reported landings) from the Baltic Sea are not readily available, nor have they been comprehensively accounted for. ICES is the agency responsible for disseminating information about the state of the living resources in the Baltic Sea (based on information received from the individual countries), and provides scientific advice to governments and the international regulatory bodies that manage the Baltic Sea (ICES, 2009c). From 1973-2004, scientific advice from ICES, including recommended Total Allowable Catches (TACs) for cod, herring, sprat and salmon estimated through scientific stock assessment procedures, was taken under consideration by the International Baltic Sea Fishery Commission (IBSFC). The IBSFC members negotiated and considered socio-economic factors and political considerations, which generally resulted in higher TACs being allocated for the species covered under the Gdansk Convention (cod, herring, sprat and salmon) than stock assessments recommended. It is important to note that in some years agreements could not be reached and no TACs were agreed upon, leading to even higher fishing mortalities on these species, especially in the mid-1980s. Since 2005, with the changes in the membership of the European Union, TACs are now negotiated between the EU and Russia (Aps *et al.*, 2007). Since 2006, the Baltic Sea Regional Advisory Council advises the member states of the EU and the European Commission on matters concerning the management of fisheries under the EU Common Fisheries Policy.

Changes in the fishing areas within the Baltic Sea where national fleets were allowed to operate have also changed during the time period considered here. In earlier time periods, countries claimed a 3 nm

territorial sea, which later increased to 12 nm. In 1978, Sweden became the first country in the Baltic to claim a 200 nm Exclusive Economic Zone (EEZ) under the provisions of the United Nations Law of the Sea (UNCLOS), but because of overlapping claims, the mid-line principle was used to settle claims. The changes brought about by the introduction of EEZs during the later part of the 1970s had the effect of shrinking the fishing areas of some countries (e.g., Denmark; Borberg, 1976). However, with the adoption of the Common Fisheries Policy by members of the EU in 1983, fishing fleets of member countries had access to each other's fishing areas (outside of the 12 nm territorial waters, unless fishery access agreements between individual countries were established). With EU membership expanding since 1983, more area of the Baltic Sea has come under EU management.

The officially reported fisheries data, as represented by ICES sources, are known to almost exclusively account for landings, not total catches. ICES stock assessment working group reports do provide some information and data on unallocated (unreported) catches and discards for some species, but unfortunately not in a transparent manner. The unallocated (unreported) catches from working group reports are presented as Baltic Sea-wide total amounts, and not by country, even though it is known that not all countries report these catches. Unfortunately, the default approach by the working groups is to substitute 'zero' for those countries not presenting data for unallocated catches. This approach leads to under-estimation in this catch categories because there is no expansion (or substitution with estimates) methods used to account for countries not reporting. Further, the working group reports do not indicate which countries' data are included. This incomplete accounting in scientific stock assessment reports is apparently done for confidentiality reasons, but does not lead to a transparent and publicly accountable catch accounting system. It also hampers attempts to comprehensively assess the true nature of fisheries catches. Yet, to fully account for all catches, estimates of Illegal, Unreported and Unregulated catches (IUU), discards and recreational catches need to be assessed and included to better estimate likely total fisheries catches in the Baltic Sea. A further data source, presently called '*Fishframe*' (FishFrame, 2009) that contains information on discards by gear type, species, country and year, as well as some data on unallocated catches is available to authorized users. However, these data are also considered confidential, and access to these data was not given. This database is maintained by Denmark's National Institute of Aquatic Resources (DTU Aqua).

Additional data sources used include national data, published and grey literature case studies, unpublished reports, media sources and personal information based on communications and discussions with country- and region-specific experts from around the Baltic Sea region. Interestingly, many of the personal sources were very willing and keen to share their knowledge and information with us, but have expressed a clear preference for not being named, i.e., wanting to remain anonymous, usually out of concern about their perceived scientific standing, or concerns about their job security. Throughout this report, we treat such concerns seriously, and cite 'anonymous source' for such material. We also endeavor to use such information in a manner so as not to make the original source apparent. However, the scientific and public community in Europe should consider it as a point of concern if scientists, environmental and fisheries experts are not willing to speak publicly on their knowledge and experience.

The approach to retroactively estimate total catches uses a bottom-up approach to reconstruct catch time series (Zeller *et al.*, 2007; Pauly *et al.*, 2008). Such an approach often requires assumption-based inferences and interpolations, but is justified, despite data uncertainties, given the less acceptable alternatives that users of official data will interpret non-reported or missing data components as zero catches (Pauly *et al.*, 1998). Estimates of total catches derived from catch reconstructions will clearly not be statistically 'precise' in the sense of having small uncertainty. However, of importance here is the realization that, given our conservative approach to estimation, the estimates that will be derived are 'less wrong' i.e., likely more 'accurate' in the sense of being closer to the 'true' value than the currently assumed 'zero' catch substituted for 'no data' by stock assessments.

The rational for fisheries catch reconstruction lies in creating a baseline of total catches rather than reported landings to better inform policy makers and the general public, and to contribute to the development of ecosystem-based fisheries management, which cannot be done without a comprehensive time-series of fisheries catches. It is hoped that by casting the net wide, and not relying on one set of data, that a better and more comprehensive picture will emerge on the likely total catches taken in the Baltic Sea over the last 50+ years.

METHODS

ICES maintains two different publicly accessible databases that provide time series data of fisheries statistics. The '*ICES catch statistics database'* describes countries' reported landings by species (or higher taxonomic grouping), ICES statistical reporting area and year (in two parts: 1950-1972 and 1973-present). Throughout the present report, data from this database are referred to as '*ICES landings statistics'*. The second ICES database, officially called '*ICES stock assessment results database'*, describes countries' catches by stock and year, and presents data used by the ICES stock assessment working groups for their annual stock assessments. Hence, this database only presents data on cod, herring, sprat, brill (*Scophthalmus rhombus*), dab (*Limanda limanda*), turbot (*Psetta maxima*), plaice (*Pleuronectes platessa*) and flounder (*Platichthys flesus*) and no data on the remaining 145 taxa being caught. As we utilize some of these data, generally in conjunction with information taken directly from the ICES stock assessment working group reports (e.g., ICES Working Group on Baltic salmon and trout 2008 [ICES, 2008a]), we refer to the combined data source (i.e., '*ICES stock assessment results database'* and ICES stock assessment working group reports) as '*ICES stock assessment working group data'*. In addition to the reported landings by stock, the '*ICES stock assessment reports'* also contain some data on unallocated (unreported) catches of cod, salmon and Riga herring. Both databases are available electronically from ICES (ICES, 2009a) as are recent ICES stock assessment reports (ICES, 2009b).

As the aim of this study is to estimate total catches (as opposed to reported landings) taken in the Baltic Sea for the time period considered here, all fisheries components were estimated for the nine Baltic countries. The 'reported data' baseline is represented by 'ICES landings statistics'. To this, we added four IUU components: 'adjustments' to ICES landings statistics (i.e., data source adjustments to reported landings), unreported landings', 'discards', and 'recreational catches'. 'ICES landings statistics' formed the baseline for estimating total catches, and estimates of IUU catches were added to these. Discard estimates were applied to the sum of ICES landings, adjustments, and estimates of unreported catches. Recreational catch estimates were also made for each country, allowing estimates of total catches taken from the Baltic Sea from 1950-2007 to be derived. Catches reported by ICES on behalf of non-Baltic countries were presented here, but excluded from this catch reconstruction as they amounted to only 60,000 t over the entire time period considered. The basic methodological approach used here consisted of utilizing as wide a range of information and data sources as possible. Information and data for each catch component that were considered usable were transformed to create so-called 'anchor points', and, when time series were lacking, expansion methods, including linear interpolations between anchor points in time, were done to create full time-series coverage for each catch component (Zeller *et al.*, 2006; Zeller *et al.*, 2007).

ICES landings statistics (ICES, 2009a)[2] are available as two data sets covering the time periods 1950-1972 and 1973-2007, and describe the annual commercial landings data by each country for each taxon and statistical reporting area (Figure 1). ICES landings data were adjusted with information provided by our Baltic collaborators, from national sources, or from other ICES documents (e.g., ICES working group reports), and the adjustments plus ICES landings statistics represent what we consider to be the best estimate of reported landings. Unreported catches were generally transformed into anchor points by considering the available data as a proportion of corresponding reported landings per year (e.g., unreported landings data for cod for Denmark was related to the reported landings of cod by Denmark) in order to expand unreported catch estimates to time periods when data were lacking. The same method was used for discards; however, discard rates were applied to the sum of ICES landings statistics, adjustments, and unreported landings. In order to expand to time periods when there was no neighboring anchor point to interpolate to, an assumption-based approach was used. These methods allowed for a complete time series of catch data to be estimated for each catch component for each country that participates in Baltic Sea fisheries.

The general methods presented here represent the default approach for each component for each country. However, whenever country specific data on any of the components were available, such specific data were utilized in preference to the default approach. Each individual country report (this volume) describes such details. To account for some political and economic differences between countries, we accounted for catch components by considering groupings of countries. Western countries were considered to include Denmark, Finland, West Germany (1950-1990) and Germany (after re-unification, 1991-2007), and Sweden; former eastern bloc countries included East Germany (1950-1990), Poland, Russia Federation,

[2] ICES refers to these data as 'catch statistics'.

and the Baltic states of Estonia, Latvia and Lithuania. Non-Baltic countries that have had fishing access to the Baltic Sea as reported in ICES landings statistics include Faeroe Islands, Netherlands, Norway, Spain, England and Wales.

Illegal, Unreported and Unregulated (IUU) catches

Here, we consider that adjustments to ICES landings statistics, unreported landings, discards and recreational catches all form components of IUU catches. Each of these components was treated separately in both a taxon- and country specific manner when information was available, or a country's IUU components were estimated with assumed default methods, when information was not available.

Adjustments to ICES landings statistics

Adjustments to ICES landings statistics were taken from ICES stock assessment working group data (e.g., ICES, 2008a), the 'ICES stock assessment results' database (ICES, 2009a), and nationally reported data. These adjustments were incorporated to present the best estimate of reported landings.

National data were used for some countries in the early time periods (1950s) to fill gaps from the first year of ICES reported data back to 1950 (i.e., some countries data time series in ICES reported landings statistics do not start until after 1950, even though data are reported in national documents). Landings reported by the ICES stock assessment working groups were generally used for cod and flatfishes, as the stock assessment working group data provided specific landings data for the eastern and western cod stocks (ICES, 2007; 2008a), while the stock assessment working group data for flatfishes (ICES, 2008a) provided a better taxonomic breakdown.

Unreported landings

The foundation for our estimates of unreported landings was guided by what ICES calls 'unallocated' catches and which we refer to as unreported landings throughout this report. The ICES stock assessment working group data only contain Baltic-wide summary data of unreported landings for the western and eastern cod stocks, salmon, and Riga herring.[3] Unreported landings of both cod stocks and salmon were converted into percentages of the Baltic-wide reported landings for salmon and each cod stock (as reported in the respective working group reports) to form anchor points. Unfortunately, the ICES source did not provide country-specific transparency in regards to unreported landings. The Baltic-wide percentage rates, which were adjusted if a country was known to not report unallocated landings to ICES (see cod below), were then applied to the sum of each country's ICES landings statistics and adjustments. As it is known that not all countries provide data on unreported landings (or even estimates thereof) to stock assessment working groups, the resulting unreported landings totals obtained through our approach are minimal estimates at least at the aggregated level.

Table 1. Default anchor points (%) used for estimating unreported landings from the western cod stock in the Baltic Sea based on ICES (2007, Table 2.4.1). Dashes (-) indicate years of linear interpolation between anchor points.

	Countries	
Year	**Western**	**Eastern**
1950	5.00[a]	0.00[b]
1951-1979	-	0.00[b]
1980	20.10[c]	0.00[b]
1981-1990	-	0.00[b]
1991-1992	-	-
1993	40.20	40.20
1994	39.64	39.64
1995	-	-
1996	5.34	5.34
1997-1999	-	-
2004	0.07	0.07
2005	0.04	0.04
2006-2007	0.04[d]	0.04[d]

[a] assumption of 5% of reported landings; [b] assumption of zero unreported landings; [c] assumption of ½ the 1993 rate; [d]2005 value carried forward.

Cod: Anchor points for unreported catches of western cod were available for 1993, 1994, 1996, 2004, and 2005 (Table 2.4.1 in ICES, 2007) as a total for all countries, while the eastern cod stock had anchor points developed for 1993-1996, and from 2000-2007 (Table 2.3.1 in ICES, 2008a). However, these anchor points were adjusted by excluding Sweden's reported landings from the total landings because Sweden does not report any unallocated cod landings to the ICES working groups (Persson, this vol.). Despite repeated requests to ICES to obtain information on which countries did not contribute data, we were not permitted access to that knowledge (Table 1). The adjusted rate was estimated as,

[3] For details regarding unreported catches of Riga herring, see reports on Estonia (Veitch *et al.*, this volume) and Latvia (Rossing *et al.*, this volume), which are the countries that exploit this stock.

Unreported % = unallocated catches /(total cod landings – Sweden's cod landings)

In order to account for historical and political differences, the former eastern bloc countries (East Germany, Estonia, Latvia, Lithuania, Poland, and the Russian Federation) were treated separately from western countries. The western countries, which already had market economies in 1950, were assumed to have unreported landings throughout the time period considered here. As there were no reports documenting unreported landings prior to 1993, we used an assumption-based approach to derive an anchor point for 1980 and 1950. For 1950, it was conservatively assumed that unreported landings were 5% of the reported landings, while for 1980, unreported landings were assumed to have been half the 1993 estimated rate (Table 2). For the former eastern bloc countries, with state controlled economies in the early years, it was assumed that there was no incentive to not report all landings because prices for different species were similar enough to discourage mis-reporting (R. Oeberst, pers. comm., Johann Heinrich von Thünen-Institut). Thus, unreported landings by eastern countries were conservatively set to zero from 1950 to 1990, and then linearly interpolated to 1993, the first year when estimates of unreported catches were available (Table 2).

Table 2. Default anchor points (%) used for estimating unreported landings of eastern cod stocks in the Baltic Sea based on ICES (2007, Table 2.3.1). Dashes (-) indicate years of linear interpolation between anchor points.

	Eastern cod	
Year	**Western countries**	**Eastern countries**
1950	5.0[a]	0.0[b]
1951-1979	-	0.0[b]
1980	31.1[c]	0.0[b]
1981-1990	-	0.0[b]
1991-1992	-	-
1993	62.2	62.2
1994	103.0	103.0
1995	30.0	30.0
1996	10.0	10.0
1997-1999	-	-
2000	46.0	46.0
2001	47.6	47.6
2002	46.6	46.6
2003	61.5	61.5
2004	52.9	52.9
2005	46.4	46.4
2006	47.9	47.9
2007	43.2	43.2

[a]assumption of 5% of reported landings; [b]assumption of zero unreported catches; [c]assumption of ½ the estimated rate for 1993.

Atlantic salmon: Unreported landings of salmon are not presented in the ICES stock assessment results database; however, some information on unreported landings of salmon were available from ICES working group reports (ICES, 2008b). The working group reports Baltic-wide estimates of the mode, minimum and maximum of unreported landings for all Baltic countries combined from 1981-2007. Countries whose reported landings data included recreational catches (Denmark, Finland, and Sweden; see Table 2.1.2 in ICES, 2008b) had anchor points derived in a slightly different manner than countries that did not report recreational catches.

Thus, we used two separate assumption-based approaches to estimate salmon IUU catches:

a) for Denmark, Finland, and Sweden, whose reported landings in Table 2.1.2 in ICES (2008b) included estimates of recreational catches, we utilized both the mode and the minimum value of unreported landings from the ICES salmon working group report (Table 2.1.2 in ICES, 2008b) to estimate country specific unreported salmon catches. The mode was used prior to countries reporting recreational catches, and after countries started to report recreational catches the minimum was used; and
b) for all other countries, whose reported landings data in Table 2.1.2 in ICES (2008b) did not include recreational catches, we used the mode value of unreported landings from Table 2.1.2 in ICES (2008b) to estimate country specific unreported catches.

In keeping with the assumption-based approach, the former eastern bloc countries were assumed to report all landings, and thus, were conservatively assumed to have no unreported landings from 1950-1990 (Table 3). To account for the shift to market economies and the associated underreporting incentives, linear interpolations were made between 1990 and the first anchor point in 1993 based on the above described method for estimating unreported landings. Prior to applying this method to the western countries, a correction was applied to reported landings, as it was assumed that the eastern bloc countries reported all landings of salmon prior to 1990. For the earlier time periods, assumption-based approaches were used, but when unreported landings were first documented in ICES working group data, the estimates of unreported landings between 1950 and 1990 for western countries in each year were calculated as,

Unreported landings % = mode of unreported catches/[total reported landings – eastern bloc landings]

In 1950, West Germany's unreported landings of salmon were assumed to be 5% of reported landings and linear interpolations were used to the first anchor point in 1981 (Table 4). After 1981, West Germany's unreported landings were based on the mode. Finland has reported its recreational catches since 1953, and in order to estimate unreported landings of salmon, we set the 1950 rate to 5% of ICES reported landings and linearly interpolated to the mode estimate in 1981, but used the minimum value from 1981-2007. Sweden and Denmark started to report recreational catches in 1988 and 1998, respectively, and thus were treated differently than Germany and Finland. In these cases, it was also assumed that the 1950 unreported rate was 5%, and linear interpolations were carried out to the first unreported landings rate using the adjusted unreported landings percentage for each year i.e.,

Unreported landings % = min of unreported catches /[total reported landings– eastern bloc landings]

Table 3. Default anchor points (%) used for estimating unreported landings of Atlantic salmon in the Baltic Sea for the former eastern bloc countries based on Table 2.1.2 in ICES (2008b). Dashes (-) indicate years of linear interpolation between anchor points.

Year	Rate (%)	Year	Rate (%)
1950-1990	0.0[a]	2000	19.9
1991-1992	-	2001	20.4
1993	19.4	2002	20.5
1994	18.7	2003	20.1
1995	19.5	2004	20.6
1996	20.4	2005	20.7
1997	20.8	2006	22.2
1998	20.1	2007	21.4
1999	20.4		

[a] assumption of zero unreported catches.

For Finland, Sweden and Denmark, the minimum estimate was used for the year that recreational catches (1981, 1988 and 1998, respectively) were included in the reports to ICES. Thus, for Finland, the 1950 estimate of unreported catches was 5% in 1950 and this rate was linearly interpolated to the mode-based rate for 1981. However, since Finland started to report its recreational catches in 1981, the estimate of unreported landings for the 1981-2007 time period were based on the minimum rate-based estimate of unreported catches (Table 4).

Table 4. Default anchor points (%) used for estimating unreported landings of Atlantic salmon in the Baltic Sea for western countries reporting recreational catches (Finland, Sweden and Denmark), and for Germany based on Table 2.1.2 in ICES (2008b). Dashes (-) indicate years of linear interpolation between anchor points.

Year	Finland	Sweden	Denmark	Germany	Year	Finland	Sweden	Denmark	Germany
1950	5.0[a]	5.0[a]	5.0[a]	5.0[a]	1993	6.0[b]	5.9[b]	19.4[c]	19.4[c]
1951-1979	-	-	-	-	1994	6.0[b]	5.9[b]	18.7[c]	18.7[c]
1980	19.9[b]	19.9[c]	19.9[c]	19.9[c]	1995	6.0[b]	6.2[b]	19.5[c]	19.5[c]
1981	6.0[b]	20.4[c]	20.4[c]	20.4[c]	1996	6.0[b]	6.4[b]	20.4[c]	20.4[c]
1982	6.0[b]	20.7[c]	20.7[c]	20.7[c]	1997	6.0[b]	6.5[b]	20.8[c]	20.8[c]
1983	7.0[b]	22.6[c]	22.6[c]	22.6[c]	1998	6.7[b]	6.7[b]	6.7[b]	20.1[c]
1984	6.0[b]	20.7[c]	20.7[c]	20.7[c]	1999	6.6[b]	6.6[b]	6.6[b]	20.4[c]
1985	6.0[b]	19.7[c]	19.7[c]	19.7[c]	2000	6.8[b]	6.8[b]	6.8[b]	19.9[c]
1986	7.0[b]	22.0[c]	22.0[c]	22.0[c]	2001	6.6[b]	6.6[b]	6.6[b]	20.4[c]
1987	6.0[b]	21.4[c]	21.4[c]	21.4[c]	2002	6.5[b]	6.5[b]	6.5[b]	20.5[c]
1988	7.0[b]	7.1[b]	22.2[c]	22.2[c]	2003	6.7[b]	6.7[b]	6.7[b]	20.1[c]
1989	7.0[b]	7.1[b]	22.6[c]	22.6[c]	2004	6.0[b]	6.0[b]	6.0[b]	20.6[c]
1990	7.0[b]	7.2[b]	24.4[c]	24.4[c]	2005	6.2[b]	6.2[b]	6.2[b]	20.7[c]
1991	6.0[b]	5.8[b]	19.5[c]	19.5[c]	2006	6.0[b]	6.0[b]	6.0[b]	22.2[c]
1992	6.0[b]	5.6[b]	20.1[c]	20.1[c]	2007	6.5[b]	6.5[b]	6.5[b]	21.4[c]

[a] assumption of 5% of reported landings; [b] based on minimum value; [c] based on mode value.

Other taxa: Baltic-wide, unreported landings were reported separately for salmon and the eastern and western cod stocks, but no other information regarding Baltic-wide unreported landings was found. Thus, to estimate unreported catches for all remaining species listed in the ICES reported landings statistics, (n = 151), an assumption-based approach was used based on the estimates of unreported landings of cod and salmon. The anchor points for all other species were based on the 1993, 1994, 2004 and 2005 cod and salmon anchor points, which were years when data on unreported landings existed for salmon and the two stocks of cod, simultaneously. The rates for unreported landings both calculated as illustrated above for these two species were averaged and then halved, and these modified rates were used as anchor points for the other species (Table 5). Thus, it was assumed that the other species had unreported landings rates that were half the average rate of underreporting of cod and salmon. Linear interpolations were made between the 1994 and 2004 anchor points, and the 2005 anchor point was carried forward in time. Going back in time to 1950, the eastern and western countries were treated differently. For western countries, the 1950 rate was set to 5 %, and for 1980 the anchor point was set to one-half of the 1993 anchor point, and linear

Table 5. Default anchor points (%) used for estimating unreported landings of other taxa, excluding cod and salmon in the Baltic Sea based on sources (Tables 2.3.1 and 2.4.1 in ICES, 2007; and Table 2.1.2 in ICES, 2008b). Dash (-) indicates year of linear interpolation between anchor points.

	Countries	
Year	Western	Eastern
1950	5.0[a]	0.0[d]
1951-1979	-	0.0[d]
1980	10.1[b]	0.0[d]
1981-1990	-	0.0[d]
1991-1992	-	-
1993	20.3	20.3
1994	26.9	26.9
1995-2003	-	-
2004	12.3	12.3
2005	11.2	11.2
2006-2007	11.2[c]	11.2[c]

[a] assumption of 5% of reported landings; [b] assumption of ½ the reported rate for 1993; [c] 2005 value; [d] assumption of zero unreported catches.

interpolations were done between anchor point years. For eastern bloc countries, unreported landings were assumed to be zero until 1990 after which unreported landings were estimated using linear interpolations between anchor points.

Discards

Discards were separated into four categories: 1) 'underwater' discards caused by deployed gear engaged in fishing; 2) 'ghostfishing' caused by gear that is lost, but continues to fish; 3) 'boat-based' discards resulting from fisher's behavior after the catch is brought on board; and 4) 'seal-damaged' discards. Available information on discards was converted into a percentage rate to apply to the sum of ICES landings, adjustments and unreported landings. ICES stock assessment working group reports contain data on discards for the eastern and western cod stocks (ICES, 2007; 2008a), and for salmon (ICES, 2008b). Separate studies provided data on underwater discards by active fishing gear (Rahikainen *et al.*, 2004) and ghostfishing by lost gear (Tschernij and Larsson, 2003; Brown *et al.*, 2005). A Danish study (Anon., 2006) examined boat-based discard practices for their entire fleet over a one year period and these data were used to derive default discard rates for species other than cod and salmon.

Underwater discards: Estimates of underwater discards were applied for all countries in all years, but to herring and sprat catches only. While other gear types targeting other species are likely to also experience underwater discarding, we had no information to reliably apply this to other gear types. Hence, our estimates of this type of discarding are conservative. Sprat and herring, which are targeted by the same trawl fleet, may be caught simultaneously in trawl gear no matter which species is the primary target. Inaccurate catch composition data for these two species, and the fact that they are both targeted by the same fleet, led us to apply the underwater discard rate to both species combined (M. Rahikainen, pers. comm., University of Helsinki).

A Finnish study examined mortality levels associated with underwater discards in the herring trawl fishery (Rahikainen *et al.*, 2004). This study used length-age relationships to determine the number of fish by age class that were lost from trawl gear while it was deployed fishing, and also to determine the amount of catch brought on board. We converted the numbers-at-age to weights using average weights from ICES (2008a) for age classes 1 – 12 and information from Cardinale (2000) for age zero herring to determine the weight of fish that were lost prior to gear retrieval. We then determined the rate of underwater discards by deriving a ratio of underwater discards to the amount of fish brought on board. We quantified the loss as approximately 9% of catches brought on board. We also applied this underwater discard rate to sprat since it is likely that underwater discards are similar to those of herring (M. Rahikainen, pers. comm., University of Helsinki).

Trawl landings of herring and sprat by Denmark and Finland had 9% added to their landings (ICES landings + adjustments + unreported landings) to account for underwater discards. All

Table 6. Anchor points (%) used for estimating boat-based discards of eastern cod by western countries in the Baltic Sea (Sources: Tables 2.4.1 and 2.4.5b in ICES, 2007; Table 2.4.1, 2.4.5b and 2.4.20 in ICES, 2008a). Former eastern bloc countries had the same rates applied beginning in 1993.

Year	Anchor point	Year	Anchor point
1950-1965	10.0[a]	1987	5.9
1966	9.2	1988	4.5
1967	12.4	1989	1.9
1968	8.3	1990	3.0
1969	9.6	1991	2.2
1970	6.6	1992	3.5
1971	4.7	1993	3.4
1972	12.7	1994	2.1
1973	8.9	1995	1.7
1974	10.5	1996	1.2
1975	10.4	1997	3.9
1976	2.3	1998	3.4
1977	1.6	1999	2.5
1978	15.5	2000	6.8
1979	16.0	2001	3.2
1980	3.6	2002	2.2
1981	16.3	2003	2.8
1982	5.8	2004	1.8
1983	4.7	2005	3.0
1984	2.3	2006	13.2
1985	3.1	2007	11.3
1986	1.2	-	-

[a] assumption based average from 1966-1968.

Table 7. Anchor points (%) used for estimating boat-based discards for western cod by western countries in the Baltic Sea based on sources (Table 2.3.6 in ICES, 2007; Tables 2.3.1 and 2.3.6, and Figure 2.3.1 in ICES, 2008a). Former eastern bloc countries had the same rates applied beginning in 1993.

Year	Anchor point	Year	Anchor point
1950-1969	65.1[a]	1989	77.9
1970	71.5	1990	79.4
1971	57.0	1991	96.0
1972	66.9	1992	19.2
1973	21.3	1993	14.5
1974	42.6	1994	10.6
1975	22.4	1995	11.3
1976	18.3	1996	15.7
1977	25.6	1997	10.0
1978	27.5	1998	17.3
1979	10.8	1999	11.6
1980	17.1	2000	12.5
1981	13.8	2001	11.2
1982	35.3	2002	10.4
1983	40.7	2003	15.8
1984	17.9	2004	10.1
1985	71.8	2005	18.6
1986	15.2	2006	8.6
1987	20.8	2007	8.3
1988	10.2	-	-

[a] assumption based average from 1970-1973.

other countries had a more conservative rate of 5% added to their estimated landings of herring and sprat (i.e., ICES landings + adjustments + unreported landings) since landings by gear type were not available.

Ghostfishing: Ghostfishing is a global problem (Macfadyen *et al.*, 2009) that results from fishing gear that continues to fish after it is lost at sea for various reasons (Brown *et al.*, 2005). Since fishing gear is now mostly made of synthetic material, it can continue to fish, and it has been found that a lost cod gillnet can continue to catch fish for as long as two years after being lost (Tschernij and Larsson, 2003). A ghostfishing rate of 1.65% was applied to all species excluding pelagic species (e.g., herring and sprat) for all countries in all years based on data presented in Brown *et al.* (2005).

Boat-based discards and seal-damaged discards: Boat-based discarding was treated separately for the former eastern bloc countries and the western countries from 1950 to 1990. Thereafter, former eastern bloc countries' data were linearly interpolated from the assumed value of zero for the 1950-1990 time period to values reported in 1993. After 1993, when the eastern bloc countries became market oriented economies, the rules from the western countries were applied to the former eastern bloc. Data used for default boat-based discard estimates for the eastern cod stock (Table 6), the western cod stock (Table 7), and for salmon (Table 8) were based on ICES stock assessment working group reports (ICES, 2007; 2008a; 2008b), and discards for all other taxa were based on a study that documented discards for all Danish fleets over a one-year period (Anon., 2006).

To assess discards backwards in time, an assumption-based approach was used. For the former eastern bloc countries, prior to becoming market-oriented economies, it was assumed that all species, excluding herring and sprat, were discarded at a rate of 2% per year from 1950-1990. After 1990, the discard rates were interpolated to the anchor points in 1993 for salmon, cod and all other taxa (Anon. 2006).

For western countries, ICES stock assessment working group reports have estimates of discards beginning in 1966 for the eastern cod stock, 1970 for the western cod stock, and 1981 for salmon. These discard estimates were reported as a single number for all countries in each year, and given the assumed 2% discard rates for the former eastern bloc countries, an adjustment could be made for the 1950 to 1990 time period to the reported discard amounts based on the discard rates for the former eastern bloc countries in each year of reported discards,

Western countries' discard rate = [reported discards – (0.02*eastern bloc landings)]/western countries' landings

Discards by western countries of the eastern cod stock were reported from 1966-2007 in ICES working group reports (ICES, 2007; 2008a). For the period 1950 to 1965, the average rate of discards from the first three years of reported data (i.e., 1966-1968) were applied to estimate discards. Discards by the western countries of the western cod stock are reported from 1970 to 2007 (ICES, 2007; 2008a). The average discards reported for the first three years of reported data (i.e., 1970-1972) in the ICES stock assessment working group reports were transformed into an average rate and applied to the 1950-1969 time period.

In order to assess salmon discards, two basic data sources were available. Data originating from the ICES stock assessment working group report (ICES, 2008b) detailing Baltic-wide estimates of boat-based discards of salmon, which are known to include discards due to seal damage, that cover the time period 1981 to 2007 (Table 8), and data obtained from the Finnish Game and Fisheries Research Institute (FGFRI) detailing the level of discards resulting from seal damage only in Finland that covered the time period 2000 to 2007 (A. Ahvohenen and P. Söderkultalahti, pers. comm., FGFRI). In years of data overlap

between the two sources, the source providing the higher discard rate was used as the sole estimate of salmon discards, which avoided the potential for double accounting (see country specific reports, this volume). The FGFRI data were used to also estimate seal-damaged salmon discards for Russia and Estonia in subdivision 32 (Figure 1). Sweden had it own nationally reported data which was used.

Table 8. Anchor points (%) used for estimating boat-based discards for salmon from 1950-2007 based on Table 2.1.2 in ICES (2008b). Dashed lines (-) indicate years when linear interpolations were used.

Year	Eastern countries	Denmark	West Germany	Finland	Sweden
1950	2.0[a]	14.4[b]	14.4[b]	14.4[b]	14.4[b]
1951-1980	2.0[a]	-	-	-	-
1981	2.0[a]	13.9	13.9	8.3	13.9
1982	2.0[a]	14.1	14.1	8.3	14.1
1983	2.0[a]	15.3	15.3	9.0	15.3
1984	2.0[a]	13.9	13.9	8.1	13.9
1985	2.0[a]	13.3	13.3	7.7	13.3
1986	2.0[a]	14.9	14.9	8.8	14.9
1987	2.0[a]	14.5	14.5	8.5	14.5
1988	2.0[a]	14.7	14.7	8.6	8.6
1989	2.0[a]	15.1	15.1	8.9	8.9
1990	2.0[a]	17.3	17.3	10.2	10.2
1991	-	13.6	13.6	8.0	8.0
1992	-	14.1	14.1	7.8	7.8
1993	14.1	14.1	14.1	8.5	8.5
1994	12.9	12.9	12.9	7.8	7.8
1995	13.9	13.9	13.9	8.4	8.4
1996	15.1	15.1	15.1	9.0	9.0
1997	14.9	14.9	14.9	8.6	8.6
1998	14.2	8.6	14.2	8.6	8.6
1999	14.8	8.8	14.8	8.8	8.8
2000	10.3	5.7	10.3	5.8	5.8
2001	15.0	9.1	15.0	9.1	9.1
2002	15.8	9.6	15.8	9.6	9.6
2003	15.4	9.8	15.4	9.8	9.8
2004	15.6	9.1	15.6	9.1	9.1
2005	15.2	8.8	15.2	8.8	8.8
2006	17.3	10.0	17.3	10.0	10.0
2007	14.2	10.0	14.2	10.0	10.0

[a] assumed default discard rate; [b] assumption based average from 1981-1983.

For the former eastern bloc countries, it was assumed that the boat-based salmon discard rate from 1950-1990 was 2. This rate was linearly interpolated to the Baltic-wide estimate of boat-based salmon discards represented by the mode in 1993 (see boat-based salmon discards section above). The annually reported mode was also used to estimate salmon discards from 1994 onwards. This value was compared to the seal only discard data and in years when both data are available the larger value was used.

For western countries, Baltic-wide estimates of boat-based salmon discards are reported in ICES stock assessment working group reports from 1981 to 2007 as a mode, minimum and maximum. The mode was used for Germany throughout the time period and for the other western countries (Denmark, Finland and Sweden) until they started to report recreational catches, after which the minimum value was used. A 3-year average from 1981-1983 was carried back in time to 1950 as an adjusted rate,

Western countries' discard rate = [reported discards – (0.02*eastern bloc landings)]/western bloc landings

This adjusted discard rate accounts for the assumed discarding behavior of fishers in the former eastern bloc countries. The adjusted discard rate was then applied to the estimated landings (i.e., ICES landings statistics + adjustments + unreported landings) of each year to estimate salmon discards by western countries.

Species other than salmon are also discarded because of seal damage in the eastern portion of the Baltic Sea (subdivisions 28 and 32; Figure 1). Seal damage discard estimates for the Gulf of Riga herring (*Clupea harengus*), European perch (*Perca flaviatilis*), European eel (*Anguilla anguilla*), European flounder (*Platichthys flesus*), pikeperch (*Sander lucioperca*), sea trout (*Salmo trutta*), turbot (*Psetta maxima*), vendace (*Coregonus albula*), whitefishes (*Coregonus* spp.), and seal-damaged discards for both cod stocks by Lithuanian and Swedish fishers are dealt with in the country specific chapters for Estonia (Veitch *et al.*, this vol.), Finland (Rossing *et al.*, this vol.), Latvia (Rossing *et al.*, this vol.), Lithuania (Veitch *et al.*, this vol.), Russia (Harper *et al.*, this vol.), and Sweden (Persson, this vol.).

Estimates of boat-based discards for all other taxa were based on a Danish study, which reported the amount of discards over a one-year period by taxa (Anon., 2006). The study reported on the tonnage of

discard for cod, dab, flounder, plaice (*Pleuronectes platessa*), whiting (*Merlangius merlangus*), thorny skate (*Amblyraja radiate*) and 'others'. We transformed the discard tonnage for each specific taxon into a rate by considering the amount of discards as a proportion of the reported landings for the respective taxa. The discard rates for herring and sprat were assumed to be zero as boat-based discards is considered to be almost non-existent in fisheries targeting these species (ICES 2009). The discard rates for dab (33.4%), flounder (48.0%), and plaice (34.0%) were averaged and applied to both brill and turbot (38.5%). The discard rate for whiting (36.1%) was used solely for this species, while the reported discard amount of thorny skate was pooled with other taxa and formed the basis of the discard rate (6.2%) for all taxa that did not have species specific discard data. For western countries, the data from the Danish DTU study was used unaltered for the entire time period (1950-2007). For eastern bloc countries the assumed default discard rate of 2 % was held constant until 1990 and then was linearly interpolated to the derived rates, which we set for 1993 to remain consistent with our methodology for eastern bloc countries.

Recreational catches

Unregulated catches are predominantly represented here by recreational fisheries. Recreational catch estimates were made for all western countries and Russia back to 1950. In Poland, recreational fisheries of cod were known to start in 1986 (Radtke and Dabrowski, 2007). For the former East Germany and the remaining former eastern bloc countries (Lithuania, Latvia and Estonia) recreational catch estimates were not made until they became market economies, as their previous legal framework did not permit recreational fishing (R. Oeberst, pers. comm., Johann Heinrich von Thünen-Institut). As some type of information or data were available for nearly all countries, details for each country's approach to estimate recreational catches are given in each specific report (this volume).

RESULTS

We present reconstructed catch data for the total marine fisheries catches in the Baltic Sea Large Marine Ecosystem (LME) for the period from 1950 to 2007. Our reconstruction used landings statistics reported to ICES on behalf of 9 coastal countries (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia, and Sweden) as baseline data. Estimates of IUU catches were comprised of: a) adjustments to reported landings; b) unreported landings; c) discards; and d) recreational catches. We also present landings data reported by non-Baltic countries as pertaining to the Baltic Sea. See Appendix Tables (B1-B7) for complete time series data.

ICES landings statistics

For the period 1950 to 2007, ICES reports a total of approximately 41.3 million t in the ICES 'landings statistics' for the nine countries fishing in the Baltic Sea LME (including the former USSR and five non-Baltic countries; Figure 2, Table 9). Fisheries landings for non-Baltic countries totaled approximately 64,000 t for the time period 1950 to 2007. We chose to exclude these landings from our catch reconstruction due to their low tonnage.

Table 9. Total ICES landing statistics (t) by decade including non-Baltic countries, for each of the taxonomic entities considered.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	1,086,642	1,630,235	2,087,633	3,218,265	1,128,696	627,149
Herring	1,351,129	2,422,444	3,902,019	4,224,589	3,478,612	2,179,34
Sprat	135,873	781,259	1,817,317	642,655	3,019,670	3,007,36
Flatfishes	99,261	206,473	208,250	160,845	167,927	178,079
Salmon	20,227	30,743	27,385	31,155	32,716	11,890
'Others'	449,022	697,882	844,611	487,735	481,212	433,642

All landings reported from the Baltic Sea LME were reported from ICES subdivisions 22-32, which includes the transition zone in Denmark (subdivisions 22-25) and the Baltic Sea proper (subdivisions 24-32; Figure 1).Reported landings increased from approximately 168,000 t·year^{-1} in 1950 to around 950,000 t·year^{-1} during the late 1970s and mid 1980s, before declining to about 615,000 t·year^{-1} in 1991 (Figure 2).

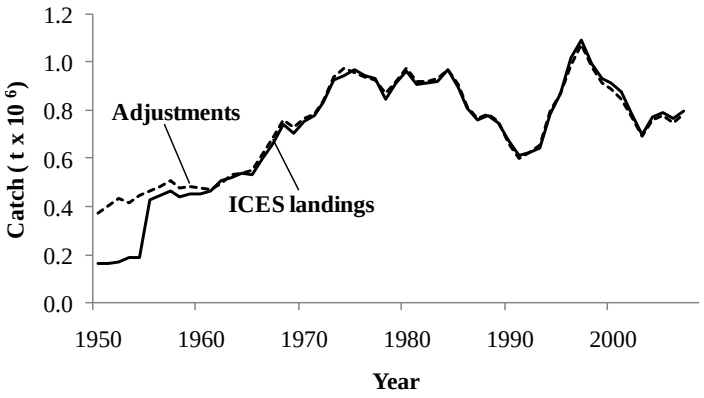

Figure 2. Officially reported fisheries landings as presented by ICES (solid line) with adjustments (dashed line) for the Baltic Sea Large Marine Ecosystem for the period 1950-2007.

Table 10. Landings, and the proportion of total landings reported (by country) in the Baltic Sea (ICES subdivisions 22-32) on behalf of 9 coastal countries. Source: ICES (2009).

Country	Reported landings (t)	(%)
USSR	8,603,314	20.8%
Poland	7,075,563	17.1%
Sweden	6,786,623	16.4%
Denmark	6,766,169	16.4%
Finland	4,468,766	10.8%
Germany	4,221,739	10.2%
Latvia	1,211,724	2.9%
Estonia	1,165,996	2.8%
Russia	739,288	1.8%
Lithuania	206,850	0.5%
Non-Baltic	63,917	0.2%

Subsequently, reported landings reached an all-time peak of approximately 1.1 million t·year^{-1} in 1997, before declining to approximately 800,000 t·year^{-1}in 2007 (Figure 2).

Reported landings by decade and major taxa indicated that the top three species reported by ICES over the entire period (1950-2007) were herring, cod, and sprat, which totaled approximately 43% (17,600,000 t), 24% (9,700,000 t) and 23% (9,400,000 t) of total reported landings), respectively (Table 9).

According to officially reported data, between 1950 and 2007, the former USSR was the top fishing country representing 21% of total ICES statistics. Poland, Denmark and Sweden were the other top fishing countries in the Baltic Sea, each having reported approximately 17%, 16% and 16% of the total ICES landings statistics respectively (Table 10). Finland's and Germany's total reported landings (1950-2007) were comparable and represented each approximately 11% and 10% of the Baltic-wide reported landings to ICES (Table 10). Independent Latvia, Estonia and Russia, (i.e. excluding former USSR) each represented 2-3% of the total reported landings, while Independent Lithuania reported less than 1% of the total landings in the ICES landings statistics (1950-2007; Table 10).

Adjustments to reported landings

Adjustments to ICES reported landings added a net positive tonnage of over 1.2 million t between 1950 and 2007 (Table 11), the majority of which was applied to the 1950s (Figure 2). This added approximately 3% to landings reported to ICES between 1950 and 2007 (Figure 2). In the 1950s alone, an estimated 1.3 million t were added to ICES landings statistics, which added 42.9% to reported landings during that time period (Table 11). Between 1950 and 1959, the majority of adjustments added were those of cod (47%), followed by herring (33%) and sprat (12%; Table 11). In the 1970s, an estimated 31,685 t were added to officially reported landings (the majority were herring, then cod, then sprat) and beginning in the 1990s, adjustments made to reported landings for the Baltic Sea were negative due to over reporting of herring and sprat (Table 11). In the 1990s, negative adjustments totaled an estimated -130,403 t and in the 2000s, an estimated -159,021 t (Table 11). The majority of these negative landings were of herring and 'others' (Table 11). Between 2000 and 2007, positive adjustments were made only to

Table 11. Adjustments (t) added to reported landings from the ICES landings statistics database for each of the taxonomic entities considered. See text for sources.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	637,767	88,087	35,715	15,496	18,486	68
Herring	448,879	4,343	-15,572	15,458	-216,395	-65,171
Sprat	156,937	25,114	45,050	2,278	81,309	-27,265
Flatfishes	52,672	9,560	-7,665	1,493	4,191	-183
Salmon	2,839	-497	-406	908	581	-188
'Others'	46,315	-25,365	-25,437	400	-17,728	-66,282

cod, and negative adjustments ranging from – 88,096 t to -183 t were added to our remaining taxa (Table 11).

Over the entire period of study (1950-2007), adjustments added to reported landings for Latvia, Russia and Estonia combined represented 80% of the adjustments made for all countries (Table 12). The majority of these adjustments were added to these countries prior to 1990 (see country specific reports) and illustrates our preference for adjustments to reflect purely country specific catch accounting preferences. The remaining countries' adjustments contributed the remaining 15% of the total adjustments made to all countries (Table 12). Finland, Sweden and Denmark all had net negative adjustments added to ICES landings statistics between 1950 and 2007 (Table 12). Overall, Denmark received the smallest magnitude of adjustments to reported landings (Table 12).

Table 12. Adjustments (t) to reported landings and their proportion (%) of the overall total Baltic-wide adjustments to landings reported in the ICES landings statistics, by country, for the period from 1950 to 2007.

Country	Adjustments (t)	(%)
Latvia	3,062,556	31.2
Russia	2,660,518	27.1
Estonia	2,585,171	26.3
Lithuania	895,941	9.1
Germany	628,609	6.4
Poland	328,085	3.3
Finland	-180,437	-1.8
Sweden	-143,739	-1.5
Denmark	-8,493	-0.1

Unreported landings

Unreported landings totaled approximately 5.7 million t between 1950 and 2007 for all taxa and all countries fishing in the Baltic Sea LME (Figure 3). Estimated unreported landings increased slowly from approximately 9,000 t·year^{-1} in 1950, to approximately 50,000 t·year^{-1} in the late 1970s. During the 1980s they increased to approximately 110,000 t·year^{-1}, before increasing to approximately 350,000 t·year^{-1} in 1996-1997. Unreported landings apparently declined steadily since then, reaching approximately 155,000 t·year^{-1} in 2007 (Figure 3).

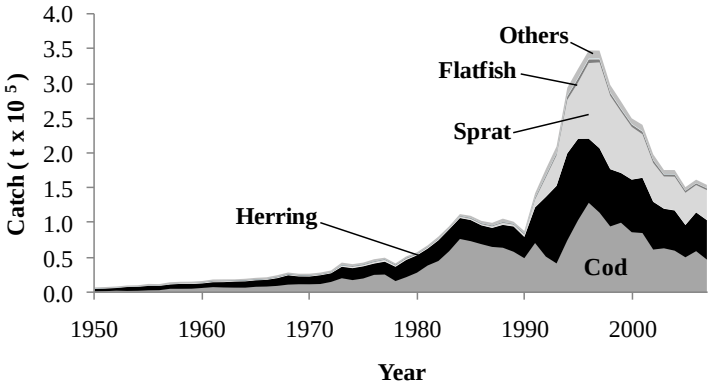

Figure 3. Total unreported landings for cod, herring, sprat, flatfishes and 'others' in the Baltic Sea Large Marine Ecosystem for the period 1950-2007.

Cod had the greatest amount of unreported landings, totaling about 2.3 million t over the period of study (1950-2007; Table 13). By the 2000s (2000-2007) unreported landings of cod averaged 66,000 t·year^{-1} (Figure 3). The total unreported landings of cod (1950-2007) were about 18% greater than those of herring, which had the second greatest volume of unreported landings (Table 13). By the 2000s unreported landings of herring and sprat were on average 62,000 t·year^{-1} and 52,000 t·year^{-1}, respectively. Unreported landings of all species peaked in the 1990s, with those of cod and herring being the most signficiant (Table 13). The only species whose estimates of unreported landings remained quite stable between 1950 and 2007 were those of salmon (Table 13).

Table 13. Total estimated unreported landings (t) by major taxa for the Baltic Sea Large Marine Ecosystem for the period from 1950-2007.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	47,187	98,764	200,939	593,744	844,289	525,182
Herring	54,547	92,751	166,211	292,845	860,401	495,525
Sprat	3,225	5,768	13,722	17,051	669,814	416,659
Flatfishes	4,481	8,399	8,621	9,390	35,463	24,016
Salmon	1,238	2,233	2,555	2,365	3,885	1,679
'Others'	17,016	21,188	25,507	29,150	93,411	51,267

For the entire period, unreported landings were greatest in Poland, Denmark, and Sweden (Table 14). For country-specific data, see individual country reports (this volume). Each of these countries had unreported landings that totaled more than 1 million t over the period of study (Table 14), with Poland having the greatest amount of unreported landings totaling approximately 1.7 million t, or 29% of the total unreported landings of all Baltic countries between 1950 and 2007. The total unreported landings of Finland were representative of the mean proportion of unreported landings Baltic-wide, with

approximately 12% of the total (Table 14). Germany, Russia and the Baltic States all represented less than 10% of the overall estimate of unreported landings taken from the Baltic Sea between 1950 and 2007.

Table 14. Total unreported landings (t) and their proportion of total unreported landings, by country, estimated for the Baltic Sea Large Marine Ecosystem for the period from 1950 to 2007.

Country	Unreported landings (t)	(%)
Poland	1,648,754	28.7
Denmark	1,328,628	23.1
Sweden	1,088,310	19.0
Finland	663,525	11.6
Germany	342,486	6.0
Latvia	248,608	4.3
Estonia	207,850	3.6
Russia	146,003	2.5
Lithuania	66,322	1.2

Discards

The total estimated discards of all Baltic countries fishing in ICES subdivisions 22-32 for the period from 1950 to 2007 was approximately 3.8 million t (Figure 4). This estimate included underwater discards of herring and sprat, ghostfishing, seal-induced discards and boat-based discards for all countries in all fishing areas. Seal-induced discards are especially a growing concern to fisheries in some Baltic countries, and aspects for each discard type are discussed in detail in each country report (this volume). The total discards for all species increased steadily from approximately 35,000 t·year^{-1} in 1950 to around 80,000 t·year^{-1} in the early 1970s. During the 1980s, discards fluctuated around 60,000 t·year^{-1} before increasing substantially in the 1990s to a peak of approximately 110,000 t·year^{-1} in 1997, before declining to around 85,000 t·year^{-1} in 2007 (Figure 4).

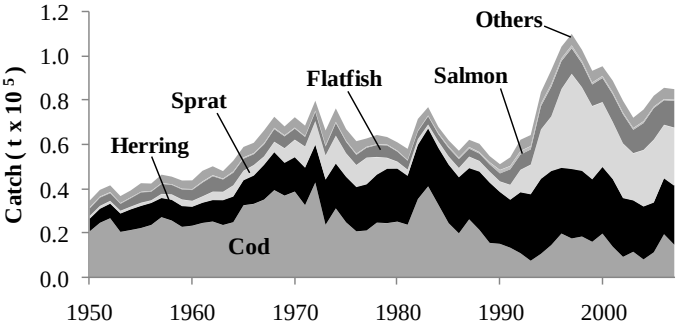

Figure 4. Total discards for cod, herring, flatfishes, salmon and 'others' in the Baltic Sea Large Marine Ecosystem for the period 1950-2007.

The discard total for cod was the largest by volume, representing approximately 36% of all discards between 1950 and 2007 (Figure 4; Table 15), ranging from a peak of approximately 43,000 t·year^{-1} in 1972 to approximately 15,000 t·year^{-1} in 2007. Discards of cod, herring and sprat totaled approximately 1.3 million, 1.1 million t and 623,000 t respectively over the period 1950-2007.

Table 15. Total estimated discards (t) for the Baltic Sea Large Marine Ecosystem from 1950 to 2007.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	237,445	300,400	286,682	267,469	146,419	109,952
Herring	84,295	122,961	198,868	248,960	281,061	195,711
Sprat	15,138	41,372	96,216	35,086	230,252	204,678
Flatfishes	40,001	56,527	48,601	37,271	93,123	96,476
Salmon	3,138	4,503	3,976	5,270	12,531	5,450
'Others'	33,291	44,602	48,419	35,828	47,380	39,203

Discards of cod and herring accounted for 66% of all discards, while discards of sprat accounted for approximately 16% of our total discard estimate (Figure 4; Table 15). Starting in the 1990s, however, sprat appears to have become the major discard species, averaging 26,000 t·year^{-1} since 2000 (Figure 4). Discards of flatfishes, salmon and 'others' each accounted for less than 10% of our total discards, but estimated discards of flatfishes accounted for about 36% of flatfish landings reported to ICES, Appendix Table B6).

Discards were found to be the largest in Denmark (Table 16). Denmark's discards accounted for approximately 31% (over 1.1 million t) of the total estimate of discards for the Baltic Sea Large Marine Ecosystem between 1950 and 2007. The total estimates of discards in each of the remaining countries were less than 600,000 t each when summed over the study period (1950-2007), and ranged between a minimum of around 68,000 t in Lithuania, to about 520,000 t in Sweden (Table 16). For country-specific details see individual reports (this volume).

Table 16. Total estimated discards (t) and the proportion of discards (%) attributed to each of 9 coastal countries examined in our reconstruction of fisheries catches from the Baltic Sea Large Marine Ecosystem between 1950 and 2007.

Country	Discards (t)	(%)
Denmark	1,161,995	30.9
Sweden	521,491	13.9
Germany	494,694	13.2
Poland	489,488	13.0
Finland	372,467	9.9
Estonia	243,635	6.5
Estonia	228,270	6.1
Russia	178,652	4.8
Lithuania	67,862	1.8

Recreational catches

Estimates of recreational catches for all countries fishing in the Baltic Sea LME between 1950 and 2007 totaled approximately 1.5 million t. Recreational catches increased steadily from approximately 9,500 t·year^{-1} in 1950 to approximately 31,000 t·year^{-1} in the early 1990s, before rising to an all-time peak of 47,000 t·year^{-1} in 1993 (Figure 5). More recently, recreational catches appear to have declined to approximately 29,000 t·year^{-1} in 2007 (Figure 5).

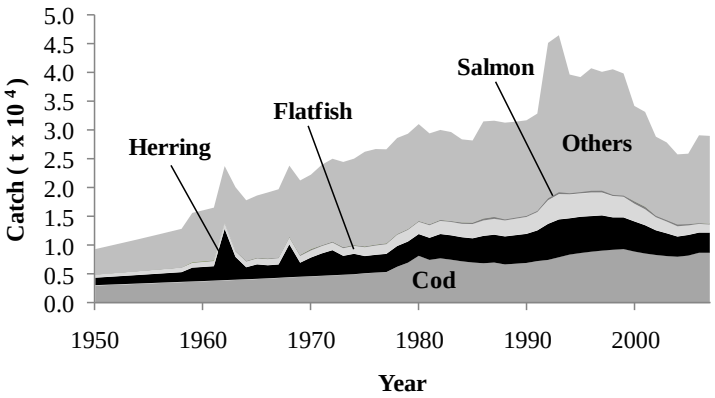

Figure 5. Total recreational catches for cod, herring, flatfishes, salmon and 'others' in the Baltic Sea Large Marine Ecosystem for the period 1950-2007. Recreational catches of sprat not shown due to low overall tonnage.

Recreational catches increased steadily for cod, herring, salmon and flatfishes between 1950 and 1990, while recreational catches of 'others' increased more rapidly (Figure 5). Recreational catches of most species peaked in the 1990s with a total of approximately 398,000 t, or an average of about 40,000 t·year^{-1} for all species considered (Table 17). Recreational catches of 'others' (including species such as European perch, Northern pike, whitefishes, sea trout and garfish) dominated for the entire period considered, totaling over 800,000 t and representing 54% of the total recreational catch in the Baltic Sea LME betweeen 1950 and 2007 (Figure 5; Table 17). Recreational catches of cod (the second most prevalent recreational species) totaled about 350,000 t for the same time period, and accounted for about 23% of the total recreational catch estimated for the Baltic Sea (1950-2007; Table 17). Recreational catches of herring and flatfishes represented approximately 15% and 8%, respectively. Recreational catches of sprat and salmon were fairly insignificant relative to the total recreational catch (Table 17).

Table 17. Estimated total recreational catches (t) for the period from 1950 to 2007, taken from the Baltic Sea.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	33,686	41,287	52,840	72,392	83,165	67,648
Herring	15,748	35,186	34,835	43,943	59,393	32,511
Sprat	134	392	478	437	35	345
Flatfishes	8,011	11,119	15,905	24,799	37,085	15,486
Salmons	509	1,250	1,759	2,733	3,939	2,630
'Others'	58,473	108,946	153,834	159,609	212,779	113,973

Recreational catches in Sweden and Finland accounted for the majority of the total estimated recreational catches in the Baltic Sea for the period from 1950 to 2007 (Table 18). These countries combined, represented more than 70% of all recreational catches estimated here (Table 18). The only other countries with significant recreational catches relative to other Baltic countries were Denmark and Germany, whose recreational catches accounted for about 21% and 5%, respectively, of all recreational catches. Estonia, Latvia, Lithuania, Poland and Russia all had fairly minor recreational catches when compared to the other countries. The countries accounting for minor proportions of the total recreational catch were all members of the former eastern bloc, re-emphasizing the recent development of recreational fishing in these countries. For country-specific info on recreational catches, see individual country reports (this volume).

Table 18. Estimated total recreational catches (t) and the proportion (%) of recreational catches attributed to each of the 9 coastal Baltic countries examined in our reconstruction of fisheries catches from the Baltic Sea Large Marine Ecosystem between 1950 and 2007.

Country	Recreational catch (t)	(%)
Sweden	626,822	41.6
Finland	456,679	30.3
Denmark	321,581	21.3
Germany	70,740	4.7
Russia	14,824	1.0
Lithuania	6,326	0.4
Poland	4,512	0.3
Estonia	3,421	0.2
Latvia	2,386	0.2

Total catch reconstruction

Overall, our reconstructed catch for all 9 coastal countries fishing in the Baltic Sea LME totaled over 53.5 million t for the period 1950-2007 (Figure 6). This estimate includes landings previously reported to ICES

on the behalf of each country, as well as our estimates of IUU including adjustments derived from national datasets and ICES stock assessment reports, as well as estimates of unreported landings, discards, and recreational catches. Our total catch reconstruction adds IUU catches of approximately 12.3 million t (nearly 30%) to ICES landings statistics (Figure 6). Total reconstructed catches peaked in 1997 at approximately 1.5 million t·year^{-1}, being 36% higher than the officially reported landings of 1.1 million t·year^{-1} for that year (Figure 6). More recently, our estimate of total catches of approximately 1 million t·year^{-1} for the late 2000s are about 32% higher than reported landings (Figure 6).

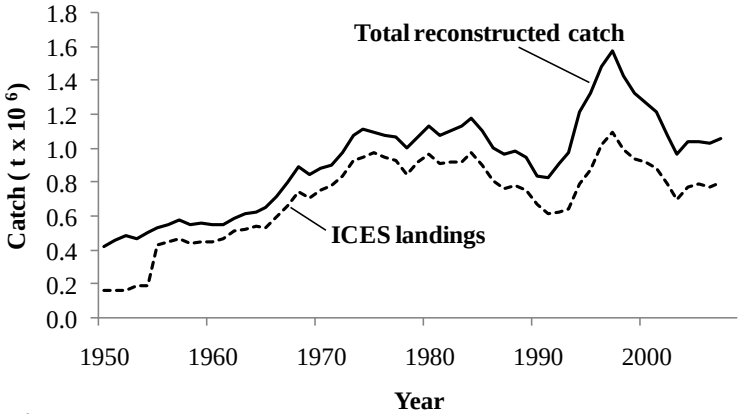

Figure 6. Total reconstructed catch (solid line) for the Baltic Sea Large Marine Ecosystem, as well as landings reported to the ICES landings statistics (dashed line) for the period 1950-2007.

The majority of IUU catches began to occur during the early 1980s, and increased dramatically in the early 1990s (Figure 7). During the period 1950-2007, IUU catches were dominated by unreported landings, which accounted for approximately 47% of our total estimate of IUU catches and represented 11% of the total reconstructed catch (Figure 7). Prior to 1991, when members of the former eastern bloc were assumed not to have unreported landings, unreported landings represented approximately 5% of our total reconstructed catch (1950-1990). After 1991, when the former eastern bloc had dissolved, unreported landings represented approximately 20% of our total reconstructed catch (1991-2007; Figure 7). Overall, unreported landings added approximately 14% to landings presented in the ICES landings statistics by all countries for the period, 1950-2007.

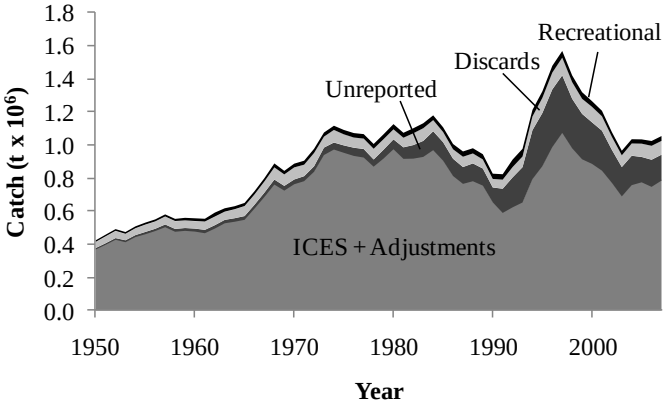

Figure 7. Total reconstructed catch by component, including adjustments, unreported landings, discards and recreational catches for the Baltic Sea Large Marine Ecosystem for the period 1950-2007.

Discards were also signficant, representing approximately 7% of the total reconstructed catch, and adding approximately 9% to the landings officially reported by ICES (Figure 7). Discards accounted for 30% of all estimated IUU.

Recreational catches represented approximately 3% of total catches for all species, and added approximately 4% to landings reported by ICES for the period 1950-2007 (Figure 7).

Overall, we found herring to have the greatest total catches of all taxa in our reconstruction (Table 19). Herring catches increased from 1950 and were the dominant catch from the early 1970s until the late

Table 19. Estimated total reconstructed catches (t), including landings reported in the ICES landings statistics on behalf of each of 9 coastal countries, and our estimates of IUU for the Baltic Sea LME for the period 1950-2007.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	2,042,508	2,158,775	2,663,809	4,116,265	2,210,467	1,330,000
Herring	1,954,598	2,677,685	4,286,361	4,825,795	4,462,950	2,837,924
Sprat	311,278	853,904	1,972,783	697,506	4,000,094	3,601,777
Flatfishes	204,424	292,079	273,711	233,797	337,789	313,874
Salmon	27,936	38,232	35,269	42,430	53,624	21,461
'Others'	604,107	847,254	1,046,931	712,717	816,253	571,796

1990s, accounting for about 40% of the total reconstructed catch of all taxa between 1950 and 2007. Over the last 7 years, however, sprat catches have been larger than herring (Table 19). On a decade by decade basis, cod was consistently significant, but had not exceded herring catches since the 1960s (Table 19). The total reconstructed catches of flatfishes, salmon and 'others' each represented less than 10% of the total reconstructed catch for all species (Table 19).

Of the 9 coastal countries examined in detail Denmark, Poland and Sweden's total reconstructed catches each accounted for 17-18% of the total reconstructed catch (1950-2007), while Finland and Germany each accounted for approximately 11% of the overall catch, and Russia and the Baltic States each accounted for less than 10% of the overall catch (1950-2007; Table 20).

Table 20. Estimated total reconstructed catches (in tonnes) and the proportion (%) represented by each of 9 coastal countries considered in our reconstruction of fisheries catches from the Baltic Sea large marine ecosystem between 1950 and 2007.

Country	Total reconstructed catch (t)	(%)
Denmark	9,569,881	17.9
Poland	9,546,402	17.8
Sweden	8,879,513	16.6
Finland	5,781,000	10.8
Germany	5,758,267	10.8
Latvia	4,754,544	8.9
Estonia	4,206,072	7.9
Russia	3,739,224	7.0
Lithuania	1,243,301	2.3

DISCUSSION

Our reconstruction of total fisheries catches from the Baltic Sea Large Marine Ecosystem (LME) combined reported landings from ICES 'landings statistics' with adjustments to landings, unreported landings, discards, and recreational catches which totaled approximately 53.5 million tonnes for the period 1950-2007. The total catch peaked in 1997 at 1.5 million t·year^{-1} and declined to a total of approximately 1.1 million t·year^{-1} between 2005 and 2007. This contrasts with landings of approx. 41 million t reported by the 9 coastal Baltic Sea countries over the entire time period. The difference of approximately 12.3 million tonnes represents an increase of approximately 30% between landings officially reported to ICES and our total catch reconstruction (1950-2007). For the most recent period (2000-2007), the difference between reported ICES landings and total reconstructed catch was 35%. This difference is accounted for by our estimates of IUU catches for the Baltic Sea, which highlights the magnitude of fishing mortalities that are unaccounted for by records provided by countries to ICES. We believe our reconstruction not to be an overestimate, as our derivations used minimum values which were based on conservative assumptions. Therefore, our total catch reconstruction for the Baltic Sea LME represents the best currently available estimate of the total fisheries catches taken from the Baltic Sea between 1950 and 2007, and provides an improved baseline for management of fisheries resources, as well as the Baltic ecosystem as a whole. The ICES landings statistics provide only reported landings, and the ICES database presents these landings as 'catch totals', meaning there is an underlying perception of equality between 'landings' and 'catches', clearly a flawed concept in light of known but unaccounted IUU activities. This means information on the total catches of living resources from the Baltic Sea are not readily available to the public, who are the ultimate 'owners' or beneficiaries with regards to the impacts of fisheries on the Baltic Sea LME. Our catch reconstruction seeks to provide an improved dataset which is available to the general public, displaying clearly disaggregated catch data (including all IUU components) for each of the 9 coastal Baltic countries examined, representing an estimate of the likely total fisheries catches from the Baltic Sea LME from 1950 to 2007.

Our total catch reconstruction for the Baltic Sea showed unreported landings of cod to be the main component of IUU (1950-2007). Unreported landings of cod peaked in 1996 at approximately 130,000 t·year^{-1} and comprised about 40% of the unreported landings estimated for all taxa between 1950 and 2007. IUU fishing of cod has been an issue of great importance since cod landings peaked in the 1980s, and declined substantially in the early 1990s. Prior to 1990, unreported landings comprised approximately 5% of the total reconstructed catch (Baltic-wide), and after the dissolution of the former eastern bloc in the early 1990s, unreported landings represented approximately 20% of the total reconstructed catch. Our results indicated that the addition of underreporting in eastern bloc countries, and in particular, underreporting of cod in Poland (Bale *et al.*, this volume), contributed substantially to this increase. Overall, our catch reconstruction indicated that Poland (Bale *et al.*, this volume), Denmark (Bale *et al.*, this volume) and Sweden (Persson, this volume) were responsible for the bulk of unreported landings in the Baltic Sea from 1950 to 2007. Poland and Denmark's unreported landings were dominated by cod, while Sweden's unreported landings were dominated by herring and sprat. These countries receive the largest share of the Baltic TAC for these commercial species (Anon., 2007a), implying that the responsibility for facing up to and curbing the behaviors driving IUU catches weighs heavily upon them.

Various sources have speculated unreported landings to be the greatest component of IUU catches in the Baltic Sea (Anon., 2007b) and similarly, 46% of our estimated IUU catches were unreported landings. At a Baltic Sea Regional Advisory Council (BSRAC) meeting, members concluded that unreported landings of cod represented the greatest aspects of non-compliance in the Baltic Sea (BSRAC, 2007). Unreported landings of all species contribute to an excess of unaccounted fishing mortalities which skew scientific data, directly impact decisions made by policy-makers, and mis-lead the public's opinion on the health of a common resource. It also has the potential to substantially bias and even undermine stock assessment and the resulting scientific advice to management. While ICES stock assessment working groups do try to account for some unreported landings ('unallocated catches'), the lack of country specific data transparency in ICES stock assessment working group reports make it impossible for interested parties and the resource owners (general public) to assess country compliance and enforcements (Pfeiffer and Nowak, 2006).

Our estimates of discards were slightly less significant than unreported landings, comprising approximately 30% of our overall IUU estimate. We examined several different forms of discarding in our catch reconstruction including: i) ghostfishing; ii) underwater discards; iii) seal-induced discards; and iv) boat-based discards. Ghostfishing was recognized in a recently published paper by the FAO (Macfadyen *et al.*, 2009), to have become an issue of global significance, as abandoned fishing gear now represent an estimated 10% of all marine litter. Abandoned gear is found to cause mortality in fishes, seabirds and marine mammals (Macfadyen *et al.*, 2009). For the period from 1950 to 2007, we found ghostfishing to affect cod most significantly. Overall, ghostfishing was responsible for approximately 330,000 tonnes of discards over the entire study period. Details of the various discard types are described in each country specific report (this volume).

We considered underwater discards to be a significant threat to species caught by pelagic trawl fisheries (herring and sprat). There is no simple solution to mortalities caused by actively fishing gear, except improved design and modification of gears as a preventative measure (Matsuoka, 2008). Regardless, our study illustrates the potential magnitude of this mortality, and it is important that these estimates be included in management decisions for the Baltic Sea LME, including TACs for species directly affected by trawl gear.

Seal-induced discards were found to be of importance mostly in eastern Baltic countries, and were considered to affect fisheries catches of herring, salmon, trout, whitefish, perch, pikeperch and vendace mainly in Estonia, Finland, Latvia, Lithuania and Russia. This problem has been inevitable with current trap-netting techniques since the early 1990s when grey seal populations increased dramatically. Since this time there have been several advances in trap-net design which have been successful in reducing mortalities caused by seal populations. The pontoon trap, described by Hemmingsson *et al.* (2008) has demonstrated the best avoidance of seal-induced damages of catches thus far. Mitigation of seal-induced discards is necessary from biological, economical and social perspectives, as commercial fishers in the Gulf of Bothnia have suffered significant economic losses in the last two decades (Siira, 2007). Reducing the damages caused by seals to fish caught in trap-nets in the eastern Baltic is necessary as improved trap-net design will reduce the overall fishing pressure on salmon stocks. It will also allow fishers to have the opportunity to be accountable for all catches taken by fishing gear, since estimates of catches taken completely by seals would become unnecessary.

Boat-based discards were found to be the most significant form of discarding in the Baltic Sea, but in theory, should be one of the easiest to address, since human behavior is the single determinant. Our catch reconstruction indicated that boat-based discards of cod were predominant, peaking at approximately 39,500 $t \cdot year^{-1}$ in 1972, and accounting for approximately 11,650 $t \cdot year^{-1}$ in recent years (2005-2007). These results are likely due to the effects of high-grading. In addition, large catches of herring have been known to contain a large amount of cod as bycatch (Alm, 1961). Significant also were the number of boat-based flatfish discards in proportion to the total reconstructed catch of flatfishes. Given the increasing concern for, and consideration of ecosystem-based management approaches, such waste is rapidly becoming a serious management concern and needs to be urgently addressed. Boat-based discards of cod were rarely higher than about 15% of total catch; discards of flatfishes were consistently greater than 30% of total catch for flatfishes (as sourced from Jensen, 2004), indicating a potential cause for concern with regards to the overall fishing pressure exerted on flatfish populations. Flatfish are characteristic lower value bycatch of the trawl fisheries targeting cod (Alm, 1961), leaving significant potential for high grading by fishers under current TACs. Reductions in flatfish discards have been made elsewhere by reducing the

Minimum Landing Size, and in countries such as Norway and Iceland where 'no discard' policies have been instated (Kelleher, 2005).

We included estimates of recreational catches for all countries in our catch reconstruction. These catches were found to contribute approximately 3% to total catches for all taxa in all countries. Thus, overall, recreational fishing does not appear a significant component. However, for several species (e.g., cod) and in some countries (e.g., Sweden and Finland), recreational catches are substantial and therefore important components to be addressed in resource management (see several country reports, this volume). Very little information was available for the non-commercial sector (except in the case of Finland), and although recreational catches were a small proportion of our overall catch, they still represented a total of approximately 1.5 million tonnes over the time period considered (1950-2007). This is not an insignificant amount, and countries should implement more rigorous systems to regulate and record or estimate recreational catches so they can be included in ICES databases. This will help all stakeholders become accountable for all forms of human-induced fisheries mortalities.

Our efforts to reconstruct total fisheries catches in the Baltic Sea LME used all data and information available to us. Under the guidelines of the EU Common Fisheries Policy (CFP), it is the responsibility of the Member States to record national fisheries catch data to pass on to the governing scientific body (ICES, in most cases) before negotiations are undertaken for management purposes. Often the data passed between Member States and ICES represent only reported landings, and exclude reports or estimates of IUU catches. Landings statistics are often updated or corrected by the respective countries, and these changes are usually not made to the public data presented in the ICES database. Thus, we had to use data presented in the ICES stock assessments, or national data (when available) to cross-check and adjust any misreported landings in ICES landings statistics. Since no estimates of IUU catches were presented in ICES landings statistics, and at best, estimated rates of IUU fishing were provided by fisheries experts in some Baltic nations, we often relied on Baltic-wide sub-set estimates of unreported landings and discards from ICES stock assessment working group reports. It is unknown exactly how many countries were considered by ICES to contribute to these totals, since ICES can choose to either estimate or ignore IUU catches, and proceed only with the information provided by the country or stock assessment surveys (BSRAC, 2007). Thus, since it was known to us that at least one country (Sweden, in the case of unreported landings) was not included in the Baltic-wide estimate of unreported landings (Persson, this volume), our calculations were likely underestimates, since our derived rates for estimating unreported landings were weighted by the reported landings of all Baltic countries (less those of Sweden). Unfortunately, our catch reconstruction was limited in depth and scope by a lack of transparency and accountability on the part of Member States and ICES databases, which (in theory) serve to disseminate information on the state of the living resources of the Baltic Sea (ICES, 2009c). For the information ICES does have regarding IUU catches, there are confidentiality agreements between Member States and ICES which prevent ICES from revealing the true nature of all available data. This lack of accountability from Member States to document, report and publish total catches as opposed to total landings, presents a hindrance to public accountability and implementation of ecosystem-based management systems (as planned in the reform of the CFP in 2012; Veem *et al.*, 2009). The amounts of IUU catches estimated in our study provide evidence of substantial non-compliance on the part of fishers to stay within the TACs agreed upon by the European Council of Ministers.

Some preliminary efforts to increase transparency, accountability and compliance have been implemented in the Baltic Sea. These have included mandatory Vessel Monitoring Systems (VMS) on boats greater than 25 m since 2005 (Witt and Godley, 2007). Denmark has proposed implementation of mandatory video recording to eliminate discards while increasing the volume of catches permitted to be landed; providing fishers less incentive to high grade (Anon., 2009). The most reliable method, however, is 100% observer coverage (including video coverage), but historically, observer coverage has not been used to its full potential. Unless observer coverage is 100%, fishers' behavior is known to change when an observer is onboard (Kelleher, 2005). Observers could be used to document extractions of all marine life while at sea to help generate databases including comprehensive data on all species affected by the fishing industry. Complete (100%) observer coverage is also instrumental in enhancing buy-in, trust and co-operation within industry and between industry, science and management, as has been shown elsewhere (e.g., Canada). Greater enforcement is also required at ports to eliminate the possibilities for fishers to not report all landed catches. One of the main criticisms of the TAC system is that it is thought to result in a 'race-to-fish' (Sutinen and Soboil, 2001), leading to greater potentials for irresponsible fishing practices in some fisheries (Kelleher, 2005). The proposed alternative is a reduction of overall effort in a system with

transferability among fishers and vessels (Veem *et al.*, 2009), with limited time permitted at sea (along with the auxiliary aids such as VMS, on-board cameras and 100% observer coverage mentioned above).

In 2012, the CFP is set to be renewed with new recommendations for fisheries management, which should have a set of clear objectives, a strategy for increased transparency, elements of precaution, and attention to the rights and accountability of fishers, decision-makers and society. Better, more comprehensive accounting (and/or estimation) and greater transparency of total catches will greatly facilitate trust and cooperation among the Baltic countries whose future stakes in the fisheries resources of the Baltic depend on one another.

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APPENDIX A

Appendix Table A1. List of ICES species, common and scientific names used in this report.

ICES Species Name	Scientific Name	Common Name
African striped grunt	*Parapristipoma octolineatum*	African striped grunt
Allis shad	*Alosa alosa*	Shads
American plaice	*Hippoglossoides platessoides*	American plaice
Angler(=Monk)	*Lophius piscatorius*	Angler
Aquatic invertebrates, nei	Miscellaneous marine invertebrates	Miscellaneous marine invertebrates
Argentines	*Argentina sphyraena*	Argentine
Asp	*Aspius aspius*	Asp
Atlantic cod	*Gadus morhua*	Atlantic cod
Atlantic gobies, nei	Gobiidae	Gobies
Atlantic halibut	*Hippoglossus hippoglossus*	Atlantic halibut
Atlantic herring	*Clupea harengus*	Atlantic herring
Atlantic horse mackerel	*Trachurus trachurus*	Atlantic horse mackerel
Atlantic mackerel	*Scomber scombrus*	Atlantic mackerel
Atlantic pomfret	*Brama brama*	Atlantic pomfret
Atlantic redfishes, nei	Sebastes	Redfishes
Atlantic salmon	*Salmo salar*	Atlantic salmon
Atlantic saury	*Scomberesox saurus*	Atlantic saury
Atlantic wolffish	*Anarhichas lupus*	Wolf-fish
Beaked redfish	*Sebastes mentella*	Deepwater redfish
Bighead carp	*Aristichtys nobilis*	Bighead Carp
Blackfin icefish	*Chaenocephalus aceratus*	Blackfin icefish
Blue ling	*Molva dypterygia*	Blue ling
Blue mussel	*Mytilus edulis*	Blue mussel
Blue shark	*Prionace glauca*	Blue shark
Blue skate	*Dipturus batis*	Blue skate
Blue whiting	*Micromesistius poutassou*	Blue whiting
Brill	*Scophthalmus rhombus*	Brill
Burbot	*Lota lota*	Burbot
Chars, nei	Salvelinus	Char
Clams, etc., nei	Bivalves	Clams
Clupeoids, nei	Clupeidae	Herrings, shads, sardines, menhadens
Common carp	*Cyprinus carpio*	Common Carp
Common dab	*Limanda limanda*	Dab
Common edible cockle	*Cerastoderma edule*	Common edible cockle
Common prawn	*Palaemon serratus*	Common prawn
Common shrimp	*Crangon crangon*	Common shrimp
Common sole	*Solea solea*	Common sole
Crangonid shrimps, nei	Crangonidae	Crangonid shrimp
Crucian carp	*Carassius carassius*	Crucian Carp
Cuttlefish, bobtail squids, nei	Cephalopoda	Cuttlefish, squids
Cyprinids, nei	Cyprinidae	Minnows or carps
Dab	*Limanda limanda*	Dab
Deepwater redfish	*Sebastes mentella*	Deepwater redfish
Demersal percomorphs, nei	Perciformes	Perch-like
Diadromous fishes, nei	Miscellaneous diadromous fishes	Miscellaneous diadromous fishes
Edible crab	*Cancer pagurus*	Edible crab
Eelpout	*Zoarces viviparus*	Viviparous blenny
Eelpouts	Zoarcidae	Eelpouts
European anchovy	*Engraulis encrasicolus*	European anchovy
European eel	*Anguilla anguilla*	European eel
European flat oyster	*Ostrea edulis*	European flat oyster

Appendix Table A1. List of ICES species, common and scientific names used in this report.

ICES Species Name	Scientific Name	Common Name
European flounder	*Platichthys flesus*	Flounder
European hake	*Merluccius merluccius*	European hake
European lobster	*Homarus gammarus*	European lobster
European perch	*Perca fluviatilis*	European perch
European pilchard(=Sardine)	*Sardina pilchardus*	European pilchard
European plaice	*Pleuronectes platessa*	European plaice
European seabass	*Dicentrarchus labrax*	European seabass
European smelt	*Osmerus eperlanus*	European smelt
European sprat	*Sprattus sprattus*	European sprat
European whitefish	*Coregonus lavaretus*	Common whitefish
Finfishes, nei	Miscellaneous marine fishes	Finfishes
Flatfishes nei	Pleuronectiformes	Flatfishes
Flounder	*Platichthys flesus*	Flounder
Fourbeard rockling	*Enchelyopus cimbrius*	Fourbeard rockling
Freshwater bream	*Abramis brama*	Common bream
Freshwater breams, nei	Cyprinidae	Minnows or carps
Freshwater fishes, nei	Miscellaneous freshwater fishes	Miscellaneous freshwater fishes
Fringescale sardinella	*Sardinella fimbriata*	Fringescale sardinella
Gadiformes, nei	Gadiformes	Cods
Garfish	*Belone belone*	Garfish
Gobies, nei	Gobiidae	Gobies
Golden redfish	*Sebastes marinus*	Ocean perch
Great Atlantic scallop	*Pecten maximus*	Great Atlantic scallop
Greater forkbeard	*Phycis blennoides*	Greater forkbeard
Greater weever	*Trachinus draco*	Greater weever
Greenland halibut	*Reinhardtius hippoglossoides*	Greenland halibut
Grey gurnard	*Eutrigla gurnardus*	Grey gurnard
Groundfishes, nei	Miscellaneous marine groundfishes	Miscellaneous groundfishes
Gurnards, searobins, nei	Triglidae	Searobins
Haddock	*Melanogrammus aeglefinus*	Haddock
Houting	*Coregonus oxyrinchus*	Houting
Ide	*Leuciscus idus*	Ide
Lampreys, nei	Petromyzontidae	Lampreys
Lefteye flounders, nei	Bothidae	Lefteye flounders
Lemon sole	*Microstomus kitt*	Lemon sole
Ling	*Molva molva*	Ling
Lumpsucker	*Cyclopterus lumpus*	Lumpsucker
Marine crabs, nei	Miscellaneous marine crabs	Miscellaneous marine crabs
Marine crustaceans, nei	Miscellaneous marine crustaceans	Marine crustaceans
Marine fishes, nei	Miscellaneous marine fishes	Miscellaneous marine fishes
Marine molluscs, nei	Miscellaneous marine molluscs	Marine molluscs
Megrim	*Lepidorhombus whiffiagonis*	Megrim
Mullets, nei	Mugilidae	Mullets
Northern bluefin tuna	*Thunnus thynnus*	Northern bluefin tuna
Northern pike	*Esox lucius*	Northern pike
Northern prawn	*Pandalus borealis*	Northern shrimp
Northern shortfin squid	*Illex illecebrosus*	Northern shortfin squid
Northern shrimp	*Pandalus borealis*	Northern shrimp
Norway lobster	*Nephrops norvegicus*	Norway lobster
Norway pout	*Trisopterus esmarkii*	Norway pout
Ocean perch	*Sebastes marinus*	Ocean perch
Ox crab	*Cancer pagurus*	Ox crab
Pelagic fishes, nei	Miscellaneous marine pelagic fishes	Miscellaneous marine pelagic fishes
Periwinkles, nei	Littorinidae	Periwinkles

Appendix Table A1. List of ICES species, common and scientific names used in this report.

ICES Species Name	Scientific Name	Common Name
Piked dogfish	*Squalus acanthias*	Piked dogfish
Pikeperch	*Sander lucioperca*	Pikeperch
Pink(=Humpback)salmon	*Oncorhynchus gorbuscha*	Pink salmon
Pollack	*Pollachius pollachius*	Pollack
Poor cod	*Trisopterus minutus*	Poor cod
Porbeagle	*Lamna nasus*	Porbeagle
Queen scallop	*Aequipecten opercularis*	Queen scallop
Rainbow trout	*Oncorhynchus mykiss*	Rainbow trout
Raja rays, nei	Rajidae	Skates
Red mullet	*Mullus barbatus barbatus*	Red mullet
Roach	*Rutilus rutilus*	Roach
Roundnose grenadier	*Coryphaenoides rupestris*	Roundnose grenadier
Rudd	*Scardinius erythrophthalmus*	Rudd
Ruffe	*Gymnocephalus cernuus*	Ruffe
Saithe(=Pollock)	*Pollachius virens*	Saithe
Salmonoids nei	Salmonidae	Salmonids
Sandeels(=Sandlances) nei	Ammodytidae	Sandlances
Scallops nei	Pectinidae	Scallops
Scorpionfishes nei	Scorpaenidae	Scorpionfishes or rockfishes
Sculpins	Cottidae	Sculpins
Sea trout	*Salmo trutta*	Sea trout
Sichel	*Pelecus cultratus*	Sichel
Silver carp	*Hypophthalmichthys molitrix*	Silver Carp
Slender guitarfish	*Rhinobatos holcorhynchus*	Slender guitarfish
Spinous spider crab	*Maja squinado*	Spinous spider crab
Sticklebacks	Gasterosteidae	Sticklebacks and tubesnouts
Striped bass	*Morone saxatilis*	Striped bass
Sturgeons nei	Acipenseridae	Sturgeons
Swordfish	*Xiphias gladius*	Swordfish
Tench	*Tinca tinca*	Tench
Three-spined stickleback	*Gasterosteus aculeatus*	Three-spined stickleback
Tope shark	*Galeorhinus galeus*	Tope shark
Trouts nei	Salmonidae	Salmonids
Turbot	*Psetta maxima*	Turbot
Tusk(=Cusk)	*Brosme brosme*	Tusk
Twaite shad	*Alosa fallax*	Twaite shad
Various sharks nei	Selachimorpha	Sharks
Various squids nei	Teuthidae	Squids
Vendace	*Coregonus albula*	Vendace
Vimba bream	*Vimba vimba*	Vimba bream
Viviparous blenny	*Zoarces viviparus*	Viviparous blenny
Wels catfish	*Silurus glanis*	Wels catfish
Whelks	*Buccinum undatum*	Whelks
Whitefishes nei	Coregonus	Whitefishes
Whiting	*Merlangius merlangus*	Whiting
Witch flounder	*Glyptocephalus cynoglossus*	Witch flounder
Wolf-fish	*Anarhichas lupus*	Wolf-fish
Wolffishes(=Catfishes) nei	Anarhichadidae	Wolf-fishes

APPENDIX B

Appendix Table B1. ICES landing statistics excluding former USSR, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, ICES reported foreign landings, and reconstructed total for all Baltic countries combined (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	ICES Foreign	Total
1950	167,929	204,392	8,658	34,756	9,465	0	425,200
1951	167,009	233,719	9,189	39,589	9,889	122	459,517
1952	171,525	259,544	9,988	41,625	10,318	111	493,110
1953	194,369	222,027	11,394	36,846	10,747	0	475,382
1954	193,077	254,239	11,733	39,386	11,180	0	509,614
1955	433,573	30,769	13,652	42,655	11,627	0	532,276
1956	449,257	34,520	13,401	42,491	12,072	0	551,742
1957	468,974	37,998	16,044	46,501	12,529	0	582,045
1958	441,408	38,134	16,745	45,603	12,982	42	554,914
1959	454,760	30,065	16,890	43,858	15,752	0	561,324
1960	456,353	24,138	17,795	43,921	16,201	0	558,409
1961	467,051	3,582	20,016	48,239	16,667	0	555,555
1962	514,138	-15,675	20,177	50,269	23,880	0	592,791
1963	527,045	3,447	20,218	48,097	20,222	0	619,029
1964	543,297	-3,518	21,024	52,765	17,942	0	631,510
1965	537,459	13,827	22,383	58,999	18,766	0	651,432
1966	601,832	17,101	23,125	60,857	19,301	0	722,216
1967	666,737	22,276	26,166	66,413	19,856	0	801,448
1968	745,224	18,574	29,978	72,576	23,957	0	890,310
1969	709,901	17,490	28,220	68,230	21,387	0	845,228
1970	759,536	6,288	28,305	72,366	22,393	0	888,888
1971	781,051	3,183	29,893	68,578	24,094	3	906,801
1972	836,922	4,109	32,894	79,802	25,152	0	978,878
1973	929,109	12,942	44,168	66,400	24,597	0	1,077,216
1974	952,091	22,744	41,919	76,344	25,163	0	1,118,260
1975	973,761	-18,536	44,161	67,050	26,367	0	1,092,803
1976	950,396	-13,802	48,950	61,586	26,838	0	1,073,970
1977	935,623	-8,915	51,175	62,812	26,791	0	1,067,485
1978	850,838	20,880	43,051	64,369	28,757	0	1,007,895
1979	917,885	2,793	53,039	63,454	29,500	0	1,066,670
1980	967,395	9,384	58,931	61,063	31,166	4,152	1,132,092
1981	911,848	7,110	68,904	58,055	29,556	2,765	1,078,238
1982	920,263	-160	81,375	71,489	30,154	4,300	1,107,420
1983	923,160	7,397	96,166	76,778	29,791	6,065	1,139,357
1984	976,624	-5,398	113,541	67,795	28,517	6,354	1,187,432
1985	900,608	7,042	111,075	61,701	28,324	5,890	1,114,639
1986	810,901	4,511	103,804	56,941	31,636	4,600	1,012,393
1987	766,280	1,828	101,048	61,821	31,760	5,567	968,303
1988	783,200	662	107,041	59,890	31,419	6,915	989,128
1989	753,859	3,656	102,661	54,352	31,589	4,499	950,615
1990	675,681	-18,944	89,254	50,406	31,829	3,558	831,784
1991	615,063	-22,181	145,564	53,629	32,963	2,992	828,029
1992	629,291	-2,724	180,014	61,727	45,223	602	914,136
1993	646,530	9,242	212,541	63,864	46,522	577	979,276
1994	789,977	6,569	294,762	82,969	39,673	2,671	1,216,621
1995	877,248	-2,454	319,899	92,598	39,203	1,070	1,327,566
1996	1,025,510	-35,841	347,293	103,119	40,708	1,003	1,481,792
1997	1,097,330	-22,307	346,670	108,716	40,065	33	1,570,506
1998	1,000,337	-17,864	298,003	101,715	40,481	21	1,422,692
1999	939,338	-23,052	273,264	92,024	39,729	0	1,321,302
2000	919,164	-30,576	250,061	94,129	34,065	0	1,266,841
2001	883,126	-35,552	240,832	87,412	32,993	4	1,208,816
2002	789,136	-15,073	198,890	78,227	28,667	0	1,079,847
2003	702,713	-10,273	176,586	70,448	27,644	1	967,120
2004	774,203	-13,794	176,691	74,042	25,541	0	1,036,684
2005	793,744	-16,338	152,401	80,192	25,731	0	1,035,729
2006	772,120	-22,039	163,138	83,827	28,995	0	1,026,041
2007	803,257	-15,375	155,729	83,192	28,956	0	1,055,759

Appendix Table B2. ICES landing statistics excluding former USSR, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, ICES reported foreign landings, and reconstructed total for cod (*Gadus morhua*) for all Baltic countries combined (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	ICES Foreign	Total
1950	58,798	101,317	2,944	20,961	3,046	0	187,066
1951	59,523	114,126	3,307	24,809	3,117	117	204,998
1952	66,179	134,068	4,028	26,881	3,188	103	234,447
1953	54,642	90,022	3,627	20,734	3,259	0	172,284
1954	53,421	102,376	3,843	21,562	3,331	0	184,534
1955	135,003	13,468	4,518	22,468	3,404	0	178,861
1956	168,141	15,948	4,700	23,844	3,477	0	216,111
1957	195,559	24,399	6,701	27,346	3,551	0	257,556
1958	152,200	22,828	6,703	25,843	3,624	0	211,197
1959	142,956	19,215	6,815	22,997	3,690	0	195,673
1960	168,276	10,161	7,923	23,525	3,763	0	213,647
1961	151,471	1,380	9,092	24,757	3,837	0	190,538
1962	153,278	-149	8,625	25,390	3,926	0	191,071
1963	154,601	-1,445	8,390	23,827	3,994	0	189,367
1964	133,203	-3,643	8,355	25,086	4,077	0	167,078
1965	133,656	13,383	9,589	32,705	4,152	0	193,485
1966	164,689	15,047	9,947	33,339	4,242	0	227,265
1967	175,542	18,893	10,895	35,236	4,331	0	244,898
1968	198,644	20,045	12,707	39,502	4,442	0	275,339
1969	196,875	14,415	13,243	37,033	4,521	0	266,088
1970	192,465	5,666	13,185	38,846	4,607	0	254,770
1971	159,717	5,313	13,570	32,743	4,686	0	216,029
1972	186,338	6,337	16,583	42,936	4,780	0	256,974
1973	189,297	8,170	21,846	23,914	4,866	0	248,094
1974	188,898	5,805	19,189	31,300	4,959	0	250,151
1975	234,156	857	21,514	25,032	5,131	0	286,690
1976	255,276	2,352	26,678	20,984	5,240	0	310,530
1977	213,042	-7,841	27,199	21,359	5,335	0	259,094
1978	195,925	5,699	17,789	24,890	6,263	0	250,567
1979	272,519	3,357	23,384	24,678	6,974	0	330,912
1980	384,035	1,557	29,859	25,352	8,171	4,151	453,125
1981	377,412	1,749	40,167	23,954	7,455	2,765	453,502
1982	357,003	-3,690	46,666	35,475	7,733	4,300	447,487
1983	369,709	1,865	60,706	41,199	7,492	6,065	487,036
1984	436,050	-5,187	78,199	32,947	7,210	6,354	555,574
1985	338,309	7,611	75,093	24,656	7,003	5,890	458,563
1986	266,609	4,561	70,760	20,083	6,871	4,596	373,480
1987	232,150	-12	66,806	26,382	6,995	5,567	337,888
1988	218,459	1,635	65,640	21,629	6,664	6,915	320,944
1989	187,427	5,407	59,848	15,791	6,796	4,499	279,768
1990	163,888	2,621	50,662	15,404	6,926	3,558	243,059
1991	135,723	890	72,362	13,651	7,252	2,992	232,869
1992	72,748	-182	52,957	11,175	7,455	593	144,745
1993	39,819	7,187	43,147	7,777	7,921	558	106,409
1994	73,826	5,525	76,129	10,893	8,390	779	175,541
1995	116,195	4,669	105,080	14,808	8,661	1,070	250,483
1996	162,989	-1,259	130,115	19,987	8,893	1,003	321,727
1997	134,444	-1,878	116,040	17,779	9,082	33	275,499
1998	101,686	1,009	96,240	18,656	9,234	0	226,825
1999	116,792	-96	101,558	16,288	9,354	0	243,896
2000	105,057	89	87,898	19,960	8,925	0	221,929
2001	102,638	-649	86,737	14,097	8,584	0	211,407
2002	74,133	147	63,022	9,518	8,328	0	155,147
2003	74,148	-226	64,812	11,806	8,138	0	158,679
2004	73,377	-2,454	61,448	8,361	8,024	0	148,757
2005	63,012	331	51,914	11,561	8,221	0	135,040
2006	71,305	-133	60,722	19,698	8,714	0	160,306
2007	63,480	2,964	48,628	14,950	8,714	0	138,736

Appendix Table B3. ICES landing statistics excluding former USSR, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, ICES reported foreign landings, and reconstructed total for herring (*Clupea harengus*) for all Baltic countries combined (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	ICES Foreign	Total
1950	70,454	59,726	3,523	5,773	1,291	0	140,767
1951	70,469	71,896	3,683	6,423	1,338	0	153,809
1952	69,073	77,776	3,741	6,654	1,385	0	158,629
1953	98,869	87,005	5,587	8,350	1,433	0	201,245
1954	97,383	107,704	5,636	9,396	1,480	0	221,599
1955	205,727	7,983	6,325	10,048	1,531	0	231,613
1956	200,151	9,955	6,128	10,014	1,580	0	227,828
1957	170,852	8,700	6,117	8,748	1,630	0	196,047
1958	182,909	10,265	7,058	9,431	1,680	0	211,343
1959	185,242	7,869	6,749	9,458	2,400	0	211,718
1960	168,101	8,402	6,426	8,640	2,451	0	194,021
1961	183,347	-726	6,954	9,199	2,504	0	201,277
1962	186,140	5,548	7,598	9,778	8,934	0	217,999
1963	225,722	1,238	8,601	11,280	3,977	0	250,818
1964	223,709	-391	8,953	11,679	2,082	0	246,032
1965	226,249	-1,137	9,209	11,413	2,510	0	248,244
1966	251,330	-168	9,565	12,899	2,260	0	275,886
1967	310,091	-225	11,031	15,827	2,312	0	339,036
1968	352,426	-8,104	13,297	17,279	5,723	0	380,620
1969	295,329	-94	11,117	14,967	2,433	0	323,751
1970	312,119	-2,691	11,070	15,679	3,250	0	339,428
1971	334,694	-2,126	12,495	17,060	3,883	0	366,006
1972	344,576	-3,424	12,304	17,210	4,359	0	375,025
1973	404,172	-1,765	16,400	20,503	3,283	0	442,593
1974	407,081	-4,119	17,068	20,359	3,550	0	443,938
1975	414,757	-7,136	17,348	20,638	2,983	0	448,590
1976	393,488	-1,987	16,128	20,079	3,090	0	430,798
1977	412,711	-6,909	18,358	20,926	3,164	0	448,250
1978	419,602	1,897	20,427	21,761	3,599	0	467,286
1979	458,819	12,688	24,613	24,653	3,673	0	524,446
1980	452,873	6,449	24,769	24,023	3,779	0	511,892
1981	418,867	5,253	24,115	22,101	3,841	0	474,178
1982	441,765	3,503	29,540	24,482	4,225	0	503,515
1983	458,860	5,314	31,206	26,135	4,240	0	525,755
1984	426,478	-346	29,986	25,581	4,190	0	485,890
1985	431,437	-690	30,213	26,222	4,206	0	491,389
1986	400,524	-186	26,917	25,045	4,765	0	457,065
1987	372,947	-707	27,199	22,805	4,851	0	427,095
1988	407,313	-1,056	32,706	25,876	4,875	0	469,714
1989	413,525	-2,076	36,194	26,689	4,970	0	479,302
1990	360,225	-5,054	30,385	22,746	5,063	0	413,364
1991	300,894	-3,207	53,824	21,334	5,337	0	378,182
1992	343,083	-4,808	87,716	27,027	6,283	0	459,301
1993	352,022	765	113,399	29,544	6,587	0	502,318
1994	353,289	1,344	125,254	33,165	6,319	122	519,493
1995	346,450	-1,977	115,340	32,515	6,315	0	498,642
1996	325,631	-30,063	91,563	28,735	6,204	0	422,070
1997	370,266	-49,684	91,447	30,253	6,137	0	448,419
1998	383,488	-69,105	81,738	28,717	5,637	0	430,475
1999	343,142	-54,606	69,734	27,026	5,512	0	390,808
2000	371,017	-55,251	74,895	28,942	5,247	0	424,850
2001	339,241	-30,181	78,799	29,122	4,917	0	421,898
2002	281,545	-7,922	68,252	25,007	4,289	0	371,171
2003	231,984	5,244	56,667	21,541	3,956	0	319,392
2004	232,922	413	57,749	22,128	3,505	0	316,717
2005	221,678	2,228	46,499	20,630	3,582	0	294,617
2006	242,766	13,584	55,799	23,487	3,508	0	339,144
2007	258,195	6,714	56,864	24,854	3,508	0	350,135

Appendix Table B4. ICES landing statistics excluding former USSR, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, ICES reported foreign landings, and reconstructed total for sprat (*Sprattus sprattus*) for all Baltic countries combined (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	ICES Foreign	Total
1950	3,247	18,322	224	1,107	5	0	22,904
1951	3,401	18,517	234	1,142	5	0	23,299
1952	3,317	18,007	246	1,117	5	0	22,691
1953	3,236	19,792	181	1,165	5	0	24,379
1954	4,090	17,721	231	1,138	5	0	23,185
1955	13,261	12,147	277	1,346	5	0	27,036
1956	8,452	12,906	266	1,101	5	0	22,729
1957	20,664	13,122	432	1,766	5	0	35,988
1958	33,746	12,538	541	2,369	5	28	49,227
1959	42,431	13,868	593	2,889	87	0	59,867
1960	34,225	15,125	599	2,552	87	0	52,588
1961	49,583	2,969	703	2,791	87	0	56,133
1962	80,611	-8,851	660	3,706	19	0	76,145
1963	69,037	2,997	588	3,700	21	0	76,343
1964	95,482	719	588	4,945	17	0	101,751
1965	84,865	-1,799	319	4,213	40	0	87,638
1966	91,428	272	370	4,641	20	0	96,732
1967	72,473	-763	694	3,720	11	0	76,135
1968	84,914	5,268	465	4,622	42	0	95,310
1969	118,641	9,177	783	6,482	46	0	135,130
1970	153,027	1,166	703	7,830	90	0	162,816
1971	184,838	2,177	538	9,428	24	0	197,005
1972	207,343	2,895	597	10,585	35	0	221,455
1973	212,788	-38	1,340	10,822	38	0	224,951
1974	241,652	-97	1,723	12,490	40	0	255,809
1975	201,434	2,596	1,509	10,548	49	0	216,137
1976	194,775	-7,931	1,930	9,832	51	0	198,658
1977	210,735	15,478	2,312	11,953	49	0	240,528
1978	132,360	17,389	1,485	7,895	50	0	159,179
1979	78,365	11,415	1,583	4,832	49	0	96,245
1980	57,488	0	1,108	3,066	53	0	61,716
1981	47,489	4	1,426	2,698	57	0	51,675
1982	44,742	0	1,328	2,519	70	0	48,659
1983	30,896	0	820	1,687	47	0	33,451
1984	51,880	0	1,880	2,813	47	0	56,621
1985	68,639	0	1,720	3,610	47	0	74,018
1986	75,328	0	1,497	4,062	56	0	80,943
1987	91,249	2,273	2,064	5,083	56	0	100,726
1988	85,699	0	2,742	4,672	0	0	93,114
1989	89,244	0	2,464	4,875	0	0	96,584
1990	91,964	-5,697	3,442	4,742	0	0	94,450
1991	114,014	-11,599	11,188	6,648	0	0	120,252
1992	147,314	641	27,781	10,033	0	0	185,770
1993	193,865	283	43,775	13,271	1	0	251,194
1994	299,569	-580	76,927	22,193	1	966	399,075
1995	334,537	-6,734	80,806	24,509	1	0	433,119
1996	463,776	-4,887	108,775	35,451	1	0	603,116
1997	519,769	28,691	123,425	42,848	1	0	714,734
1998	445,429	49,891	105,548	37,601	16	21	638,507
1999	408,444	31,300	88,148	32,957	16	0	560,864
2000	368,722	34,511	75,721	29,201	109	0	508,263
2001	353,779	5,740	62,484	25,720	109	0	447,831
2002	345,198	3,082	55,757	24,574	13	0	428,624
2003	324,601	-7,800	46,170	21,213	13	0	384,196
2004	387,975	-5,657	48,340	25,434	7	0	456,100
2005	434,007	-13,008	46,098	28,302	7	0	495,405
2006	386,061	-28,891	39,178	24,090	45	0	420,483
2007	407,017	-15,242	42,910	26,144	45	0	460,874

Appendix Table B5. ICES landing statistics excluding former USSR, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, ICES reported foreign landings, and reconstructed total for salmon (*Salmo salar*) for all Baltic countries combined (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	ICES Foreign	Total
1950	3,118	564	180	470	33	0	4,365
1951	2,698	286	158	406	36	0	3,584
1952	2,522	305	147	394	40	0	3,409
1953	1,606	253	97	257	43	0	2,256
1954	1,871	378	119	310	47	0	2,725
1955	1,392	92	81	205	51	0	1,820
1956	2,069	246	130	312	54	0	2,811
1957	1,644	240	108	263	58	0	2,312
1958	1,595	254	108	258	62	14	2,290
1959	1,696	225	110	262	86	0	2,378
1960	2,440	-5	150	336	90	0	3,010
1961	3,094	-18	219	471	93	0	3,858
1962	2,804	123	191	417	100	0	3,635
1963	2,606	-65	165	348	129	0	3,182
1964	3,742	-115	254	517	133	0	4,530
1965	3,429	-46	249	507	117	0	4,256
1966	2,917	-98	215	429	137	0	3,599
1967	3,251	-65	263	503	127	0	4,079
1968	3,558	-149	283	532	155	0	4,378
1969	2,902	-58	245	444	173	0	3,706
1970	2,622	-127	218	386	220	0	3,318
1971	2,147	-25	195	329	177	0	2,823
1972	2,194	17	210	343	187	0	2,951
1973	4,012	-44	335	515	195	0	5,013
1974	3,387	6	312	481	152	0	4,338
1975	2,953	-61	281	434	160	0	3,767
1976	3,095	-44	301	464	165	0	3,980
1977	2,616	-44	266	389	167	0	3,394
1978	2,091	-41	209	306	167	0	2,731
1979	2,267	-43	228	329	172	0	2,953
1980	1,592	884	247	354	183	0	3,260
1981	2,379	-2	180	305	201	0	3,063
1982	2,165	-3	136	239	203	0	2,740
1983	2,462	1	160	315	206	0	3,144
1984	3,681	0	262	522	285	0	4,749
1985	4,055	0	295	611	288	0	5,249
1986	3,529	19	254	608	382	0	4,791
1987	3,854	10	265	704	385	0	5,217
1988	3,220	0	246	638	298	0	4,401
1989	4,219	0	320	974	302	0	5,814
1990	5,610	-34	380	1,531	305	0	7,793
1991	4,543	107	420	1,491	319	0	6,879
1992	4,436	-1	518	1,577	476	9	7,014
1993	3,392	388	461	1,469	490	19	6,220
1994	2,903	5	446	1,100	358	0	4,812
1995	2,702	0	372	1,181	373	0	4,627
1996	2,633	4	361	1,167	463	0	4,629
1997	2,572	1	340	1,240	472	0	4,625
1998	2,144	14	309	941	341	0	3,749
1999	1,753	97	277	833	342	0	3,303
2000	2,002	-11	290	850	440	0	3,570
2001	1,731	18	279	804	454	0	3,285
2002	1,583	-33	255	738	338	0	2,882
2003	1,318	108	237	727	333	0	2,724
2004	1,823	-80	194	799	389	0	3,125
2005	1,454	-80	169	625	322	0	2,489
2006	1,064	-79	136	482	178	0	1,780
2007	916	-32	120	425	176	0	1,605

Appendix Table B6. ICES landing statistics excluding former USSR, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, ICES reported foreign landings, and reconstructed total for the category 'flatfish' for all the Baltic countries combined (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	ICES Foreign	Total
1950	6,439	6,551	322	3,443	671	0	17,425
1951	7,289	7,163	378	3,826	699	1	19,354
1952	6,584	7,228	347	3,543	728	2	18,431
1953	5,854	6,657	319	3,199	756	0	16,784
1954	7,757	7,293	438	3,877	785	0	20,148
1955	15,067	3,566	560	4,718	814	0	24,725
1956	12,068	3,585	458	3,946	844	0	20,901
1957	13,356	3,560	549	4,546	874	0	22,886
1958	11,909	3,582	540	4,328	905	0	21,264
1959	12,937	3,490	572	4,575	935	0	22,509
1960	12,947	4,457	657	4,982	965	0	24,008
1961	21,255	232	898	6,267	996	0	29,647
1962	23,075	418	1,066	6,993	1,027	0	32,579
1963	19,837	1,494	828	5,607	1,059	0	28,825
1964	22,279	1,553	844	5,766	1,093	0	31,533
1965	21,036	2,340	810	5,475	1,127	0	30,789
1966	21,356	332	700	4,933	1,163	0	28,484
1967	20,946	-182	820	5,423	1,195	0	28,202
1968	23,174	-716	905	5,716	1,229	0	30,307
1969	20,569	-368	872	5,366	1,265	0	27,704
1970	18,957	858	806	4,970	1,303	0	26,894
1971	18,889	373	710	4,365	1,336	0	25,673
1972	19,862	410	688	4,252	1,368	0	26,579
1973	17,808	-123	662	4,058	1,401	0	23,807
1974	20,596	-235	986	5,677	1,435	0	28,459
1975	23,720	-3,479	903	5,167	1,600	0	27,910
1976	19,397	-350	846	4,633	1,678	0	26,203
1977	21,898	-2,084	827	4,477	1,745	0	26,862
1978	23,030	-1,646	1,045	5,399	1,987	0	29,814
1979	24,094	-1,389	1,146	5,603	2,053	0	31,508
1980	18,236	150	918	4,526	2,130	0	25,960
1981	16,203	156	847	4,057	2,202	0	23,465
1982	17,080	65	770	3,545	2,278	0	23,739
1983	16,146	142	869	3,709	2,323	0	23,189
1984	14,944	42	799	3,223	2,332	0	21,340
1985	16,608	115	1,010	3,833	2,488	0	24,055
1986	17,569	120	1,117	4,086	2,676	0	25,568
1987	15,945	246	1,055	3,629	2,748	0	23,623
1988	14,067	78	1,008	3,361	2,772	0	21,285
1989	14,049	378	996	3,301	2,850	0	21,574
1990	12,224	58	1,205	3,656	2,929	0	20,072
1991	13,968	55	2,018	7,017	3,160	0	26,217
1992	12,045	1,241	2,276	6,905	4,036	0	26,503
1993	11,808	583	2,492	6,880	4,291	0	26,053
1994	17,960	62	4,795	10,544	4,041	0	37,402
1995	22,397	1,625	6,013	13,516	3,932	0	47,482
1996	21,801	393	5,134	12,602	3,943	0	43,872
1997	19,811	271	4,368	11,488	3,815	0	39,753
1998	18,159	77	3,753	10,783	3,540	0	36,312
1999	17,755	-174	3,409	9,732	3,401	0	34,122
2000	19,935	-319	3,512	10,863	2,901	0	36,892
2001	22,576	-331	3,673	12,470	2,594	0	40,982
2002	24,213	-325	3,602	13,130	2,100	0	42,721
2003	19,898	-148	2,686	10,555	1,868	0	34,858
2004	22,548	433	2,813	12,113	1,606	0	39,513
2005	24,677	654	2,822	14,207	1,544	0	43,904
2006	21,158	-72	2,349	11,061	1,456	0	35,952
2007	23,074	-74	2,560	12,076	1,417	0	39,053

Appendix Table B7. ICES landing statistics excluding former USSR, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, ICES reported foreign landings, and reconstructed total for the category 'others' for all the Baltic countries combined (t). Excludes any ICES reported landings from the former USSR.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	ICES Foreign	Total
1950	25,873	17,913	1,466	3,002	4,419	0	52,673
1951	23,629	21,732	1,429	2,984	4,694	4	54,472
1952	23,849	22,161	1,478	3,036	4,972	6	55,503
1953	30,162	18,299	1,583	3,141	5,250	0	58,435
1954	28,555	18,768	1,466	3,102	5,532	0	57,424
1955	63,123	-6,486	1,892	3,871	5,822	0	68,221
1956	58,376	-8,119	1,719	3,274	6,113	0	61,363
1957	66,899	-12,022	2,137	3,831	6,411	0	67,257
1958	59,049	-11,332	1,795	3,373	6,706	0	59,592
1959	69,498	-14,601	2,050	3,677	8,554	0	69,178
1960	70,364	-14,001	2,041	3,886	8,846	0	71,135
1961	58,301	-255	2,151	4,754	9,151	0	74,102
1962	68,230	-12,764	2,037	3,985	9,875	0	71,363
1963	55,242	-772	1,647	3,335	11,042	0	70,494
1964	64,883	-1,641	2,031	4,773	10,540	0	80,586
1965	68,224	1,086	2,207	4,686	10,819	0	87,021
1966	70,112	1,716	2,328	4,616	11,479	0	90,250
1967	84,434	4,618	2,463	5,704	11,879	0	109,098
1968	82,509	2,230	2,323	4,927	12,366	0	104,355
1969	75,585	-5,582	1,960	3,937	12,949	0	88,850
1970	80,346	1,416	2,322	4,654	12,923	0	101,661
1971	80,766	-2,529	2,384	4,653	13,987	3	99,265
1972	76,609	-2,127	2,512	4,477	14,422	0	95,894
1973	101,031	6,742	3,583	6,587	14,814	0	132,758
1974	90,477	21,384	2,640	6,037	15,028	0	135,565
1975	96,741	-11,313	2,606	5,231	16,445	0	109,710
1976	84,365	-5,842	3,067	5,595	16,615	0	103,800
1977	74,621	-7,515	2,212	3,707	16,331	0	89,357
1978	77,830	-2,418	2,096	4,119	16,690	0	98,317
1979	81,821	-23,235	2,084	3,358	16,578	0	80,605
1980	53,171	343	2,030	3,743	16,850	1	76,138
1981	49,498	-50	2,170	4,938	15,799	0	72,355
1982	57,508	-34	2,934	5,228	15,644	0	81,280
1983	45,087	75	2,404	3,732	15,482	0	66,781
1984	43,591	92	2,415	2,709	14,453	0	63,259
1985	41,560	6	2,742	2,768	14,291	0	61,366
1986	47,342	-3	3,259	3,056	16,885	4	70,544
1987	50,136	19	3,659	3,217	16,725	0	73,755
1988	54,442	5	4,698	3,714	16,810	0	79,670
1989	45,396	-53	2,838	2,722	16,670	0	67,574
1990	41,769	-10,837	3,181	2,327	16,606	0	53,046
1991	45,921	-8,426	5,752	3,488	16,895	0	63,629
1992	49,666	384	8,765	5,010	26,974	0	90,803
1993	45,624	35	9,268	4,923	27,232	0	87,082
1994	42,430	213	11,211	5,074	20,566	804	80,297
1995	54,967	-36	12,288	6,068	19,923	0	93,212
1996	48,681	-29	11,346	5,177	21,204	0	86,378
1997	50,468	292	11,049	5,108	20,559	0	87,476
1998	49,431	249	10,414	5,016	21,714	0	86,824
1999	51,451	428	10,138	5,188	21,104	0	88,310
2000	52,431	-9,595	7,744	4,313	16,444	0	71,337
2001	63,161	-10,148	8,861	5,199	16,336	4	83,413
2002	62,464	-10,022	8,001	5,259	13,600	0	79,302
2003	50,764	-7,451	6,014	4,605	13,338	1	67,271
2004	55,559	-6,450	6,146	5,206	12,011	0	72,473
2005	48,917	-6,464	4,898	4,867	12,056	0	64,275
2006	49,766	-6,448	4,954	5,010	15,094	0	68,376
2007	50,575	-9,705	4,648	4,742	15,095	0	65,355

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

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ABSTRACT

Denmark's fisheries activities in the Baltic Sea from 1950-2007 were estimated using a 'catch reconstruction' technique. Using ICES landing statistics as reported landings baseline, we used other available data sources to estimate for Illegal, Unreported and Unregulated (IUU) catch components: data source 'adjustments' to reported landings, estimates of 'unreported' ('unallocated') catches, 'discards', and 'recreational catches'. ICES landing statistics report approximately 6.8 million tonnes of Danish fish landings in the Baltic Sea from 1950-2007, and our reconstruction estimates an additional increase of 41% to reflect total marine resource exploitation. Cod (*Gadus morhua*) accounted for 1.5 million tonnes of this 2.7 million tonne increase, mainly through unreported landings. We believe this reconstruction remains a conservative estimate. Improved data collection, full transparency and accountability, 100% observer coverage on fishing vessels, and Vessel Monitoring Systems are some strategies that Denmark should initiate to reduce illegal fishing.

INTRODUCTION

Denmark is located on the boundary of the Baltic and North Seas (Figure 1). Jutland, the main peninsula of Denmark, extends northward dividing the Skagerrak from the Kattegat, which connects to the Baltic Sea through the Danish Sound and Belts. The Danish archipelago is comprised of many islands, with the most easterly being Bornholm, some 180 km southeast of Copenhagen. Denmark has a total land area of approximately 43,000 km² and a population of about 5.4 million (UN, 2009). Historically, Denmark controlled Greenland, Iceland, and the Faroe Islands, but ties between Iceland and Denmark were severed during WWII, and both the Faroe Islands and Greenland have since gained home rule. Denmark joined the European Union (EU) in 1973 and has a strong market economy.

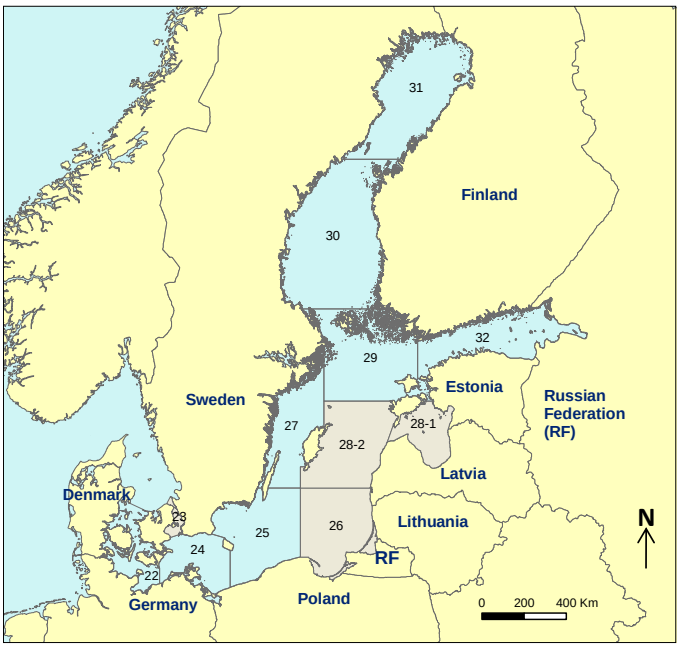

Figure 1. Map of the Baltic Sea with ICES subdivisions and surrounding countries. Denmark's coastline borders ICES subdivisions 22, 23, 24 and 25.

Though fisheries contribute only 0.5% of the GDP, they have been integral to the livelihoods of communities in north and west Jutland, and the island of Bornholm (Anon., 2007c). Detailed records of cod (*Gadus morhua*), salmon (*Salmo salar*), and herring (*Clupea harengus*) landings in Bornholm date as far back as the late 1800s (Bager *et al.*, 2007). The Baltic Sea is the third most important fishing area for Denmark

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after the North Sea and the Skagerrak (Anon., 2007c). In 2006, Denmark's catches in the Baltic Sea amounted to approximately 12% of the country's catches (Anon., 2007a). This paper will consider only catches from the Baltic Sea Large Marine Ecosystem (LME, Figure 1; Sherman and Hempel, 2008), and therefore excludes those from the Kattegat, Skagerrak and North Sea.

Denmark's fisheries in the Baltic Sea can be divided into four categories: 1) the industrial sector for fishmeal and fish oil; 2) the commercial pelagic fishery for human consumption; 3) the commercial demersal fishery for human consumption; and 4) the marine recreational fishery (Anon., 2007c). Since the 1950s, the three main species targeted by Denmark in the Baltic Sea, according to the International Council for the Exploration of the Sea (ICES), have been cod, herring and sprat (*Sprattus sprattus*).

Denmark has become the predominant industrial fishing nation in the EU, producing the most fishmeal from both domestically caught and imported fish (Anon., 2007c). Nearly all that is produced is exported, and in the last decade, Denmark's allocated quotas (of the Baltic's Total Allowable Catches [TACs]) have been reduced, further increasing reliance on imported fish for industrial reduction purposes.

In the Baltic, the Danish fleet consists mostly of gillnetters, trawlers, and multi-purpose vessels. In 2006, the number of fishing vessels with homeports in the Baltic numbered approximately 1,400 (Anon., 2007a). Vessels operating in the industrial reduction fisheries for fishmeal/oil (targeting herring and sprat) as well as pelagics for human consumption (targeting herring and mackerel), are based mostly out of ports in North and West Jutland. Vessels targeting demersal species have traditionally operated out of ports in Bornholm and currently target cod, whiting (*Merlangius merlangus*), haddock (*Melanogrammus aeglefinus*), hake (*Merluccius merluccius*), saithe (*Pollachius virens*), sole (*Solea solea*), plaice (*Pleuronectes platessus*), and flounder (*Platichthys flesus*), as well as lobster (*Homarus gammarus*) and prawns (*Palaemon serratus:* (Anon., 2004). Prior to the 1970s, the majority of bycatch in the cod fishery was plaice; however in the 1980s, plaice stocks collapsed and other flatfish species including dab (*Limanda limanda*), flounder, turbot (*Psetta maxima*) and brill (*Scopthalmus rhombus*) became the predominant bycatch from both trawl and gillnet fisheries targeting cod (ICES, 1986; 1992).

In earlier periods, landings were reported by ICES divisions IIIb, IIIc and IIId. Division IIIb represents the Sound, IIIc the Belt Sea (located between the Skagerrak and Baltic Seas and collectively known as the transition zone), and IIId the Baltic Sea (Figure 1; Table 1). These divisions are further segregated into subdivisions 22-32 (Table 1; Figure 1; ICES, 1987). Denmark began reporting by subdivision in the 1990s, while other countries such as Germany, were reporting by subdivision in the early 1980s (Table 2).

Table 1. ICES divisions and corresponding subdivisions representing the Danish Sound, Belt and Baltic Sea. Source: (ICES, 1987).

ICES Division	ICES Subdivision
IIIb- Sound	23
IIIc- Belt Sea	22
IIId- Baltic Sea	24-32

The majority of landings were reported in ICES divisions IIIb and IIIc during the 1950s and 1960s (Table 2), but between the 1970s-1990s, substantially more landings were reported from division IIId. This shift may reflect a spatial expansion of exploitation, or declining fish stocks in the transition zone (divisions IIIb + IIIc). In the 1990s, 67% of landings were reported in division IIId (subdivisions 24-32). In the 2000s, slightly more than 50% of landings have been reported from IIId, and approximately 48% are reported from IIIb and IIIc (Tables 1, 2). The majority of Denmark's catches of herring, sprat, cod, plaice, flounder, dab, and brill are reported from subdivision 22. The second largest catch volumes are derived from subdivisions 24 and 25, which are popular fishing areas for sprat, salmon, herring and cod. Minor catch volumes are reported from subdivisions 23, 26-29, and 32 (Table 2).

Recreational fishing is a popular activity in Denmark, with approximately 650,000 active anglers and 30,000 people that fished with fixed gear in 2009 (K. Manniche Ebert, pers. comm., Danmarks Sportsfiskerforbund). Management of recreational fishing depends on whether the fisher is part-time, spare-time (for household consumption) or for sport (rod and line). A license must be purchased and permissible gears are restricted to rod and line, gillnet, longline, other standing gear, nets or traps. Sale of recreationally caught fish is illegal, and there are severe fines for those caught using inappropriate gears or fishing without a license. There are currently disputes between commercial and recreational fishers over rights to fish migratory species such as salmon and sea trout (*Salmo trutta*), as recreational fishers contribute substantially to management and restocking costs through annual license fees (Pawson *et al.*, 2007).

Management of commercial fisheries in Denmark is guided by the EU Common Fisheries Policy (CFP). The main strategy of the CFP is the use of TACs, which are determined for most species on an annual basis and divided amongst all EU members. Each year, countries are given the same percentage of the total TAC for a given species. It is the responsibility of the national authorities to manage the country's TAC and allocate this among the various fisheries sectors. The responsible national authority in Denmark is the Danish Directorate of Fisheries, which is part of the Ministry of Food, Agriculture and Fisheries (MFAF).

Table 2. Distribution of Denmark's reported landings by ICES statistical fishing area, by decade. Source: ICES (2009).

ICES Statistical Areas	Percentage of Catch[a]					
	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Divisions						
IIIb	3.3	0.2	0.0	0.0	0.0	0.0
IIIc	58.0	3.7	0.0	0.0	0.0	0.0
IIIb+c	0.0	53.4	45.6	45.6	14.1	0.0
IIId	38.8	42.7	54.4	54.4	67.3	15.3
Sub-divisions						
22	n/a	n/a	n/a	0.0	16.7	43.1
23	n/a	n/a	n/a	0.0	1.9	4.9
24	n/a	n/a	n/a	0.0	0.0	12.2
25	n/a	n/a	n/a	0.0	0.0	15.0
26	n/a	n/a	n/a	0.0	0.0	5.2
27	n/a	n/a	n/a	0.0	0.0	0.8
28	n/a	n/a	n/a	0.0	0.0	3.1
29	n/a	n/a	n/a	0.0	0.0	0.4
32	n/a	n/a	n/a	0.0	0.0	0.0

[a] 0.0 includes values of less than 0.1

The MFAF controls fishing rights and quota allocation with the distribution of licenses, which until recently were based on a Common Pool Quota (CPQ) regulation system (TACs rationed according to vessel length). Annual quotas have been used for cod in the Baltic and all pelagic fisheries since 1995. Individual Transferrable Quotas (ITQs) are now being introduced for herring and Individual Quotas (IQs) may be initiated for mackerel and fisheries for non-human consumption (Nielson and Christensen, 2006).

It has been argued that the TAC system leads to unsustainable practices (Nielson and Christensen, 2006). As permissible fishing is increasingly restricted through TACs, the motivation and gains from Illegal, Unreported and Unregulated (IUU) fishing tend to rise (Bray, 2000). The most significant component of IUU in the Baltic Sea is underreporting, resulting in unreported landings, and this is especially so for the cod fishery (Anon., 2007c). The EU fleet capacity reduction program has been very active in Denmark, but underreporting is still a major problem in Denmark for species such as cod, since Denmark receives one of the largest shares of the EU TAC for this species. Between 1987 and 2001, 1,197 vessels were decommissioned, and the number of new vessels entering the fleet was restricted (Anon., 2007c). The number of vessels continued to decrease throughout the 2000s, with 2,893 vessels in 2008 as compared to 4,059 vessels in 2001 (Anon., 2009a). Denmark is interested in increasing the roles of stakeholders by allowing governmental authorities, fishers, environmental groups and businesses to participate in decision making processes. The introduction of ITQs and IQs are seen as ways of introducing some form of self-management to commercial fishers (Nielson and Christensen, 2006).

The purpose of this study is to provide an estimate of total marine fisheries catches in the Baltic Sea by Denmark (1950-2007), using a catch reconstruction approach based on Zeller and Pauly (2007) and Zeller *et al.* (2007). ICES make their landings statistics publicly available for the period 1950-2007, but there has been no apparent effort to fully represent total catches (which, in contrast to reported landings, would include IUU estimates) in a clear and transparent manner. Sources of IUU considered here include 'adjustments' to reported landings (data source adjustments), 'unreported landings', 'discards' and 'recreational catches'. Our approach uses previously reported data by ICES, peer-reviewed and grey literature, and correspondence with local experts. We have relied heavily on historical studies of Danish fisheries by Holm and Mackenzie (2003) to shape our assumptions regarding IUU (Holm, 2003; Holm and Mackenzie, 2003). Our approach utilizes assumption-based estimation to cover all aspects of IUU for all years.

METHODS

Fisheries data for Denmark were extracted from the 'ICES catch statistics database' (ICES, 2009). For the purposes of our study, we refer to this database as the 'ICES landings statistics', which reflects the nature of the data presented by ICES (i.e., the data represent '*reported landings*', not catches). ICES landings statistics were treated here as the officially reported data, being the only source readily available to the public, reporting landings for all countries, all taxa and all fishing areas within the Baltic Sea from 1950-2007. ICES landings formed the official baseline of our catch reconstruction, to which four components of Illegal, Unreported and Unregulated (IUU) catches were added: i) '*adjustments*', being positive or negative

data source additions to officially reported landings data; ii) '*unreported*' landings, being landed catches not reported to authorities (which ICES refers to as 'unallocated'); iii) '*discards*', being fish caught by fishing operations but not retained; and iv) '*recreational*' catches. Supplementing reported landings with IUU catches aims to represent the total fisheries catches in Denmark from 1950-2007.

Adjustments to reported landings and estimates of IUU were derived using high-quality, alternate data sources including ICES stock assessment working group data (ICES, 2009), national datasets, and interviews with Baltic fisheries officials. For a lack of country-specific data for unreported landings and discards in the Baltic, we derived an assumed default method using Baltic-wide estimates of unreported landings and discards from ICES stock assessment working group data. We considered these reported estimates as proportions of ICES landings statistics, plus adjustments, to derive Baltic-wide rates (%) of underreporting and discarding which were applied to landings in Denmark. Other assumed default anchor points were also formed to expand estimates of unreported and discarded catches to time periods when no data were reported. For years between anchor points, linear interpolations were used to estimate the various components of IUU. Our catch reconstruction for Denmark was taxon-specific for cod (eastern and western stocks); herring; sprat; Atlantic salmon; flatfishes, which included common dab, European plaice , European flounder, brill and turbot; and a miscellaneous grouping, 'others' comprised of 97 taxa.

Illegal, Unreported and Unregulated (IUU) catches

Four components of IUU were estimated in our catch reconstruction: i) '*adjustments*' to reported landings data; ii) '*unreported*' landings; iii) '*discard*' catches; and iv) '*recreational*' catches. The sum of ICES landings statistics, adjustments, unreported landings, discards and recreational catches represents the total reconstructed catch for Denmark from 1950-2007.

Adjustments to reported landings

Adjustments to the 'officially reported' ICES landings statistics for Denmark were based on data and information originating from ICES stock assessment working group data (ICES, 2007; 2008b). After comparing these alternate data to ICES landings statistics, adjustments were made for cod (eastern and western stocks), salmon, and the group flatfishes (Table 3). Sprat and herring did not have any adjustments incorporated, as ICES stock assessment working group reports (focusing on stock rather than area of capture), include data representative of an area including the Baltic Sea, the Skagerrak, and the Kattegat (ICES, 2008a)

Table 3. Years for which adjustments were made to reported landings data (ICES landings statistics) for Denmark by taxon. Data sources (ICES, 2007; 2008a).

Common name	Years
Cod (eastern and western stocks)	1965-2007
Atlantic salmon	1980, 1993, 1998-2006
Flatfishes	
Brill	1995, 2005
Common dab	2005
European flounder	1968-1970, 1973, 1989, 1992-1994
European plaice	1996, 2005
Turbot	1993

Adjustments to reported landings of cod were made in all years for the 1965 to 2007 period (Table 3). Flatfishes and salmon had changes made in years for which ICES stock assessment working group data indicated higher landings than the ICES landings statistics database (Table 3). Thus, the ICES landings statistics plus adjustments form the best estimate of commercial landings data to which other IUU components were applied.

Unreported landings

All rates of unreported landings (%) from 1950-2007, were applied to the sum of ICES landings statistics (t) plus adjustments (t) to estimate unreported landings (t) in Denmark.

Cod: Estimates of unreported landings from 1950-2007 in Denmark were derived according to a combination of default, assumption-based methods, ICES stock assessment working group data (Tables

2.3.1 and 2.4.1 in ICES, 2007), and information from a Swedish fisheries expert, (P-O. Larsson, pers. comm., Swedish Board of Fisheries). All estimated rates of unreported landings were applied in the form of a percentage (%) to the sum of reported landings (t) plus adjustments (t).

Anchor points for rates of unreported landings of eastern and western cod were set at 5% in 1950 (Table 4), according to the assumed default methodology outlined in chapter 1. Information derived from correspondence with a Swedish fisheries expert, (P-O. Larsson, pers. comm., Swedish Board of Fisheries), led us to use a rate of 50% in 1987 for both eastern and western cod (Table 4). Following the general pattern (and conservative approach) set by our assumed default methodology, we applied half of the rate in 1987 to landings plus adjustments in 1980 (Table 4).

ICES stock assessment working group data provided information to derive anchor points for cod during the 1993 to 2007 period. We derived annual rates (%) to estimate unreported landings (t) in Denmark by dividing the total, Baltic-wide 'unallocated' landings (t) by the total Baltic-wide landings of cod (see 'Methods' in Zeller *et al.,* this volume). These statistics were available for the period 1993-2007 for eastern cod, and the years, 1993, 1994, 1996, and 2004-2007 for western cod (Table 4). Linear interpolation was used in all intervening years between anchor points during the 1950 to 2007 period.

Table 4. Anchor points (%) used for estimating unreported landings for cod from 1950-2007 based on sources (Tables 2.3.1 and 2.4.1 in ICES, 2007). Dashed lines (-) indicate years when linear interpolations were used.

Year	Eastern Cod	Western cod
1950	5.0[a]	5.0[a]
1951-1979	-	-
1980	25.0[b]	25.0[b]
1981-1986	-	-
1987	50.0[c]	50.0[c]
1988-1992	-	-
1993	87.7[d]	40.2[d]
1994	123.6[d]	39.6[d]
1995	29.7[d]	-
1996	13.1[d]	5.3[d]
2000	46.0[d]	-
2001	47.6[d]	-
2002	47.5[d]	-
2003	59.8[d]	-
2004	52.9[d]	0.07[d]
2005	46.4[d]	0.04[d]
2006	46.9[d]	0.04[e]
2007	43.2[d]	0.04[e]

[a] assumed default value (Zeller *et al.,* this volume); [b]assumed default (50% of rate in 1987); [c]P-O. Larsson, pers. comm.; [d]derived from Tables 2.3.1 and 2.4.1 in ICES (2007); see Zeller *et al.* (this volume); [e]rate from 2005 carried forward.

Salmon: Following the assumed default methodology outlined in chapter 1, a rate of 5% was applied to Denmark's landings (sum of ICES landings statistics + adjustments) to estimate unreported landings in 1950 (Table 7). Anchor points were also derived for the period from 1981-2007 using ICES stock assessment working group data (Table 2.1.2, p.18-19 in ICES, 2008b). Linear interpolation was used for intervening years (1951-1980; Table 5).

Table 5. Anchor points in % used for estimating unreported landings of salmon based on source (Table 2.1.2 in ICES, 2008b). Dashed (-) lines indicate years when linear interpolations were used.

Year	Unreported landings	Year	Unreported landings
1950	5.0[a]	1994	26.9[c]
1951-1980	-	1995	25.4[c]
1981	10.9[b]	1996	24.0[c]
1982	11.7[b]	1997	22.5[c]
1983	12.5[b]	1998	21.0[d]
1984	13.3[b]	1999	19.6[d]
1985	14.0[b]	2000	18.1[d]
1986	14.8[b]	2001	16.7[d]
1987	15.6[b]	2002	15.2[d]
1988	16.4[b]	2003	13.7[d]
1989	17.2[b]	2004	12.3[d]
1990	17.9[b]	2005	11.2[d]
1991	18.7[c]	2006	11.2[e]
1992	19.5 [c]	2007	11.2[e]
1993	20.3 [c]		

[a]assumed default value (Zeller *et al.,* this volume); [b]assumed default value, adjusted for only western countries using mode (Zeller *et al.,* this volume); [c]assumed default value, adjusted for all countries using mode (Zeller *et al.*, this volume); [d]assumed default, adjusted for all countries using minimum (Zeller *et al.,* this volume); [e]2005 rate carried forward.

Our unreported landings of salmon were based on the mode and minimum estimates presented in ICES stock assessment working group data (ICES, 2008b) (after correcting for the former eastern-bloc countries [see 'Methods' in Zeller *et al.*, this volume). In years when Denmark did not report its recreational catches to ICES (1950-1997), the derived unreported landings of salmon were based on the mode. After 1997, when Denmark reported its recreational catches to ICES, the unreported landings were estimated using the minimum value.

Herring, Sprat, flatfishes, and 'Others': Using our default, assumption-based methodology, a rate of 5% was applied to landings (ICES landing statistics plus adjustments) of herring, sprat and 'others' in 1950 to estimate unreported landings (Table 6). Our unreported catch rates in later years were based on the mean unreported catch rate for eastern cod, western cod, and salmon in each of the years 1993, 1994, 2004, and 2005. To be conservative in our approach, half of the mean rate derived in each of these years for cod and salmon was applied to landings of herring, sprat and 'others' (Table 6). In 1980, we adhered to default, assumption-based methodology and applied

half the value of the first anchor point in 1993 to landings of each species (Table 6). The catch rate derived for 2005 was carried forward at a constant rate for 2006 and 2007 (Table 6). Linear interpolations were performed between all anchor points.

Discards

Discards were divided into 4 categories: 1) underwater discards (mortality caused by deployed fishing gear); ii) ghostfishing (usually a result of entrapment in lost fishing gear); iii) boat-based discards (a result of fishers' selective behaviors onboard); and iv) seal-damaged discards. In Denmark however, only the first three categories were applicable because discards due to seal damage were unavailable. Discards were estimated as proportions of the total landings (i.e., ICES landings statistics + adjustments + unreported landings) by applying discard rates (%) to the total landings of each of the applicable taxa.

Underwater discards: Underwater discard rates were only applied to herring and sprat using data derived from Rahikainen *et al.* (2004). In the Baltic Sea, herring and sprat are targeted by the same trawl fleet. Thus, the pelagic trawl fishery is inherently mixed, and uncertainty exists in species composition of landings data (ICES, 2008c). It is also known that landings statistics often reflect only the targeted species (HELCOM, 2009). Rahikainen *et al.* (2004) presented tonnages of underwater discards in relation to observed catches of herring in the trawl fishery. We derived an underwater discard rate of approximately 9% which we applied to the landings of herring and sprat caught by trawl (Rahikainen *et al.*, 2004). For the period 1950-1986, catches by gear type were not available. To estimate these years we applied a rate of 8% which was the average of underwater discards as a proportion of total herring catches from 1987-1989.

Table 6. Anchor points in % used to estimate unreported landings of herring, sprat, flatfishes and 'other' taxa from 1950-2007 based on sources (Tables 2.3.1 and 2.4.1 in ICES, 2007a; Table 2.1.2 in ICES, 2008a). Dashed lines (-) indicate years when linear interpolations were used.

Year	Unreported landings
1950	5.0[a]
1951-1979	-
1980	10.1[b]
1981-1992	-
1993	20.3[c]
1994	26.9[c]
1995-2003	-
2004	12.3[c]
2005	11.2[c]
2006	11.2[d]
2007	11.2[d]

[a] assumed default (Zeller *et al.*, this volume); [b] assumed default (50% of 1993 rate; see text and chapter 1); [c] 50% of mean annual rates determined from anchor points of eastern cod, western cod and salmon; [d] 2005 rate carried forward as a constant for the years 2006-2007.

Table 7. Default anchor points (%) based on sources (Tables 2.4.1, 2.4.5b and 2.4.20 in ICES, 2008a; Table 2.4.5b in ICES, 2007) and assumed default anchor points used to estimate boat-based discards for eastern cod in Denmark, 1950-2007.

Year	Discard Rate (%)	Year	Discard Rate (%)
1950-1965	10.2[a]	1987	5.9
1966	9.4	1988	4.5
1967	12.6	1989	1.9
1968	8.6	1990	3.0
1969	9.8	1991	2.2
1970	6.8	1992	3.5
1971	4.9	1993	3.5
1972	12.7	1994	2.1
1973	8.9	1995	1.7
1974	10.5	1996	1.2
1975	10.4	1997	3.9
1976	2.3	1998	3.4
1977	1.6	1999	2.5
1978	15.5	2000	6.8
1979	16.0	2001	3.2
1980	3.6	2002	2.2
1981	1.6	2003	2.8
1982	5.9	2004	1.8
1983	4.7	2005	3.0
1984	2.4	2006	13.2
1985	3.1	2007	11.4
1986	1.2		

[a] three-year average, 1966-1968, applied as a constant.

Ghostfishing: In a recent FAO report, lost and discarded fish gear were reported to contribute to approximately 10% of marine litter, resulting in increasingly threats to fish stocks globally (Macfadyen *et al.*, 2009). Brown *et al.* (2005) reported that during a 28 month study period, between 3 t and 906 t of cod were caught by lost nets (based on data from Tschernij and Larsson [2003]). When compared to the total reported or landed catch in the same area, during the same time period, catches by lost gear were equivalent to approximately 0.01-3.2 % of the total catch of cod (Brown *et al.*, 2005). We assumed lost gear has similar effects on all species, excluding pelagics (herring and sprat), and applied the average (1.65%) from Brown *et al.* (2005) to landings from 1950 to 2007.

Boat-based discards: Discard rates for eastern cod (1966-2007; Table 7), western cod (1970-2007; Table 8) and salmon (1981-2007; Table 9 were determined using Baltic-wide discard statistics and Danish landings presented in ICES stock assessment working group reports (ICES, 2007; 2008a; 2008b). Zeller *et al.* (this volume) outlines the assumed default methods used to derive discard rates from these data for Denmark. For the years prior to those for which data were available for eastern cod (1950-1965), western cod (1950-1969) and salmon (1950-1980), we used an average based on the first three years of available data (Table 7-9).

All discard rates were applied to the total landings (i.e., ICES landings statistics + adjustments + unreported landings) of eastern cod, western cod and salmon to estimate discards.

Estimates of boat-based discarding (%) for flatfishes, whiting and 'others' were based on a Danish discard study (Jensen, 2004). Discard tonnages for each species presented in this study were divided by reported landings in Denmark in 2004, to derive discard rates for each species. We applied the average of the discard rates derived for dab (33%), plaice (34%) and flounder (48%) to turbot (38%) and brill (38%).

Discard tonnages presented for the remaining taxa in the Danish study (except whiting, see below; Jensen, 2004) had to be modified to suit our 'others' group. Chapter 1 describes in detail the methods used to derive a discard rate of 6.2% for our 'others' group. Jensen (2004) presented species-specific data for whiting from which we derived a discard rate of 36%. All discard rates were applied annually to landings (the sum of ICES landings statistics, plus adjustments, plus unreported landings) from 1950-2007.

Table 8. Default anchor points in % based on sources (Table 2.3.6 and Figure 2.3.1 in ICES, 2008a; Table 2.3.1 in ICES, 2007) and assumed default anchor points used to estimate boat-based discards for western cod in Denmark, 1950-2007.

Year	Discard Rate (%)	Year	Discard Rate (%)
1950-1969	65.0[a]	1989	7.8
1970	71.5	1990	7.9
1971	57.0	1991	9.6
1972	66.9	1992	19.2
1973	21.3	1993	14.5
1974	42.6	1994	10.6
1975	22.4	1995	11.3
1976	18.3	1996	15.7
1977	25.6	1997	10.0
1978	27.5	1998	17.4
1979	10.8	1999	11.6
1980	17.1	2000	12.5
1981	13.8	2001	11.2
1982	35.3	2002	10.4
1983	40.7	2003	15.8
1984	17.9	2004	10.1
1985	7.2	2005	18.6
1986	15.3	2006	8.6
1987	20.8	2007	8.3
1988	10.2		

[a] three-year average, 1970-1972, applied as a constant.

Recreational catches

Two groups of recreational fishers appear prevalent in Denmark: i) an angling population of approximately 650,000 who fish primarily with rod, line, net etc.; and ii) a gillnetting population of approximately 33,000 who fish with fixed gear (mainly gillnet; K. Manniche Ebert, pers. comm., Danmarks Sportsfiskerforbund). We used information from a Danish study to estimate the number of recreational fishers who fish specifically in the Baltic Sea. These numbers were combined with the catch rate (i.e., catch · fisher^{-1}) to estimate total recreational catches for the period from 1950 to 2007 (Anon., 1998). Since no catch rates were available specifically for Denmark we used Swedish data to estimate a catch rate per angler or gillnetter for each species targeted by recreational fishers (Anon., 2007b).

The number of anglers in Denmark was reported to be 650,000 in 1996, which was assumed to be representative for the 1996-2007 time period (Table 10; S. Ulnitz, pers. comm., Steen Ulnits). Prior to 1996, we used our anchor point of 650,000 to interpolate the number of fishers back to 1950 in accordance to growth in the Danish population (Table 10), with the assumption that the proportion of anglers in the population in 1950 was 10% less:

Number of anglers in 1950 = (No. of anglers in 1996/Population in 1996) x Population in 1950 x 0.9

The number of gillnetters were reported for the period, 1999-2007 by Fiskeridirektoratet (2007), and ranged from 33,575 to 34,473 during this time period (Table 11). The number of gillnetters in 1999 was carried back as a fixed rate from 1950-1998 (Table 11).This is thought to provide a conservative estimate since there were more gillnetters in the past than the most recent decade (Anon., 2009a).

Table 9. Default anchor points in % based on source (Table 2.1.2 in ICES, 2008a) used to estimate boat-based discards for salmon in Denmark, 1950-2007.

Year	Discard Rate (%)	Year	Discard Rate (%)
1950-1980	14.4[a]	1994	12.9
1981	14.0	1995	13.9
1982	14.1	1996	15.1
1983	15.3	1997	14.9
1984	13.9	1998	8.6
1985	13.3	1999	8.8
1986	14.9	2000	5.8
1987	14.5	2001	9.1
1988	14.7	2002	9.6
1989	15.3	2003	9.8
1990	17.3	2004	9.1
1991	13.6	2005	8.8
1992	14.1	2006	10.0
1993	14.1	2007	10.0

[a] three year average, 1981-1983.

Table 10. Anchor points and assumption based numbers of Danish anglers (1950-2007). Dashed line (-) indicates years wen linear interpolations were done. Data sources: (Folketal efter hovedlandsdele (2009); K. Manniche Ebert, pers. comm., Danmarks Sportsfiskerforbund).

Year	Danish population	No. of Danish anglers
1950	4,281,275	476,963[a]
1951-1995	-	-
1996	5,251,027	650,000
1997-2007	-	650,000[b]

[a] assumed 10% less than in 1996; [b] assumed constant from 1996; [c] assumed constant from 1999; [d] assumed constant from 2006.

It was reported that 72% of Danish recreational fishers fish in the marine environment, and that 45% of these fish in the Baltic Sea (Anon., 1998; 1998). Thus, the number of Danish anglers and gillnetters were apportioned appropriately. Catch rates were derived from the Swedish Fiskeriverket (2007), which reported tonnages for cod, garfish, herring, plaice, flounder, trout, pike and others, fished by approximately 40,000 Swedish recreational fishers. Since the ratio of anglers to gillnetters in Sweden was unknown, we assumed the proportions to be equivalent to those in Denmark (95.6% anglers, 4.4% gillnetters). The resulting number of anglers and gillnetters were used to derive catch rates in the Swedish recreational study (Table 12). The Danish Gallup study (1996) reported 42% of flatfish caught were flounder, and 58% were plaice. We applied these proportions to our reconstruction of recreational catches of flatfish.

The number of recreational fishers in each year was multiplied by the catch rate of each species to estimate the annual recreational catch for the two groups of fishers as,

$$\text{Danish recreational catch} = (\text{No. of recreational fishers}) \times 0.72 \times 0.45 \times (\text{Swedish catch rate})_i$$

where the Danish recreational catch (t) for species *i* is derived annually as the product of the number of gillnetters or anglers in that year (Table 11), the proportion of gillnetters or anglers fishing in the Baltic marine environment (0.72 x 0.45), and the catch rate derived for species *i* from the Swedish recreational fishing study, in t·fisher^{-1} (Table 12).

Table 11. Anchor points and assumption-based numbers of Danish gillnetters for the (1950-2007). Data source: Fiskeridirektoratet (2007).

Year	No. of Danish Gillnetters
1950-1998	33,575[a]
1999	33,575
2000	31,709
2001	33,715
2002	33,888
2003	33,516
2004	33,473
2005	33,430
2006	34,277
2007	34,277[b]

[a] assumed constant from 1999;
[b] assumed constant from 2006.

RESULTS

We present data accounting for Denmark's total marine fisheries catches in the Baltic Sea for the period 1950-2007. Our reconstruction used ICES landings statistics as baseline data and estimated various forms of Illegal, Unallocated and Unregulated (IUU) catches in Denmark. Our added estimates of IUU to ICES landings statistics were comprised of four components: i) adjustments to reported landings derived from ICES stock assessment working group reports; ii) additions of unreported ('unallocated') catches derived from national sources and ICES stock assessment working group reports; iii) discarded catches derived from a variety of auxiliary data sources; and iv) recreational catches derived from Danish and Swedish studies.

Our reconstruction focused upon the main commercially targeted species: cod (eastern and western stocks), Atlantic herring, European sprat, Atlantic salmon, flatfishes, and a miscellaneous group 'others.'

ICES landings statistics

The 'ICES landings statistics' database reported a total of 6.8 million tonnes from 1950-2007 (Figure 2). This total includes all marine and brackish water fishes and invertebrates, but excludes all aquatic plants. Reported landings peaked during the late 1990s (Figure 2) and between 1990 and 1999, landings amounted to approximately 1.7 million tonnes, which was the highest decadal total during the period, 1950-2007. In general, cod dominated landings for the period, 1950-2007, however, decadal totals of sprat exceeded those of cod after 1990. In the 1950s, cod accounted for 48% of all landings. In the 1980s, cod accounted for 62% of landings, and in the

Table 12. Catch rates by species derived for anglers from recreational gear data from Gallup (1996) and recreational catch data from Fiskeriverket (2007).

Common name	Catch rate (t·angler^{-1}) Rods, nets, etc.	Catch rate (t·fisher^{-1}) Fixed gears
Cod	0.0114	0.051
Garfish	0.0037	0.004
Herring	0.0021	0.054
Flatfish (flounder & plaice)	0.0007	0.033
Sea trout	0.0011	n/a
Northern pike	0.0006	n/a
'Others'	0.0012	0.006

n/a: not applicable (i.e. not caught by recreational fishers).

most recent decade (2000-2007), cod accounted for only 18% of all landings reported by the ICES landings statistics. While reported landings of herring and flatfishes remained relatively stable throughout the period, 1950-2007, those of sprat increased steadily from only 15,591 t in the 1950s (3% of reported landings of all species in the 1950s) to more than 700,000 t in the 1990s (42% of reported landings for all species in the 1990s). In the most recent decade (2000-2007), sprat landings totaled 375,481 t, accounting for 38% of all reported landings.

Illegal, Unreported and Unregulated (IUU) catches

IUU catches which included adjustments, unreported landings, discards and recreational catches totaled an approximate estimate of 2.8 million tonnes over the period 1950-2007. Presented below are the individual components and their respective contributions to our total estimate of IUU for Denmark.

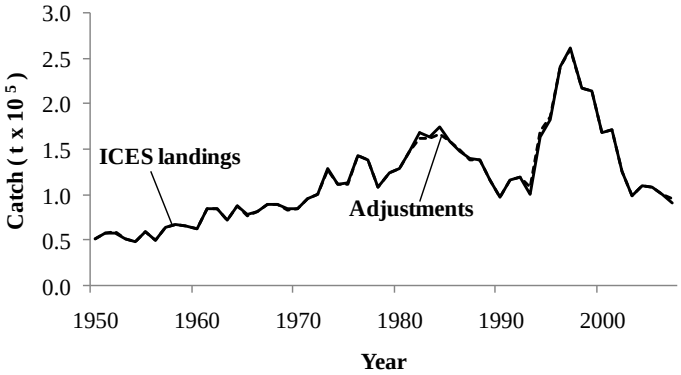

Figure 2. Adjustments to officially reported landings from the 'ICES landings statistics' for Denmark (1950-2007).

Adjustments to reported landings

Cod received the largest amount of adjustments to ICES reported landings statistics. Between 1960 and 1989, a total of approximately -30,000 t of adjustments were made to the officially reported landings (Figure 2). After 1990, a total of 17,000 t of adjustments were made to reported landings (Table 13). Flatfishes had the second largest amount of adjustments to reported landings (Table 13). The most significant period for this group was also during the 1960s-1980s (Figure 2), when a total of 1,891 t were added (Table 13). When summed, adjustments to flatfish landings from 1950 to 2007 added approximately 4.8% to landings of flatfishes reported by ICES landings statistics (Appendix Table A1).

Table 13. Decadal totals of adjustments (from ICES stock assessment working group reports) added to officially reported landings from the 'ICES landing statistics' database for cod, flatfishes, and salmon in Denmark.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	0	-4,057	-7,031	-18,010	13,161	3,840
Flatfishes	0	1,007	600	284	271	79
Salmon	0	0	0	886	390	87

A total of 1,364 t were added to reported salmon landings between 1980 and 2007 (Table 13). No adjustments were made to reported landing of herring, sprat and 'others' (see methods). Adjustments for all species were approximately -8,500 t for the period 1950-2007, reducing officially reported landings by approximately 0.13%.

Unreported landings

Unreported landings for all taxonomic entities totaled an approximate estimate of 1.3 million tonnes for the period, 1950-2007 (Figure 3), which added approximately 19.6% to landings officially reported by ICES for all species (1950-2007).

Cod had the most significant quantity of additions in this category (Table 14). Unreported landings for cod peaked during the 1980s (totaling about 365,000 t, adding approximately 39% to officially reported landings for cod in the 1980s [Table 14]), and

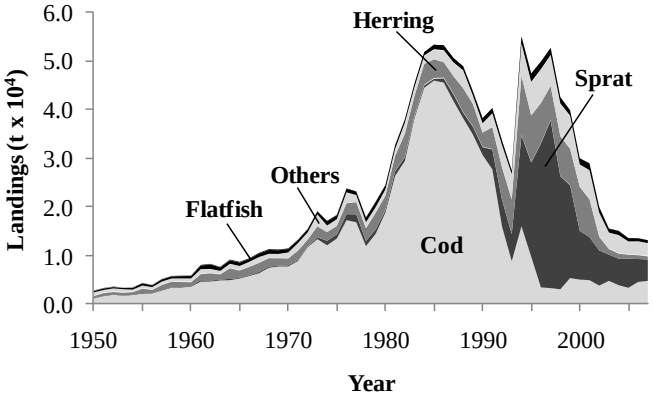

Figure 3. Total unreported catch by taxa for Denmark (1950-2007).

decreased to a total of approximately 35,000 t between 2000 and 2007 (Table 14). Unreported landings of cod totaled approximately 731,000 t for the period, 1950-2007 (Table 14), which comprised 55% of Unreported landings for all taxa during the period, 1950-2007 (Figure 3), and 29% of cod landings reported by ICES landings statistics between 1950 and 2007.

Table 14. Total unreported landings (t), for cod, herring, sprat, flatfishes, salmon and 'others' by decade in Denmark from 1950-2007.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	22,558	55,560	128,267	365,139	124,588	35,380
Herring	7,522	15,239	21,112	39,374	73,616	23,947
Sprat	909	2,110	7,503	8,230	161,580	52,191
Flatfishes	3,523	7,050	7,489	8,170	12,008	7,275
Salmon	560	1,234	1,020	1,249	1,253	360
'Others'	5,391	8,064	14,564	20,273	54,150	30,173

Sprat was also found to have significant quantities of unreported landings. The total unreported landings for sprat totaled approximately 232,000 t between 1950 and 2007, representing about 17.5% of the total unreported catch for all species during this period. Total unreported landings of sprat were greatest during the 1990s, totaling about 161,000 t, as compared to decadal totals on average of about 14,000 t for all other decades (Table 14).

Unreported landings of herring peaked in the 1990s (Figure 3) with a total of approximately 74,000 t (Table 14), a decadal total almost ten times greater than that of the 1950s (Table 14). During the most recent time period, 2000-2007, unreported landings of herring had decreased to a total of about 24,000 t (Table 14).

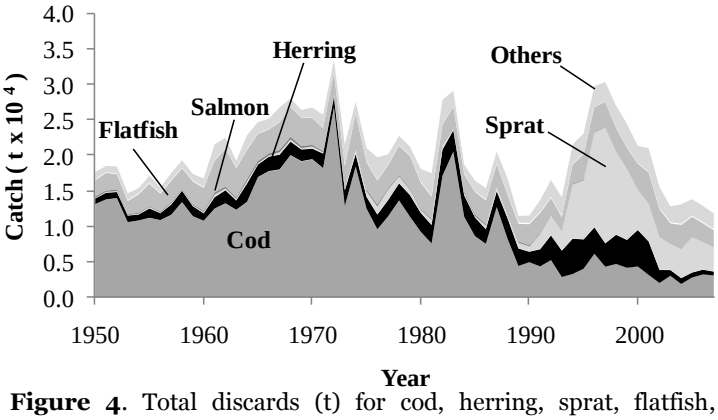

Figure 4. Total discards (t) for cod, herring, sprat, flatfish, salmon and 'others' in Denmark (1950-2007).

Unreported landings of flatfishes, salmon and 'others' were of minor importance. The combined total for these three groups was 183,806 t for the period, 1950-2007 (Table 14). These three entities combined comprised about 14% of unreported landings for all species during this period (1950-2007). Individually, flatfishes represented 3.4%, salmon 0.4%, and 'others' approximately 10% of all unreported landings for the period, 1950-2007. Unreported landings of flatfishes and 'others' peaked in the 1990s (Table 14; Figure 3) while unreported landings of salmon appear to have been highest from the 1960s through to the 1990s (Table 14).

Discards

Discarding was estimated to have been greatest during the 1960s and 1970s, with decadal totals of over 230,000 t (Table 15). Discards peaked in 1972 at 33,339 t (Fgure 4). During the 1970-1979- period, total discards of cod comprised 65% of the discards of all species, and the discards of flatfishes comprised 16% of the discards of all species. Herring, sprat, salmon and 'others' made up the remaining 19% (Table 15).

Table 15. Total discards (t) in Denmark, by decade, for cod, herring, sprat, flatfishes, salmon and 'others'.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cods	122,127	155,788	155,317	107,926	44,002	24,266
Herring	10,841	17,396	19,883	26,385	34,223	14,979
Sprat	1,320	2,434	6,961	5,323	74,519	36,214
Flatfishes	26,163	40,186	36,096	28,610	28,536	25,532
Salmons	1,668	2,827	1,957	1,654	1,075	296
'Others'	9,302	15,075	18,360	19,450	24,891	20,413

In the 1990s and 2000s, the species composition of discards changed significantly (Figure 4). During this time, discards of sprat increased from a total of about 5,300 t in the 1980s, to a total of about 74,500 t in the 1990s (Table 15). Cod was second to sprat with a total of approximately 44,000 t of discards in the 1990s, closely followed by discard totals of herring, flatfishes, 'others,' and salmon (Table 15).

Overall, discards of cod comprised approximately 53% of all discards, and flatfishes approximately 16% of the discards of all species for the period 1950-2007. Herring (10.7%), sprat (10.9%), salmon (0.8%) and 'others' (9.3%) were all minor contributors to discards (1950-2007).

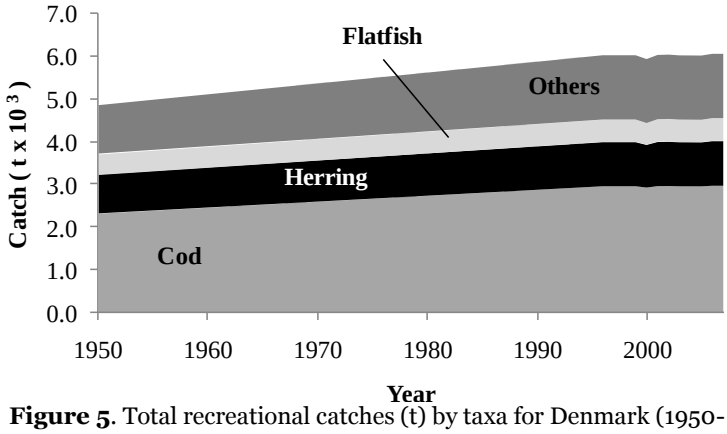

Figure 5. Total recreational catches (t) by taxa for Denmark (1950-2007).

Recreational catches

Recreational catches were estimated for cod, herring, flatfishes and 'others', but not for sprat and salmon. From 1950-2007, recreational catches of cod, herring, flatfishes and 'others' totaled approximately 321,600 t (Figure 5). These estimates added approximately 6% to the total officially reported landings by ICES for these species (1950-2007). Cod made up the majority of recreational catches (1950-2007). Recreational cod catches peaked in the 1990s with a total of about 29,000 t (Table 16); however, decadal totals were fairly consistent, ranging between 23,687 t and 29,323 t (1950-2007; Table 16).

Table 16. Total recreational catch (t) by decade for cod, herring, sprat, flatfishes, salmon and 'others' for Denmark.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	23,835	25,228	26,621	28,014	29,323	23,687
Herring	9,322	9,581	9,839	10,097	10,340	8,310
Flatfishes	4,741	4,827	4,913	4,999	5,080	4,075
'Others'	11,727	12,536	13,346	14,156	14,917	12,068

Recreational catches of 'others' included garfish (*Belone belone*), sea trout (*Salmo trutta trutta*), northern pike (*Esox lucius*) and a group of miscellaneous finfishes. Decadal totals of 'others' remained very consistent over the period of study (1950-2007), peaking during the 1990s (Table 16), and averaged approximately 13,000 t·decade^{-1} (1950-2007). Herring and flatfishes had less significant contributions to the overall recreational catch (Figure 5), with averages of approximately 9,600 t and 4,800 t respectively.

Total reconstructed catch

Our catch reconstruction from 1950 to 2007 for all species totaled an approximately 9.6 million t, and included reported landings from ICES landings statistics, our adjustments to those landings, unreported landings, discards, and recreational catches from 1950 to 2007 (Figure 6). Of this, our additions of IUU (adjustments, unreported, discards and recreational) totaled approximately 2.8 million t, which added approx. 41% to landings officially reported by ICES (Figure 7; Appendix Table A1).

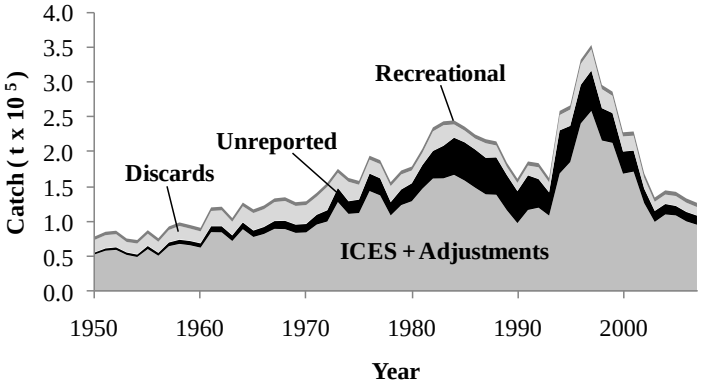

Figure 6. Total reconstruction (t) for Denmark (1950-2007) including data from 'ICES landings statistics' and all aspects of IUU: i) adjustments added to reported landings; ii) unreported landings; iii) discards; and iv) recreational catches.

Considering our estimates of IUU as proportions of our total catch

reconstruction (1950-2007), 0.1% were accounted for by adjustments, 14% by unreported landings, 12% by discarded catches, and 3% by recreational catches (Table 17). Thus, unreported catches and discards were found to be the greatest components of IUU. Both unreported and discarded catches were dominated in overall tonnage by cod. However, discards of flatfishes were more significant in proportion to the overall catch; accounting for about 28% of the total reconstructed catch for flatfishes, as opposed to discards accounting for only 14% of the overall reconstructed catch for cod.

Table 17. Total reconstructed catch (t) by component (ICES landings statistics, adjustments, unreported landings, discards and recreational catches), by decade for Denmark.

Component	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
ICES landings	586,470	824,070	1,158,534	1,493,213	1,721,203	982,679
Adjustments	0	-3,050	-6,431	-16,840	13,822	4,006
Unreported	40,461	89,257	179,956	442,434	427,195	149,325
Discards	171,421	233,706	238,573	189,348	207,247	121,700
Recreational	49,625	52,172	54,719	57,266	59,660	48,140

Overall, reconstructed catches estimated for Denmark increased from a minimum of about 848,000 t in the 1950s and peaked in the 1990s with a total of approximately 2.4 million tonnes. Total catches in the most recent decade (2000-2007) were estimated to total of 1.3 million tonnes (Figure 7; Table 18). During the 1990s when the total reconstructed catch peaked, the majority (39%) of catches were comprised of sprat, and secondly (24%), by cod (Table 18). In the most recent decade (between 2000 and 2007), the overall catch was dominated by sprat, and secondly by both cod and 'others', followed by herring, flatfishes and salmon (Table 18).

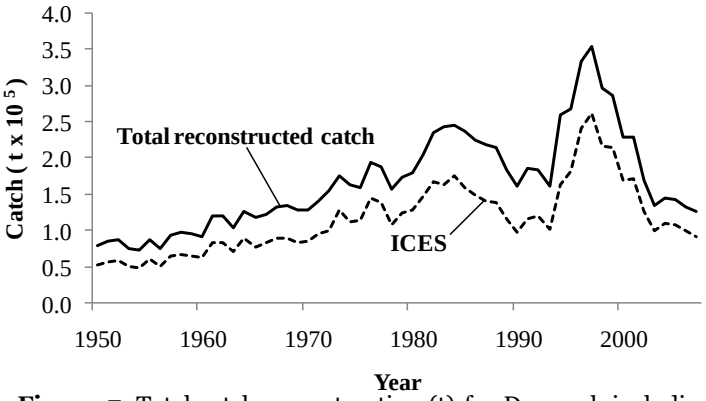

Figure 7. Total catch reconstruction (t) for Denmark including 'ICES landings statistics' and additions of IUU: i) adjustments; ii) unreported landings; iii) discards; and iv) recreational catches.

Table 18. Total reconstructed catch (t) by decade for cod, herring, sprat, flatfishes, salmon and 'others' in Denmark.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	447,164	611,233	906,919	1,413,12	572,918	271,831
Herring	155,677	244,429	278,256	368,180	452,154	198,415
Sprat	17,819	32,856	93,970	72,486	954,449	463,886
Flatfishes	94,875	146,386	129,561	102,744	100,888	88,891
Salmon	12,035	20,397	14,117	11,996	8,129	3,133
'Others'	120,406	140,855	202,528	196,894	340,589	279,695

DISCUSSION

Our reconstruction of Denmark's total catch from 1950 to 2007, including reported landings from ICES landings statistics, adjustments to landings, unreported landings, discards and recreational catches totaled approximately 9.6 million tonnes. The total landings reported to ICES on behalf of Denmark were approximately 6.8 million tonnes between 1950 and 2007. Thus, accounting for total catches, added 41% to reported landings. This discrepancy misleads the public and complicates decisions for scientists and policy makers who must rely on incomplete or underestimated catch records when setting TACs or deciding upon other management strategies (closures, gear restrictions, etc.). Our total catch reconstruction is thought to not overestimate catches, as all calculations were based on conservative assumptions. Though our estimate of Denmark's total catch is not statistically 'accurate', it provides a more accurate baseline than the current assumption of zero IUU catches which is presented in ICES landings statistics. Thus, our catch reconstruction for Denmark provides an estimate of the total catch between 1950 and 2007, accounting for all fisheries sectors, with methods used successfully in Zeller *et al.* (2006), Zeller and Pauly (2007), and Zeller *et al.* (2007).

Our catch reconstruction showed cod to be the species most affected by IUU fishing. Adjustments to reported landings, and estimates of unreported landings, discards and recreational catches of cod totaled approximately 1.5 million tonnes between 1950 and 2007. The majority of this total was represented by

unreported landings (~731,500 tonnes). In comparison, IUU catches between 1950 and 2007 totaled only about 360,000 tonnes each for herring and sprat, the majority of which were also unreported landings. Denmark contributes substantially to the total IUU of cod in the Baltic, and is also one of three countries to receive the greatest share of the TAC for Baltic cod. In Denmark, avoiding inspection and underreporting of catches were known to be a significant problem beginning in the 1980s (Holm, 2003; Sandbeck, 2003). Tactics included lookouts in ports and at the homes of inspectors to forewarn of inspection activity, and mobile phone scanners to monitor dialogue between inspectors (Anon., 2007c).

Though Poland has been noted (in our study and others) as perhaps the main culprit of IUU cod fishing in the Baltic, officials and industry representatives in Denmark have expressed far less admittance of the problem than in Poland (Bale *et al*., this volume). In the EU, it is the responsibility of the Member State to enforce and impose infringements for violations of the CFP. In 2003, Denmark imposed 485 infringements considered to be serious (this was 59% of the total number of infringements and the average fine was a very modest €455). When the European Commission believes a Member State is not fulfilling its duty to enforce CFP regulations, the matter can be taken to court. In 2004, 10 procedures were initiated against Denmark for exceeding designated fishing quotas (Anon., 2007c).

About 41% of our total estimate of IUU for Denmark was represented by discards, with cod comprising the majority. However, discards of flatfishes, though found to be less significant by volume (when compared to cod), may be of notable concern. Approximately 28% of the total reconstructed catch of flatfishes was comprised of discards, as compared to just 14% of the total reconstructed catch of cod. Flatfishes are usually bycatch of the trawl fishery that targets cod (Anon., 2007c). With the value of cod being relatively high in comparison to other species, there could be significant economic incentive to high-grade or discard both of these taxa to increase profit.

In contrast, herring and sprat catches deliver little economic incentive for IUU behaviors; given that high quantities and relatively low qualities are required for industrial processing. Discards of herring and sprat amounted to similar volumes to those of flatfishes (each about 125,000 tonnes between 1950 and 2007); however, given that the total catch of flatfishes was much lower, the rate flatfishes are being discarded appears to be of particular concern. Recently, Denmark submitted a proposal to the EU Fisheries Council that would require all Danish catches to count against fishers' quotas to curb discarding of fish at sea. The rule would require onboard observer coverage or video recording and fishers would be forced to return to port sooner. This would have the effect of fulfilling quotas more quickly with fish of lesser quality, and thus less value, than if selective high-grading had occurred. To make up for some lost revenue, fishers would be allowed to land more fish than in the recent past (Anon., 2009d). This motive encourages transparency between fishers, and officials while reducing overall fishing effort. These are both necessary aspects of designing a sustainable fishery in the Baltic Sea. Currently, to stay under quota, fishers discard approximately half of what they catch, most of which dies, increasing the overall fishing effort substantially (Anon., 2009b).

Overall, cod formed the bulk of Denmark's reconstructed catch between 1950 and 2007. Since 1980 however, cod catches have declined, while those of herring and sprat initially increased. However, but herring catches have declined substantially in the most recent decade. Both growth rates and the overall abundance of herring began declining noticeably since the 1980s-1990s due to the influence of climate on their preferred prey (MacKenzie *et al.,* 2002). High levels of dioxins were found in herring in the early 2000s, and in 2004, Denmark closed the herring fishery in the eastern Baltic. Large portions of the fishing areas east of Bornholm have also been closed since this time (Anon., 2009c). Although sprat abundance has increased since the 1980s, our reconstruction of sprat catches showed a decline into the 2000s. Sprat is caught as bycatch in the herring fishery, so declines in herring as a target species may have influenced the observed declines in the Danish sprat fishery.

Our study showed that a shift has occurred in the Baltic Sea where cod catches have declined and those of herring and sprat have increased and this demonstrates a decrease in the mean trophic level caught by Danish fisheries. This is an indicator of overexploitation which has been observed globally (Pauly *et al*., 1998). Increased abundances of herring and sprat have also been shown to have cascading effects within the Baltic Sea ecosystem, as these species predate heavily on zooplankton, leaving more phytoplankton biomass, which increases the potential for eutrophication (Casini *et al*., 2008). Herring and sprat forage on the eggs and larvae of cod, further hampering recovery of cod stocks, and a healthy cod population has been noted as a prerequisite to healthy populations of both herring and sprat (MacKenzie *et al*., 2002).

Although increases in cod abundance have not yet elevated stocks beyond historically low levels and are insufficient for long-term sustainability, the European Commission has proposed raising the TAC for cod by 15% in 2010 (Veem, 2009), which may further exacerbate the disequilibrium in the ecosystem of the Baltic Sea, by keeping cod at low levels. The methods used in our catch reconstruction for Denmark in the Baltic Sea used all the information that was accessible to the project to correct misreported catches and estimate various forms of IUU. Apart from boat-based discards of flatfishes and whiting in Denmark (which were found in nationally-sourced data), the majority of our estimates of IUU were derived from Baltic-wide data presented in ICES stock assessment working group reports. Because some countries report discards and unreported landings while others do not, it was impossible to know which countries contributed to the amounts presented in ICES reports. Therefore, our derived rates were likely underestimates, since our derived rates were weighted by reported landings from all Baltic nations (see methods). Though ICES, as the scientific advising body, has access to more details with regards to IUU fishing than we experienced, confidentiality agreements prevent the presentation of this data to the public and general scientific community. Thus, our study, and more often the public's understanding of the health of common fish stocks, is compromised by this lack in transparency of the total fisheries catches and overall impacts on the Baltic marine ecosystem. In order to attain a management system based on ecosystem principles, it will be necessary to have more complete baseline fisheries data, so all aspects of the ecosystem can be assessed thoroughly to help ensure long-term sustainability.

One effort to encourage a cooperative environment emphasizing transparency in the Baltic has been the requirement for Vessel Monitoring Systems (VMS) on all larger vessels. However, tampering with these devices is not uncommon. When a vessel stops transmitting and tampering is likely to have occurred, the vessel is often able to make unreported landings before being inspected. In order for VMS to be used to its potential, adequate inspection and cross-checking is necessary. Another initiative has been electronic logbooking. Denmark was one of the first countries to use this system in an effort to generate 'real-time' report data complemented by a cross-check of records at the point of sale. However, in 2000-2002, the European Commission found a loophole in the system, such that fishers and sellers coordinated the details of their reports, allowing unreported landings to persist. This was documented to have occurred for both cod landings in Bornholm and mackerel landings in Jutland (Anon., 2007c).

Currently, a major problem is that TACs are set too high. ICES provides scientific recommendations which are often overridden by the governing body of concern (the European Commission for all countries fishing in the Baltic Sea except Russia) due to immediate socio-economic concerns. Compliance with CFP regulations is often low, in part because many fishers disagree with the research methods used by scientists. Fishers also feel they have a better understanding of the natural fluctuations in fish stocks and safe fishing quotas. Co-management of fisheries resources has been discussed widely, as fishers who play a greater role within the decision-making processes are more likely to comply with fishing regulations. A study by Haapasaari *et al.* (2007) presented assessment models to evaluate stakeholders' opinions, perceptions, and the resulting behaviors, of various management measures to evaluate fishers' potential to comply with fishing regulations, and the overall impact on fish stocks. Their results indicated that fishers who have the opportunity to participate in management have enhanced commitment to sustainable exploitation of fish stocks. The Baltic Sea has been noted as a fishing area with significant potential for a cooperative management scheme, given the unique political and geographical circumstances of the region (Veem *et al.*, 2009). Total observer coverage would also contribute substantially to the transparency of fishers' behaviors at sea, and reduce the likelihood of misreported landings (Branch, 2006).

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APPENDIX A

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

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	53,429	0	2,671	17,668	4,848	78,616
1951	58,621	0	3,186	18,519	4,873	85,199
1952	59,819	0	3,487	18,453	4,899	86,658
1953	52,584	0	3,271	14,633	4,924	75,412
1954	49,592	0	3,312	15,372	4,950	73,226
1955	60,962	0	4,239	17,156	4,975	87,332
1956	51,411	0	3,831	15,439	5,001	75,681
1957	65,129	0	5,054	17,494	5,026	92,703
1958	68,432	0	5,679	19,306	5,052	98,469
1959	66,491	0	5,733	17,381	5,077	94,682
1960	63,073	0	5,774	16,718	5,103	90,668
1961	85,323	0	7,962	21,536	5,128	119,949
1962	85,083	0	8,176	22,467	5,154	120,879
1963	72,611	0	7,553	19,226	5,179	104,569
1964	89,572	0	9,057	22,828	5,204	126,662
1965	79,116	-677	8,597	24,663	5,230	116,929
1966	83,362	-623	9,341	25,128	5,255	122,463
1967	90,862	-739	10,451	26,755	5,281	132,610
1968	90,062	-336	11,208	28,014	5,306	134,254
1969	85,008	-675	11,137	26,371	5,332	127,173
1970	85,549	-541	11,365	26,711	5,357	128,441
1971	97,057	-732	13,175	25,689	5,383	140,571
1972	101,338	-614	15,371	33,339	5,408	154,843
1973	129,477	-706	19,044	21,356	5,434	174,605
1974	112,566	-849	17,071	27,425	5,459	161,672
1975	114,212	-1,336	18,268	20,867	5,485	157,496
1976	144,583	0	23,757	19,556	5,510	193,406
1977	139,316	-990	23,138	19,984	5,536	186,984
1978	109,736	-296	17,762	22,591	5,561	155,354
1979	124,700	-367	21,006	21,055	5,586	171,980
1980	129,547	400	24,434	17,939	5,612	177,932
1981	148,450	-507	32,649	17,315	5,637	203,545
1982	168,900	-6,303	37,954	27,638	5,663	233,852
1983	164,093	-1,238	45,421	28,955	5,688	242,918
1984	175,516	-7,596	51,888	18,494	5,714	244,015
1985	159,671	13	53,429	16,210	5,739	235,061
1986	149,015	383	53,263	15,136	5,765	223,562
1987	141,541	-1,700	50,663	20,301	5,790	216,596
1988	139,507	-277	48,949	16,316	5,816	210,310
1989	116,973	-15	43,785	11,044	5,841	177,628
1990	98,396	-2	38,249	10,995	5,867	153,504
1991	117,365	-34	40,326	13,109	5,892	176,658
1992	120,557	22	33,629	15,963	5,918	176,088
1993	101,879	7,327	27,460	13,576	5,943	156,185
1994	164,901	4,984	55,111	21,057	5,969	252,021
1995	182,722	3,637	47,448	22,619	5,994	262,420
1996	241,943	-11	49,888	29,269	6,019	327,109
1997	262,030	-2,032	52,697	29,863	6,019	348,577
1998	217,356	11	42,529	26,634	6,019	292,549
1999	214,054	-80	39,858	24,163	6,019	284,015
2000	169,565	3	29,966	21,143	5,929	226,606
2001	172,506	33	28,902	20,868	6,026	228,335
2002	127,272	-1	19,913	15,415	6,035	168,634
2003	100,142	-20	15,474	12,768	6,017	134,380
2004	110,814	27	15,008	13,065	6,015	144,929
2005	109,388	85	13,507	13,793	6,012	142,786
2006	100,829	16	13,481	12,849	6,053	133,228
2007	92,165	3,863	13,074	11,798	6,053	126,954

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

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	24,357	0	1,218	13,242	2,321	41,138
1951	29,412	0	1,667	13,912	2,335	47,325
1952	30,624	0	1,940	14,104	2,349	49,016
1953	25,216	0	1,765	10,711	2,363	40,055
1954	24,599	0	1,886	10,951	2,377	39,813
1955	26,267	0	2,189	11,331	2,390	42,177
1956	24,824	0	2,234	11,000	2,404	40,463
1957	29,198	0	2,822	11,757	2,418	46,196
1958	32,888	0	3,398	13,554	2,432	52,273
1959	31,260	0	3,439	11,564	2,446	48,709
1960	30,994	0	3,616	10,937	2,460	48,007
1961	37,671	0	4,646	12,648	2,474	57,439
1962	35,945	0	4,673	13,399	2,488	56,505
1963	35,851	0	4,900	12,483	2,502	55,735
1964	34,539	0	4,951	13,616	2,516	55,622
1965	35,990	-677	5,297	17,076	2,530	60,216
1966	37,693	-623	5,808	17,920	2,544	63,342
1967	39,844	-739	6,387	18,184	2,558	66,233
1968	45,024	-915	7,499	20,201	2,572	74,380
1969	45,164	-1,103	7,784	19,324	2,585	73,755
1970	43,443	-1,051	7,772	19,611	2,599	72,375
1971	47,563	-732	8,898	18,348	2,613	76,690
1972	60,331	-614	11,744	26,884	2,627	100,972
1973	66,846	-796	13,430	12,950	2,641	95,072
1974	58,659	-849	12,140	18,509	2,655	91,114
1975	63,860	-1,336	13,547	12,606	2,669	91,346
1976	77,570	0	17,324	9,678	2,683	107,255
1977	74,495	-990	16,906	11,519	2,697	104,627
1978	50,907	-296	11,978	13,745	2,711	79,044
1979	60,071	-367	14,528	11,467	2,725	88,424
1980	76,015	-486	18,882	9,329	2,739	106,478
1981	93,155	-507	26,471	7,690	2,753	129,562
1982	98,230	-6,303	29,548	17,193	2,767	141,435
1983	108,862	-1,238	38,437	20,601	2,780	169,443
1984	121,297	-7,596	44,668	11,452	2,794	172,616
1985	107,614	13	46,126	8,709	2,808	165,270
1986	98,081	383	45,715	7,635	2,822	154,636
1987	85,544	-1,700	41,922	12,798	2,836	141,400
1988	75,019	-277	38,363	8,180	2,850	124,135
1989	66,234	-299	35,006	4,339	2,864	108,144
1990	56,702	-2	30,778	4,759	2,878	95,115
1991	50,640	-34	27,825	4,191	2,892	85,514
1992	30,418	2	16,026	5,137	2,906	54,489
1993	10,919	6,748	8,860	2,848	2,920	32,295
1994	19,822	4,983	16,061	3,306	2,934	47,106
1995	34,612	3,592	9,806	4,118	2,948	55,075
1996	48,505	-11	3,459	6,211	2,962	61,125
1997	42,581	-2,032	3,319	4,397	2,962	51,226
1998	29,476	1	3,071	4,787	2,962	40,297
1999	38,169	-86	5,382	4,249	2,962	50,676
2000	32,049	-7	5,071	4,438	2,931	44,482
2001	29,126	24	4,954	3,247	2,964	40,315
2002	21,558	-15	3,841	2,113	2,967	30,464
2003	22,339	-36	4,812	3,130	2,961	33,206
2004	20,693	14	3,922	1,951	2,960	29,540
2005	19,044	-5	3,379	2,884	2,959	28,261
2006	21,425	1	4,586	3,315	2,973	32,300
2007	18,425	3,863	4,815	3,188	2,973	33,264

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

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	9,152	0	458	769	921	11,299
1951	10,861	0	565	914	923	13,263
1952	9,918	0	526	835	926	12,205
1953	10,712	0	589	904	928	13,134
1954	9,635	0	549	815	931	11,930
1955	15,272	0	901	1,294	934	18,400
1956	11,223	0	673	952	936	13,784
1957	16,581	0	1,028	1,409	939	19,956
1958	18,488	0	1,183	1,574	941	22,186
1959	16,150	0	1,050	1,376	944	19,520
1960	11,880	0	796	1,014	946	14,636
1961	18,399	0	1,270	1,573	949	22,191
1962	21,032	0	1,493	1,802	952	25,279
1963	14,991	0	1,079	1,286	954	18,310
1964	29,329	0	2,170	2,520	957	34,976
1965	20,058	0	1,524	1,727	959	24,268
1966	22,950	0	1,767	1,977	962	27,656
1967	23,550	0	1,860	2,033	965	28,408
1968	21,516	0	1,743	1,861	967	26,087
1969	18,508	0	1,536	1,604	970	22,617
1970	16,682	0	1,401	1,447	972	20,502
1971	23,087	0	1,985	2,006	975	28,053
1972	16,081	0	1,415	1,400	977	19,873
1973	24,834	0	2,210	2,164	980	30,188
1974	19,509	0	1,775	1,703	983	23,970
1975	18,295	0	1,701	1,600	985	22,581
1976	23,087	0	2,193	2,022	988	28,290
1977	25,467	0	2,445	2,233	990	31,135
1978	26,620	0	2,609	2,338	993	32,560
1979	33,761	0	3,376	2,971	996	41,104
1980	29,350	0	2,964	2,585	998	35,898
1981	28,424	0	3,098	2,522	1,001	35,045
1982	40,289	0	4,714	3,600	1,003	49,606
1983	32,657	0	4,082	2,939	1,006	40,684
1984	32,272	0	4,292	2,925	1,008	40,498
1985	27,847	0	3,899	2,540	1,011	35,296
1986	21,598	0	3,197	1,984	1,014	27,792
1987	23,283	0	3,632	2,149	1,016	30,080
1988	29,950	0	4,912	2,771	1,019	38,651
1989	26,654	0	4,584	2,371	1,021	34,631
1990	16,237	0	2,906	1,415	1,024	21,582
1991	23,995	0	4,487	2,319	1,026	31,827
1992	33,855	0	6,602	3,350	1,029	44,836
1993	34,945	0	7,094	3,575	1,032	46,646
1994	45,190	0	12,156	4,828	1,034	63,209
1995	37,762	0	9,592	4,016	1,037	52,407
1996	34,340	0	8,242	3,626	1,039	47,248
1997	30,876	0	6,947	3,210	1,039	42,072
1998	38,800	0	8,148	4,028	1,039	52,016
1999	37,974	0	7,443	3,856	1,039	50,312
2000	49,727	0	9,001	5,062	1,006	64,796
2001	46,297	0	7,732	4,656	1,042	59,727
2002	18,406	0	2,798	1,811	1,045	24,060
2003	8,254	0	1,131	791	1,038	11,214
2004	8,572	0	1,054	809	1,038	11,473
2005	7,175	0	804	678	1,037	9,693
2006	6,989	0	783	659	1,052	9,482
2007	5,760	0	645	512	1,052	7,969

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

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	1,051	0	53	88	0	1,192
1951	1,605	0	83	135	0	1,824
1952	1,711	0	91	144	0	1,946
1953	642	0	35	54	0	731
1954	1,623	0	93	137	0	1,853
1955	2,453	0	145	208	0	2,806
1956	1,115	0	67	95	0	1,276
1957	2,222	0	138	189	0	2,549
1958	1,373	0	88	117	0	1,578
1959	1,796	0	117	153	0	2,066
1960	2,118	0	142	181	0	2,441
1961	4,419	0	305	378	0	5,102
1962	3,100	0	220	266	0	3,586
1963	2,525	0	182	217	0	2,923
1964	3,890	0	288	334	0	4,512
1965	1,805	0	137	155	0	2,098
1966	1,816	0	140	156	0	2,112
1967	3,614	0	286	312	0	4,211
1968	3,108	0	252	269	0	3,629
1969	1,917	0	159	166	0	2,242
1970	2,948	0	248	256	0	3,451
1971	1,833	0	158	159	0	2,150
1972	1,602	0	141	139	0	1,882
1973	4,128	0	367	360	0	4,855
1974	10,246	0	932	894	0	12,073
1975	9,076	0	844	794	0	10,714
1976	13,046	0	1,239	1,143	0	15,428
1977	16,933	0	1,626	1,485	0	20,043
1978	10,797	0	1,058	948	0	12,804
1979	8,897	0	890	783	0	10,570
1980	4,714	0	476	415	0	5,605
1981	8,415	0	917	747	0	10,079
1982	6,663	0	780	595	0	8,038
1983	2,861	0	358	257	0	3,476
1984	3,450	0	459	313	0	4,222
1985	2,417	0	338	220	0	2,976
1986	5,693	0	843	523	0	7,058
1987	8,617	0	1,344	795	0	10,757
1988	6,869	0	1,127	635	0	8,631
1989	9,235	0	1,588	821	0	11,645
1990	8,858	0	1,586	772	0	11,215
1991	21,780	0	4,073	2,105	0	27,958
1992	28,210	0	5,501	2,791	0	36,502
1993	27,435	0	5,569	2,807	0	35,811
1994	69,644	0	18,734	7,441	0	95,820
1995	76,420	0	19,411	8,128	0	103,958
1996	123,549	0	29,652	13,047	0	166,247
1997	153,765	0	34,597	15,985	0	204,347
1998	111,003	0	23,311	11,524	0	145,838
1999	97,686	0	19,146	9,919	0	126,751
2000	55,521	0	10,049	5,652	0	71,223
2001	53,189	0	8,883	5,349	0	67,421
2002	47,630	0	7,240	4,687	0	59,557
2003	39,528	0	5,415	3,788	0	48,731
2004	44,289	0	5,448	4,180	0	53,917
2005	53,696	0	6,014	5,072	0	64,782
2006	42,323	0	4,740	3,988	0	51,051
2007	39,305	0	4,402	3,497	0	47,204

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

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	1,319	0	66	223	0	1,608
1951	1,099	0	57	186	0	1,342
1952	1,336	0	71	226	0	1,633
1953	760	0	42	129	0	931
1954	971	0	55	165	0	1,192
1955	615	0	36	105	0	756
1956	967	0	58	165	0	1,190
1957	899	0	56	154	0	1,108
1958	901	0	58	154	0	1,113
1959	940	0	61	161	0	1,162
1960	1,071	0	72	184	0	1,327
1961	1,672	0	115	288	0	2,075
1962	1,514	0	107	261	0	1,882
1963	1,142	0	82	197	0	1,421
1964	1,729	0	128	299	0	2,156
1965	1,954	0	149	338	0	2,441
1966	1,667	0	128	289	0	2,084
1967	1,931	0	153	335	0	2,419
1968	2,046	0	166	356	0	2,568
1969	1,610	0	134	281	0	2,024
1970	1,354	0	114	236	0	1,704
1971	1,050	0	90	183	0	1,324
1972	1,050	0	92	184	0	1,326
1973	1,128	0	100	198	0	1,426
1974	1,229	0	112	216	0	1,557
1975	1,215	0	113	214	0	1,542
1976	1,416	0	135	250	0	1,800
1977	1,015	0	97	179	0	1,291
1978	810	0	79	143	0	1,032
1979	873	0	87	155	0	1,115
1980	0	886	89	157	0	1,132
1981	863	0	94	149	0	1,106
1982	612	0	72	107	0	791
1983	697	0	87	133	0	917
1984	1,157	0	154	204	0	1,515
1985	1,375	0	193	235	0	1,802
1986	862	0	128	164	0	1,153
1987	966	0	151	180	0	1,297
1988	809	0	133	154	0	1,096
1989	866	0	149	170	0	1,186
1990	735	0	132	164	0	1,031
1991	635	0	119	115	0	869
1992	651	0	127	122	0	900
1993	201	374	117	109	0	801
1994	740	0	199	137	0	1,076
1995	557	0	141	108	0	806
1996	526	0	126	109	0	762
1997	492	0	111	99	0	702
1998	485	10	104	61	0	660
1999	389	7	77	50	0	522
2000	412	10	76	37	0	534
2001	434	9	74	56	0	573
2002	320	14	51	43	0	428
2003	439	16	62	59	0	575
2004	357	14	46	45	0	460
2005	204	11	24	25	0	263
2006	163	15	20	23	0	221
2007	64	0	7	8	0	79

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

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	5,136	0	257	2,279	470	8,142
1951	5,780	0	301	2,508	471	9,060
1952	4,943	0	262	2,144	472	7,821
1953	4,327	0	238	1,897	473	6,935
1954	6,150	0	351	2,578	474	9,552
1955	7,613	0	449	3,189	475	11,726
1956	5,864	0	352	2,505	475	9,196
1957	6,927	0	429	2,995	476	10,828
1958	6,616	0	423	2,903	477	10,419
1959	7,092	0	461	3,165	478	11,196
1960	7,465	0	500	3,224	479	11,668
1961	10,564	0	729	4,433	480	16,205
1962	12,821	0	910	5,281	481	19,493
1963	9,889	0	712	4,111	481	15,192
1964	9,593	0	710	4,053	482	14,838
1965	8,878	0	675	3,772	483	13,807
1966	7,591	0	585	3,320	484	11,979
1967	8,773	0	693	3,872	485	13,823
1968	9,048	579	780	4,154	486	15,046
1969	8,694	428	757	3,966	487	14,332
1970	7,938	510	710	3,740	487	13,385
1971	7,213	0	620	3,150	488	11,471
1972	6,817	0	600	3,022	489	10,928
1973	6,181	90	558	2,791	490	10,110
1974	9,686	0	881	4,477	491	15,536
1975	8,257	0	768	3,775	492	13,292
1976	7,572	0	719	3,337	493	12,121
1977	7,239	0	695	3,191	493	11,619
1978	9,184	0	900	4,114	494	14,692
1979	10,376	0	1,038	4,499	495	16,408
1980	8,276	0	836	3,627	496	13,235
1981	6,674	0	727	3,042	497	10,941
1982	5,819	0	681	2,709	498	9,707
1983	6,001	0	750	2,814	499	10,064
1984	5,165	0	687	2,408	499	8,760
1985	6,507	0	911	3,082	500	11,001
1986	6,810	0	1,008	3,279	501	11,599
1987	5,736	0	895	2,730	502	9,863
1988	5,094	0	835	2,477	503	8,909
1989	4,597	284	840	2,441	504	8,666
1990	5,685	0	1,018	2,867	505	10,074
1991	5,584	0	1,044	2,785	506	9,918
1992	4,578	20	897	2,210	506	8,210
1993	3,276	205	707	1,700	507	6,394
1994	5,099	1	1,372	2,632	508	9,611
1995	6,561	45	1,678	3,467	509	12,259
1996	6,394	1	1,535	3,419	510	11,858
1997	6,362	0	1,431	3,449	510	11,752
1998	5,868	0	1,232	3,181	510	10,791
1999	5,586	0	1,095	2,828	510	10,019
2000	7,000	0	1,267	3,579	490	12,336
2001	8,186	0	1,367	4,256	511	14,321
2002	7,482	0	1,137	3,798	513	12,931
2003	5,689	0	779	2,773	509	9,751
2004	6,823	0	839	3,329	509	11,499
2005	5,910	79	671	2,822	508	9,990
2006	5,486	0	614	2,569	517	9,187
2007	5,353	0	600	2,405	517	8,875

Appendix Table A7. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for the category 'others' for Denmark (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	12,414	0	621	1,067	1,136	15,238
1951	9,864	0	513	864	1,144	12,385
1952	11,287	0	599	999	1,152	14,037
1953	10,927	0	601	937	1,161	13,626
1954	6,614	0	378	726	1,169	8,887
1955	8,742	0	519	1,029	1,177	11,466
1956	7,418	0	447	723	1,185	9,772
1957	9,302	0	580	990	1,193	12,065
1958	8,166	0	528	1,005	1,201	10,900
1959	9,253	0	605	962	1,209	12,030
1960	9,545	0	648	1,178	1,217	12,589
1961	12,598	0	897	2,217	1,225	16,937
1962	10,671	0	772	1,459	1,233	14,135
1963	8,213	0	598	933	1,241	10,987
1964	10,492	0	811	2,005	1,250	14,558
1965	10,432	0	816	1,595	1,258	14,100
1966	11,644	0	914	1,465	1,266	15,289
1967	13,149	0	1,073	2,019	1,274	17,515
1968	9,320	0	770	1,173	1,282	12,544
1969	9,115	0	767	1,030	1,290	12,202
1970	13,184	0	1,120	1,421	1,298	17,024
1971	16,312	0	1,423	1,843	1,306	20,884
1972	15,457	0	1,378	1,711	1,314	19,860
1973	26,360	0	2,378	2,895	1,322	32,955
1974	13,237	0	1,230	1,626	1,331	17,423
1975	13,509	0	1,294	1,879	1,339	18,021
1976	21,892	0	2,147	3,125	1,347	28,510
1977	14,167	0	1,369	1,378	1,355	18,268
1978	11,418	0	1,138	1,303	1,363	15,221
1979	10,722	0	1,087	1,180	1,371	14,361
1980	11,192	0	1,186	1,826	1,379	15,583
1981	10,919	0	1,341	3,165	1,387	16,813
1982	17,287	0	2,160	3,432	1,395	24,275
1983	13,015	0	1,707	2,209	1,403	18,334
1984	12,175	0	1,627	1,192	1,412	16,406
1985	13,911	0	1,962	1,424	1,420	18,716
1986	15,971	0	2,373	1,552	1,428	21,324
1987	17,395	0	2,719	1,649	1,436	23,199
1988	21,766	0	3,579	2,100	1,444	28,888
1989	9,387	0	1,618	901	1,452	13,358
1990	10,179	0	1,829	1,018	1,460	14,487
1991	14,732	0	2,778	1,595	1,468	20,573
1992	22,845	0	4,477	2,354	1,476	31,152
1993	25,104	0	5,114	2,537	1,484	34,239
1994	24,406	0	6,589	2,712	1,492	35,200
1995	26,811	0	6,820	2,782	1,501	37,914
1996	28,629	0	6,875	2,857	1,509	39,869
1997	27,954	0	6,291	2,723	1,509	38,477
1998	31,724	0	6,663	3,051	1,509	42,946
1999	34,251	0	6,715	3,261	1,509	45,735
2000	24,856	0	4,501	2,374	1,503	33,234
2001	35,274	0	5,892	3,304	1,509	45,979
2002	31,876	0	4,846	2,961	1,510	41,193
2003	23,894	0	3,274	2,227	1,508	30,903
2004	30,081	0	3,700	2,751	1,508	38,040
2005	23,360	0	2,616	2,313	1,508	29,797
2006	24,443	0	2,738	2,295	1,511	30,987
2007	23,258	0	2,605	2,188	1,511	29,562

CATCH RECONSTRUCTION FOR ESTONIA IN THE BALTIC SEA FROM 1950–2007[1]

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ABSTRACT

We estimated the total marine fisheries catches taken by Estonia (including the USSR period) in the Baltic Sea from 1950-2007 using an approach called 'catch reconstruction'. Estonia-specific ICES landing statistics are available from 1991-2007, and these form the reported data baseline, to which we added disaggregated data from the USSR period for commercial landings as well as estimates of unreported commercial landings, discards, and recreational catches. Over the entire study period (1950-2007) the total reconstructed catch was estimated at 5.8 million tonnes. Our reconstruction for the period when ICES landings statistics are available for Estonia (1991-2007), yielded a cumulative catch of approximately 1.5 million tonnes. This is 300,000 t larger than the landings attributed to Estonia by ICES during this period. Our approach indicates that total catches since 1991 were approximately 28% higher than given by ICES, yet we believe this reconstruction represents a conservative estimate. The main species targeted by the commercial fisheries are cod (*Gadus morhua*), herring (*Clupea harengus*), and sprat (*Sprattus sprattus*).

INTRODUCTION

Estonia is a small country (45,100 km²) on the eastern edge of the Baltic Sea with a population estimated as 1,347,000 in 2005 (UN, 2008), which comprises approximately 0.46% of the total Baltic population. Estonia, which declared its independence from the USSR in August 1991, shares a border to the south with Latvia and an eastern border with the Russian Federation (Figure 1). Estonia has a 12 nautical mile territorial limit (within which only nationals are licensed to fish), although Estonian fishers have access to areas beyond this boundary (FAO, 2005). In recent years, the most important fisheries species have been herring (*Clupea harengus*), sprat (*Sprattus sprattus*), and Atlantic cod (*Gadus morhua*).

Figure 1. Map of the Baltic Sea with ICES subdivisions and surrounding countries. Estonia's coastline borders ICES subdivisions 28-1, 28-2, 29 and 32.

Estonia's fisheries can be divided into four segments: 1) Baltic open-sea fishing (trawling); 2) Baltic coastal small-scale fishing (using passive gears); 3) Distant Water Fleet fishing in the Atlantic; and 4) inland freshwater fishing.

1) The open-sea fishery in the Baltic targets herring and sprat using 20–25 m vessels left over from the Soviet era (late 1980s). In 2004, the number of vessels was approximately 150, two-thirds of which were

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large, steel trawlers, and one-third were smaller wooden trawlers. When Estonia was part of the USSR, it fished throughout most of the Baltic Sea and its landings were recorded as being taken from ICES Statistical Area IIId. Since the 1990s, Estonia has reported catches for ICES sub-divisions 22-32 within the Baltic. Some vessels also target Atlantic cod using trawlers and gill nets. These landings are mainly exported, for example in 2004 only 3% of this catch was sold in Estonia (Anon., 2007a).

2) The coastal fishery has historically been the most important fishery sector in Estonia, and has been providing a reliable protein source to households in coastal villages for centuries. There are an estimated 1,000 boats in operation, and they tend to be small (5 – 6 m long) with an outboard engine and only rely on passive gear such as gill nets, trap nets, and longlines. Brackish water species such as pikeperch (*Stizostedion lucioperca*), perch (*Perca fluviatilis*), and pike (*Esox lucius*) are targeted, in addition to purely marine fish such as flounders (*Platichthys flesus*), herring, garfish (*Belone belone*), sea trout (*Salmo trutta*), and whitefish (*Coregonus lavaretus*; Anon., 2007a). This fishery mainly operates within ICES subdivision 32 and a small area in the Gulf of Riga (ICES subdivision 28-1).

3) The Distant Water Fleet has declined in importance since the collapse of the USSR, decreasing from 100 vessels in 1991 to 11 in 2004. The remaining vessels are trawlers that operate in the Northwest Atlantic and target shrimp and fish to be processed on-board for export primarily to Iceland, Norway, Japan, and Canada (Anon., 2007a). This fishery is not considered further in this report.

4) The inland fishery is centered on the two big lakes in Estonia, Lake Peipsi and Lake Võrtsjärv. Fishers typically use gill nets, trap nets, longlines, and Danish seines to catch lake smelt (*Osmerus eperlanus*), pikeperch, perch, and pike. In comparison to the coastal fishery there are fewer license holders for this fishery, yet the full-time employment equivalent is similar. This fishery is not considered further in this report.

Between half (Anon., 2007a) and three-quarters (Ifremer, 2007) of Estonia's fish products are estimated to be exported to international markets, approximately 6% consumed directly by households within Estonia, and approximately 15% of catch sold to bulk sale enterprises (which re-distribute the catch among fish processors, exporters, or retailers). Estonia's reported landings currently account for approximately 9.5% of total reported landings in the Baltic Sea, and during the 1950 – 2007 time period considered here have on average accounted for approximately 7%.

Estonia has experienced several major political changes in the last century, and this has had an effect on the management of their fish stocks. At the beginning of the time series considered in this report Estonia was part of the USSR and as such, all fisheries catches were considered property of the state. The USSR exerted moderate pressure on the fish stocks in the Baltic, and the resources were likely under-utilized (Vetemaa *et al.*, 2002). Fishing was conducted by collective farms, and most of the fish was sold for artificially low prices to local markets, or transferred to other markets within the USSR (Vetemaa *et al.*, 2002; Vetemaa *et al.*, 2006).

After the dissolution of the USSR in the early 1990s, the fishing sector was privatized, and the fishing equipment was sold to fishers at low prices. Trade liberalization meant that fish could now be exported to western markets at higher prices than previously. This greatly increased fishers' income relative to other sectors of the Estonian economy. Not long after, however, ex-vessel prices reached a plateau and operational costs began increasing. The price of fuel, which used to be subsidized by the USSR, increased by a factor of 5 between 1993 and 2004, but the ex-vessel price of fish stagnated (Vetemaa *et al.*, 2006). In other sectors of the economy, incomes were rising, and these factors decreased fishers' relative and absolute wealth. In an effort to maintain their standard of living, many fishers put more pressure on stocks. This, coupled with ineffective resource management, resulted in a decline in the catch and health of the stocks that was first seen in some fishing sectors as early as the mid-1990s (see Vetemaa *et al.*, 2006 for a detailed review).

From 1991 to 1997, the portion of the Total Allowable Catch (TAC) in the Baltic that was allocated to Estonia by the International Baltic Sea Fishery Commission (IBFC) was larger than the capacity of the fishing fleet. For this reason every vessel was licensed to fish all that they could and fishing was essentially unregulated. At the end of 1997 it was estimated that with improvements in fishing technology, the capacity of the fleet would be larger than the TAC in 1998, and therefore new regulatory legislation was introduced (Vetemaa *et al.*, 2006).

From 1998 to 2001, a series of policy measures were implemented that were short-lived because many involved parties, particularly the fishers, found them unacceptable. Despite these regulatory measures, over-capacity of the Estonian trawler fleet reached approximately 25% in 2001 (Eero *et al.*, 2005). From 2001 to 2003 the Estonian fishing sector was managed by allocating 90% of fishing rights based on recent catch history (catches taken, and gear or fishing days used during the past 3 years), and 10% by auction. This approach aimed at stability, while still allowing for change and entry of new participants (Vetemaa *et al.*, 2002).

In 2002, Estonia was scheduled to have national elections, and began negotiations to enter the European Union (EU). The auction system had become unpopular with fishers because it decreased their profits, and the political parties running in the election realized that there were more people against the auctions than supporting them, thus they vowed to abolish it (Vetemaa *et al.*, 2005).

Estonia joined the EU in 2004, and receives its TAC for all internationally managed species through the EU Common Fisheries Policy (CFP) quota system. That quota is distributed to fishers on the basis of historical fishing right, based on the average of the last 3 years' actual catches, and is transferable between licensees. Commercial and recreational fishing, as well as crayfish collection, are subject to fishing right fees.

The objective of the present work is to estimate total catches (in contrast to reported landings) for Estonia, from 1950 – 2007. Components addressed in the present estimation include adjustments to ICES landings statistics, unreported catches, discards, and recreational catches. Focus is on utilizing available knowledge and information sources to derive estimated complete catch time series for all components, for Baltic Sea waters. The general methodology used relies heavily on previously described approaches for catch data reconstruction (e.g. Zeller *et al.,* 2006; Zeller *et al.*, 2007; Zeller and Pauly, 2007).

METHODS

ICES landings statistics (ICES, 2009) were used as the baseline for our reconstruction of Estonia's fisheries catches in the Baltic Sea for the period 1950-2007. Thus, the ICES landings statistics are taken as the *reported* data, as they are the only data source that is publicly available (via the ICES website) that covers all taxa landed, countries, years (since 1902) and areas of the Baltic Sea for the 1950-2007 time period. However, ICES landing statistics were only available for Estonia from 1991-2007. Prior to 1991, Estonia's landings were reported as part of 'USSR' landings, which combined the landings for the Baltic states of Estonia, Latvia, and Lithuania with Russia's. The Latvian Fish Resource Agency (LATFRA) provided USSR landings data (Table 1) disaggregated by country-entity of the former USSR from 1950-1989, the sum of which were closely comparable to ICES landings for the former USSR over the same time period (M. Plikshs, pers. comm., LATFRA).

All catches that were not included in the ICES landings statistics were considered to be generated by Illegal, Unreported and Unregulated fisheries (IUU). Here, IUU catches were considered as four components: a) '*adjustments*' to ICES landings statistics based on time series data from reliable sources (e.g., ICES stock assessment working group data, national government agencies, etc.); b) '*unreported*' landings (referred to as 'unallocated' catches by ICES); c) '*discards*' being catches or mortality caused by fishing when fish are not landed or utilized; and d) '*recreational*' catches. The sum of these components, each of which was estimated separately, plus the officially reported ICES landings statistics, provided our total reconstructed catch for Estonia from 1950-2007.

Our reconstruction considered the key commercially targeted species for Estonia, including cod (*Gadus morhua*); herring (*Clupea harengus*); sprat (*Sprattus sprattus*); salmon (*Salmo salar*); the flatfishes grouping, which only included European flounder (*Platichthys flesus*); and another 24 individual taxa grouped here as 'others'.

Illegal, Unreported and Unregulated (IUU) catches

IUU catches are a source of underreporting in many country's fisheries catches (Zeller and Pauly, 2007) and are also of concern in the Baltic Sea (Menn, 2006; Anon., 2007b; ICES, 2008a). Below, we present the methods and data sources used to estimate the four IUU components defined above: a) '*adjustments*'; b) '*unreported*' landings; c) '*discards*'; and d) '*recreational*' catches.

Adjustments to ICES landings statistics

Adjustments were made to the ICES landings statistics using a range of available sources (Table 1). Commercial landings for Estonia from 1950-1989, obtained from LATFRA, were considered adjustments to landings as the ICES landings statistics did not report data separately for Estonia prior to 1990, nor were they retroactively adjusted. Landings data for herring from 1950-1990 from Ojaveer (1999) were considered more reliable than the LATFRA data and provided this taxa's source of adjustments (H. Ojaveer, pers. comm., EMU). From 1991-2007, adjustments were made to cod (ICES, 2007; 2008a) and flatfish (ICES, 2008a) landings using ICES stock assessment working group data. The ICES working group data provided better taxonomic accounting, as cod landings were broken into eastern and western stocks, and flatfish data were disaggregated by species. A linear interpolation was done to estimate landings between 1989 and 1991 to estimate landings for all species, excluding herring, for 1990. These interpolated values were also considered adjustments to landings.

Table 1. Sources of adjustments to ICES landings statistics for Estonia from 1950-2007.

Common name	Year	Source
Cod	1950-1989	LATFRA
	1990	Interpolated
	1991-2007	ICES 2007, 2008a
Herring	1950-1990	Ojaveer (1999)
Sprat	1950-1989	LATFRA
	1990	Interpolated
Salmon	1950-1989	LATFRA
	1990	Interpolated
Flatfishes	1950-1989	LATFRA
	1990	Interpolated
	1991-2007	ICES 2008a
'Others'	1950-1989	LATFRA
	1990	Interpolated

Unreported landings

Unreported landings as a rate were applied to landings (i.e. ICES landings statistics + adjustments) to derive tonnage of unreported landings for Estonia from 1950-2007. We assumed that unreported landings for Estonia were zero from 1950-1990, following our conservative assumption-based methodology for all former eastern bloc countries (see 'Methods' in Zeller *et al.*, this volume). To estimate unreported landings for 1991 and 1992, the years which reflect the transition from a state-controlled economy to a market-based economy, rates were obtained through linear interpolation from 0% in 1990 to the first anchor point established for 1993 (Table 2). Unreported cod landings for the period 1993-2007 were estimated to range from 50-100% (Anon. pers. comm.), and we used the average of this range (75%) as the rate for unreported cod landings. Unreported landings of salmon were estimated using our default methodology. Baltic-wide unreported landings of salmon were reported for 1981-2007 (ICES, 2008b) as a minimum, mode and maximum amount, and here we used the mode, following our default approach for countries that did not report recreational catches (see 'Methods' in Zeller *et al.*, this volume). The amount of unreported landings was converted to a rate by considering the amount as a proportion of the total landings presented in the same working group report. The Baltic-wide default rate was applied since country specific contributions to unreported landings were lacking. All other taxa had unreported landings based on our default values using anchor points developed from the years 1993, 1994, 2004, and 2005 (see 'Methods' in Zeller *et al.*, this volume).

Table 2. Anchor points for unreported landings (as a %) for cod (LATFRA, see text for detail), salmon (Table 2.1.1. in ICES, 2008b) and all other taxa (Tables 2.3.1 and 2.4.1 in ICES, 2007; Table 2.3.1. and 2.4.1 in ICES, 2008a; and Table 2.1.1 ICES, 2008a). Dashed lines (-) indicate years when the rates were derived through linear interpolation.

Year	Cod	Salmon	Other taxa
1950-1990	0.0[a]	0.0[a]	0.0[a]
1991-1992	-	-	-
1993	75.0	19.4	24.6
1994	75.0	18.7	30.3
1995	75.0	19.5	-
1996	75.0	20.4	-
1997	75.0	20.8	-
1998	75.0	20.1	-
1999	75.0	20.4	-
2000	75.0	19.9	-
2001	75.0	20.4	-
2002	75.0	20.5	-
2003	75.0	20.1	-
2004	75.0	20.6	12.3
2005	75.0	20.7	11.2
2006	75.0	22.2	11.2[b]
2007	75.0	21.4	11.2[b]

[a] default assumption based rate; [b] 2005 value carried forward.

Discards

Discards were considered as four separate categories, each estimated as a rate and applied to total landings (i.e. ICES landings statistics + adjustments + unreported landings) for each respective taxonomic entity. The sum of discards in all four categories gave us total discard amounts for Estonia from 1950-2007. The four categories considered were: a) '*underwater*' discards accounting for the mortality of fish

lost from gear prior to being brought on board; b) '*ghostfishing*' due to lost or abandoned fishing gear that continues to fish; c) '*boat-based discards*', usually resulting from fishers' catch retention behavior; and d) '*seal-damaged discards*' representing the fraction of catch lost because of seal damage.

'*Underwater discards*': We only applied an underwater discard rate to herring and sprat as few studies have been conducted on this kind of discard in the Baltic (Kelleher, 2005). For herring caught with trawl-gear, Rahikainen (2004) related underwater discard amounts to observed catches of herring. We transformed this into a rate of approximately 9% for underwater discards of herring caught by trawl (see 'Methods' in Zeller *et al.*, this volume). Since herring and sprat are both caught in a mixed species fishery using similar gear-types, we applied the same underwater discard rate to both species. However, herring and sprat landings for Estonia are not reported by gear type, so the underwater discard rate of 9 % for trawl fisheries was reduced to a more conservative estimate of 5% to account for the lack of catch data by gear-type. This rate was then applied to herring and sprat landings (i.e. ICES landings statistics+ adjustments + unreported landings) for all years between 1950 and 2007.

Table 3. Boat-based discard rates (in %) for taxa included in our grouping 'others' derived from Estonian study for the period 1993-2007 (Anon., 2006b, 2007a).

Common name	Anchor point
Trout	25.72
Perch	7.67
Pikeperch	4.88
Roach	6.36
Garfish	4.74
Smelt	4.32
Burbot	3.00

Table 4. Boat-based salmon discard rates for Estonia (ICES, 2008b) used in all subdivisions except in subdivision 32 when seal-damaged discard rates based on sources (Königson *et al.*, 2005; FGFRI) were greater (1981-2007). Values in *italics* indicate an interpolated rate.

Year	Boat-based	Seal-damaged
1950-1980	2.0	0.0
1981	2.0	*6.9*
1982	2.0	*13.8*
1983	2.0	*20.7*
1984	2.0	*27.6*
1985	2.0	*34.4*
1986	2.0	*41.3*
1987	2.0	*48.2*
1988	2.0	*55.1*
1989	2.0	*62.0*
1990	2.0	*68.9*
1991	*6.0*	*75.8*
1992	*10.1*	*82.7*
1993	14.1	*89.5*
1994	12.9	*96.4*
1995	13.9	*103.3*
1996	15.1	*110.2*
1997	14.9	*117.1*
1998	14.2	*124.0*
1999	14.8	*130.9*
2000	10.3	137.8
2001	15.0	203.4
2002	15.8	255.8
2003	15.4	337.3
2004	15.6	380.5
2005	15.2	113.2
2006	17.4	149.3
2007	14.2	102.7

'*Ghostfishing*': The estimated ghostfishing discard rate was based on Tschernij and Larsson (2003), who estimated the amount of cod caught by lost gear in Sweden and related it to commercial catches in Sweden. Using these data, Brown *et al.* (2005) estimated the range of ghostfishing rates by lost gear to be between 0.01% and 3.2%, and here we used the average of 1.65% applied to all taxa, except herring and sprat, for all years from 1950-2007.

'*Boat-based discards*': Boat-based discard rates were compared to sea-damaged discard rates from 1980-2007 in subdivisions where seal-damaged discard rates were reported. The higher rate between the two categories was the only rate used to avoid the possibility of double accounting as some seal-damaged discards may have already been accounted for in estimates of boat-based discards.

From 1950-1990 a boat-based discard rate of 2% was applied to all taxa, except herring and sprat, according to our default assumption-based methodology for boat-based discards (see 'Methods' in Zeller *et al.*, this volume). Our assumption that boat-based discards for herring and sprat were zero over the entire study period was supported by an ICES report indicating that boat-based discards for herring and sprat were almost non-existent (ICES, 2005; 2007; 2008a). Rates for 1991 and 1992 were derived through linear interpolation between the default assumption-based rate for 1990 of 2% and the first available anchor point in 1993.

Boat-based discard rates for the period 1993-2007 were derived from three sources, the first being the Estonian government provided boat-based discard tonnage for various taxa for 2005. The rates were derived from the total landings presented in the same report, and were estimated for cod (3.7%), herring (3.9%), sprat (3.0%), European flounder - the only reported flatfish - (17.2%), and several other taxa (Table 3) that were included in our grouping 'others' (Anon., 2006b, 2007a). The 2005 rate was used as the discard rate throughout the 1993-2007 time period. The second source estimated boat-based discard rates of salmon from ICES stock assessment working group data (ICES, 2008b), which presents Baltic-wide, boat-based salmon discards (in tonnes) as a minimum, mode and maximum for the 1993-2007 time period (Table 4). The mode was used for Estonia, following our default assumption-based approach for countries that do not report recreational catches (see 'Methods' in Zeller *et al.*, this volume). These values were converted to rates using the total landings presented in the same working group report. The third source for estimating discards for all remaining individual taxa, included here in our group 'others', was a boat-based discard rate of 6.2% for

all years from 1993-2007, derived from a Danish study (Anon., 2006a; see 'Methods' in Zeller *et al.*, this volume).

'*Seal-damaged discards*': Seal-damaged discards have become a concern in the Baltic Sea since the 1980s when seal populations recovered from a previously depleted state (Österblom *et al.*, 2007). Seal-damaged discard data have been estimated for herring in subdivision 28 (ICES, 2008a), and for salmon and other taxa in subdivision 32 (ICES, 2008a). In these two subdivisions, seal-damaged discard rates were used in place of boat-based discards when the seal-damaged discard rate was higher than the boat-based discard rates. Landings of taxa in subdivisions that lacked seal-discard data only had the boat-based discard rate applied. Prior to 1980 the boat-based discard rate was used for all subdivisions as seal-damaged discards were considered to be a concern only from 1980 onward.

Seal-damaged discard data for herring in subdivision 28 were derived from an Estonian study of herring caught in subdivision 28 in 2005 (Ifremer, 2007). Based on this, seal-discard rates for herring in subdivision 28 were estimated to be up to 50% of the catches taken in pound nets. Here, we used a seal-damaged discard rate of 11.3% as an anchor point because in 2005 approximately 45% of herring catches in subdivision 28 (Ifremer, 2007) were taken in pound nets. The anchor point for 2000 was assumed to be half the rate for 2005, as seal populations were thought to have doubled between 2000 and 2005 (Ifremer, 2007). A linear interpolation was done to estimate seal-damaged discards of herring between anchor points in 1980, 2000 and 2005, and the 2005 rate used for 2006 and 2007 (Table 5). Seal-damaged discard rates for herring were then applied to the fraction of herring caught in subdivision 28. From 1980-1992 landings were not reported by subdivision, so to estimate the proportion of landings that were from subdivision 28, we used the average proportion from 1992-1994.

Table 5. Boat-based herring discard rates for Estonia (as a %) used in all subdivisions except in subdivision 28 when seal-damaged discard rates were greater (1981-2007) based on sources (Anon., 2007a; Ifremer, 2007). Values in *italics* indicate an interpolated rate.

Year	Boat-based	Seal-damaged
1950-1980	0.0	0.00
1981	0.0	*0.28*
1982	0.0	*0.57*
1983	0.0	*0.85*
1984	0.0	*1.13*
1985	0.0	*1.42*
1986	0.0	*1.70*
1987	0.0	*1.98*
1988	0.0	*2.26*
1989	0.0	*2.55*
1990	0.0	*2.83*
1991	*0.97*	*3.11*
1992	*1.94*	*3.40*
1993	2.91	*3.68*
1994	2.91	*3.96*
1995	2.91	*4.25*
1996	2.91	*4.53*
1997	2.91	*4.81*
1998	2.91	*5.09*
1999	2.91	*5.38*
2000	2.91	5.66
2001	2.91	*6.80*
2002	2.91	*7.93*
2003	2.91	*9.06*
2004	2.91	*10.20*
2005	2.91	11.33
2006	2.91	11.33
2007	2.91	11.33

Seal-damaged discard rates for salmon and other taxa were based on Finnish data provided by the Finnish Game and Fisheries Research Institute (FGFRI) 2000-2007 (A. Ahvohenen and P. Söderkultalahti, pers. comm., FGFRI). We used the rates derived from the Finnish data in subdivision 32 to estimate seal-damaged discards for Estonia's landings for the same taxa in subdivision 32 because of their proximity. The seal-damaged discard rates provided by FGFRI did not account for fish removed from fixed-gear by seals prior to gear retrieval so an adjustment factor of 7.4 was applied to account for these additional discards. This adjustment factor was estimated from a Swedish study by Königson (2005). To get a complete time series from 1980-2007, linear interpolations were done from the assumption-based rate for seal-damaged discards of 0% in 1980 to the first available anchor point in 2000 (Table 4, Appendix Table A1-A4).

Table 6. Anchor points for recreational catch (t) in Estonia from 1990-2007 obtained from national reports (Anon., 2006b, 2007a). Dashed line (-) indicates interpolated value.

Year	Herring	Salmon	Flounder	Trout	Perch	Smelt	Bream	Garfish
1990	0	0	0	0	0	0	0	0
1991-2003	-	-	-	-	-	-	-	-
2004	3	6	160	0	4	71	43	61
2005-2006	-	-	-	-	4[a]	71[a]	43[a]	61[a]
2007	2	2	43	3	4[a]	71[a]	43[a]	61[a]

[a] 2004 value carried forward.

Recreational catches

Recreational catches for Estonia were considered from 1990 onward, since prior to the 1990s during the USSR period, we assumed that no recreational fishing took place in Estonia (see 'Methods' in Zeller *et al.*,

this volume). Catches for 1991-2007 were estimated from two separate studies done in 2004 and 2007, which had some overlap in species. Thus, anchor points were established for these two years for the taxa reported. Linear interpolations were done between anchor points, but for those taxa that were only reported in 2004, this reported value was used to 2007 (Table 6).

RESULTS

ICES landing statistics for Estonia have only been included as a separate entity since 1991, since prior to this they were reported as a part of the USSR. In 1991, ICES landings statistics reports that Estonia landed 45,636 t, which increased to a peak of 95,293 t in 1997 (Figure 2). In 2003, landings had decreased to 59,385 t, but increased to 80,245 t in 2007. From 1991-2007, ICES landing statistics report a total of 1,165,996 t landed by Estonian fishers (Table 7).

Table 7. ICES landing statistics (t) for Estonia by decade for each of the taxonomic entities considered.

Common name	1950-1989	1990-1999	2000-2007
Cod	n/a [a]	9,893	5,379
Herring	n/a [a]	352,039	245,84
Sprat	n/a [a]	176,914	342,54
Salmon	n/a [a]	182	88
Flatfishes	n/a [a]	2,243	3,356
'Others'	n/a [a]	15,008	12,511

[a]ICES does not provide landings statistics for Estonia until 1991.

The majority of the ICES landing statistics are due to herring, with landings of 597,879 t from 1991-2007, accounting for 51%. Herring landings were 27,034 t in 1991, and increased to peak at 52,436 t in 1997. Herring landings then decreased, and ended the time period with 26,108 t reported for 2007. Sprat landings account for approximately 45% of ICES landing statistics, with a total of 519,456 t reported from 1991-2007. Sprat landings were 14,124 t in 1991, averaged 6,327 t·year^{-1} for the next three years, and then increased to an average 37,412 t·year^{-1} (with a peak of 55,285 t in 2005). The 'others' category contributed the third greatest amount, with a total of 27,519 t from 1991-2007, representing approximately 2.4% of all landings. Landings of the group 'others' were 2,361 t in 1991, averaged 1,619 t·year^{-1}, and ended the time period at 1,843 t in 2007. Cod landings account for approximately 1.3% of ICES landing statistics, with a total of 15,273 t from 1991-2007. Cod landings fluctuated greatly, ranging from 1,805 t to 36 t. Cod landings were over 1,000 t from 1991-1992, 1995-1999, and in 2004, with an average of 1,275 t·year^{-1}. For the other years in the time series, cod landings averaged 564 t·year^{-1}. Flatfish landings contributed 5,599 t to ICES landing statistics, or 0.5%, and salmon landings contributed a total of 270 t.

Illegal, Unreported and Unregulated (IUU) catches

IUU is used in this report to quantify any catches made by a country that are not included in the ICES landing statistics. Adjustments to ICES landing statistics, unreported (or 'unallocated') landings, discards, and recreational catches account for our IUU adjustments (see methods for details and sources).

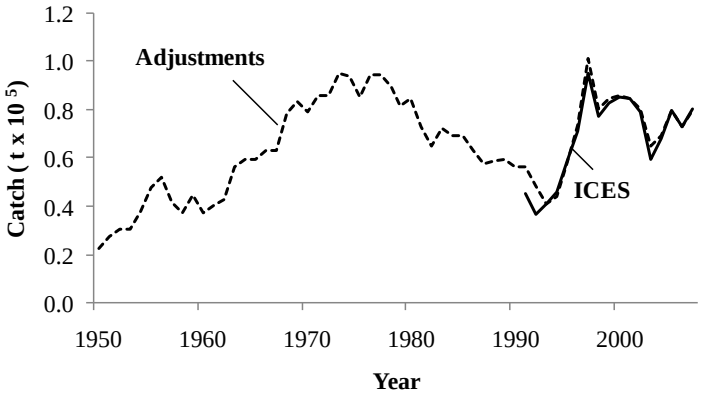

Figure 2. ICES landing statistics and adjustments to ICES landing statistics for Estonia from 1950-2007.

Adjustments to landings

Over 2.6 million t of adjustments were made to ICES landing statistics for Estonia from 1950-2007 (Figure 2, Table 8). The majority of these adjustments are due to the fact that prior to 1991, Estonian landings were recorded as part of the USSR, and ICES landing statistics have not been adjusted retroactively to account for this. Landings from 1950-1990 were adjusted from zero using national data and ICES Working Group reports (see methods for all sources), as ICES landing statistics were not reported separately for Estonia for this period.

From 1950-1990, before ICES landing statistics were recorded independently for Estonia, herring's adjustments to landings accounted for 55% of the total adjustments, over 1.4 million t. Sprat's adjustments

to landings accounted for 31% of the total adjustments for this period, with a total of approximately 794,000 t. The group 'others' accounted for 7% of the total adjustments, with a total of 187,000 t from 1950-1990. Cod accounted for 6% the total adjustments, with a total of approximately 146,000 t for the time period. Flatfishes accounted for 1.8% of total adjustments, with a total of over 47,000 t for the time period. Salmon contributed a negligible amount to the total adjustments, and landings were estimated to be 1,178 t from 1950-1990.

Table 8. Total adjustments to ICES landing statistics (tonnes) for Estonia by decade for each of the taxonomic entities considered.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	5,828	1,110	10,183	127,748	577	480
Herring	292,856	305,754	387,733	387,151	36,004	0
Sprat	39,330	199,200	420,043	116,648	18,442	0
Salmon	180	100	75	700	121	2
Flatfishes	12,282	12,597	10,229	12,164	470	1
'Others'	24,840	68,680	60,052	31,876	1,710	6

From 1991-2007, adjustments decreased significantly as ICES landing statistics were recorded separately for Lithuania. The net adjustments for this period were only 1,045 t with cod contributing 87% of this amount.

Unreported landings

Unreported ('unallocated') landings were assumed to have begun in Estonia following separation from the USSR. In 1991, the estimated unreported landing was 3,523 t. This rose steadily to a peak of 22,243 t in 1997 before falling to 8,503 t in 2003 and ending the time series at 8,503 t. The total unreported landing was estimated to be 207,850 t, or 14% of our total reconstruction for the 1991-2007 period. Unreported landings of sprat accounted for 49% of the overall unreported landings, with a total of 82,951 t from 1991-2007 (adding an additional 16% to reported sprat landings). Unreported sprat landings were estimated to have been 989 t in 1991, rising to 8,931 t in 1997, and then decreased to end the time period at 5,713 t. Herring catches contributed 52% to overall unreported landings, with an estimated total of 108,465 t from 1991-2007 (adding an additional 18% to reported herring landings). Unreported herring landings were an estimated 1,892 t in 1991, rose to a peak of 11,798 t in 1997, and then declined to 2,924 t in 2007. Unreported cod landings contributed an estimated 5% to total unreported landings, or a total of 10,884 t from 1991-2007. As a percentage of reported catches, unreported cod landings added the largest amount to reported landings – an estimated 71%. This is possibly due to the high value of cod and thus the strong incentive to not report or to misreport catches. Unreported cod landings were estimated to be 453 t in 1991, increased to 1,065 t in 1997, and decreased to 710 t in 2007. The unreported landings of the group 'others' totaled an estimated 4,570 t for the time period (adding an additional 17% to this taxa's landings), or an average 269 t annually. Unreported flatfish landings totaled an estimated 933 t over the time period (adding 17% to this taxa's landings), or an average 59 t annually. Unreported salmon landings are an estimated 46 t for the time period (adding 17% to this taxa's landings).

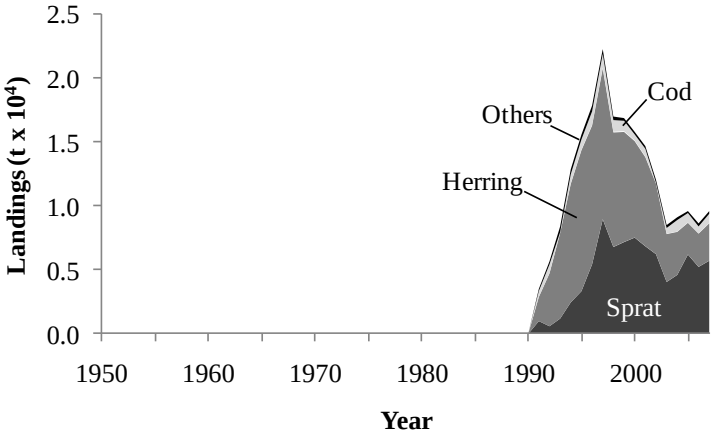

Figure 3. Unreported landings by taxa for Estonia, 1950-2007

Table 9. Total unreported landings (tonnes) for Estonia by decade for each of the taxonomic entities considered.

Common name	1950-1989	1990-1999	2000-2007
Cod	0 [a]	6,489	4,394
Herring	0 [a]	73,321	35,144
Sprat	0 [a]	36,715	46,237
Salmon	0 [a]	28	18
Flatfishes	0 [a]	465	468
'Others'	0 [a]	2,906	1,664

[a] assumption based estimate (see methods).

Discards

Discards were considered to be comprised of four components (ghostfishing, underwater discards, boat-based discards and seal-damaged discards; see Methods section for details). Discards totaled an estimated

243,635 t from 1950-2007. At the beginning of the time series, discards were estimated to be 1,095 t. This was followed by a period of increase, and annual discards averaged 4,238 t from 1968-1980. From 1981-1995, average discards decreased to 3,496 t·year^{-1}, but then increased and peaked at 9,779 t in 1997. Discards continued to fluctuate, and were estimated to be 8,605 t in 2007.

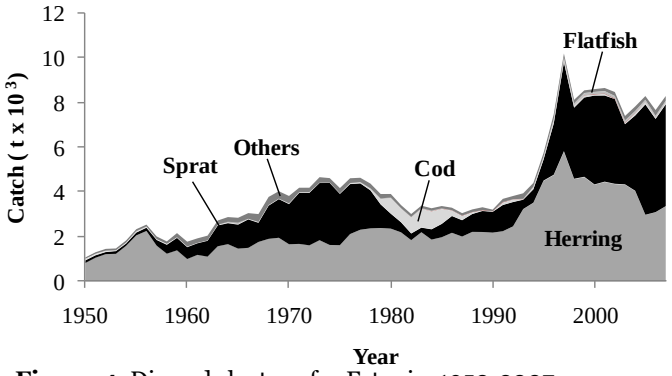

Figure 4. Discards by taxa for Estonia, 1950-2007.

Herring was estimated to have the highest amount of discards, totaling 136,333 t from 1950-2007, and accounting for approximately 6% of our reconstructed herring catch. From 1950-1994, herring discards averaged 2,351 t·year^{-1}, and this increased in the latter part of the time period to an average of approximately 4,100 t·year^{-1} from 1995-2007. Sprat was the next largest contributor to total discards, with a total of 87,526 t over the entire time period, accounting for approximately 6% of our reconstructed sprat catch. There were two periods of lower sprat discards, with an average of 370 t·year^{-1} from 1950-1964, and an average of 674 t·year^{-1} from 1980-1995. Time periods of higher sprat discards were from 1965-1979, when the average was 1,825 t annually, and 1996-2007, when the average was 3,652 t·year^{-1}. Sprat discards peaked in 2005 at 4,918 t. The group 'others' contributed a total of 9,597 t over the time period (accounting for 4.2% of our reconstructed total), and peaked at 357 t in 1968. Cod discards, approximately 3% of total discards, totaled 6,701 t over the time period. From 1979-1987, cod discards were significantly higher than the rest of the time period, with average annual discards of 535 t (with a peak of 818 t in 1983). Prior to this, cod discards averaged 14 t annually, and from 1988-2007 averaged 74 t annually. Flatfish discards had the second lowest tonnage, and accounted for 5% of our reconstructed flatfish catch. Flatfish discards totaled 2,949 t from 1950-2007, and from 1950-1995 averaged 41 t annually. This increased to an average of 87 t·year^{-1} for the rest of the time period (with a peak of 112 t in 2002). Salmon discards were estimated to be the smallest contributor to discards, yet were the highest percentage of discards relative to total reconstructed catch at an estimated 18%. Salmon discards totaled an estimated 351 t over the entire time period. From 1950-1982, salmon discards averaged 0.6 t·year^{-1}, and this increased to 13 t annually from 1983-2007 (with a peak of 34 t in 2002).

Table 10. Total discard catch (tonnes) for Estonia by decade for each of the taxonomic entities considered.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	213	41	372	4,663	866	548
Herring	14,643	15,288	19,387	20,601	36,287	30,129
Sprat	1,967	9,960	21,002	5,832	17,663	31,102
Salmon	7	4	3	78	104	156
Flatfishes	448	460	373	444	503	721
'Others'	907	2,507	2,192	1,172	1,551	1,446

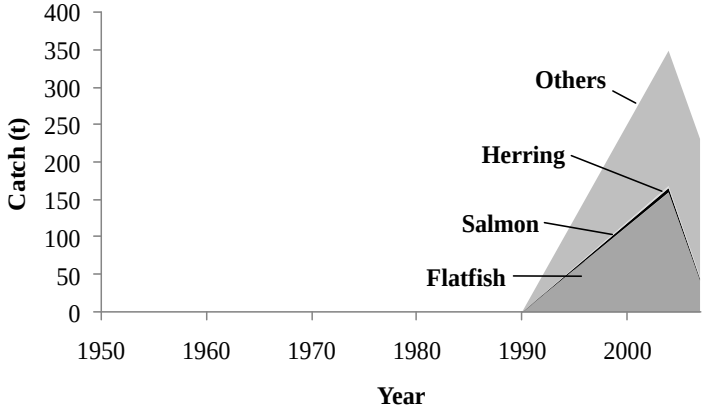

Figure 5. Estonia's recreational catches by major taxa, 1950-2007

Recreational

Recreational fishing is not accounted for in ICES landing statistics, and in our reconstruction we assumed that no recreational fishing occurred in Estonia prior to 1991. Our recreational catches include salmon, herring, and the groups 'others' and flatfishes (Table 11; Figure 5). There was an estimated 3,421 t of fish caught by the recreational sector of Estonian fisheries from 1991-2007. The 'others' category was the largest, 1,896 t from 1991 to 2007, accounting for 55% of the total recreational catch. The catches increased from 0 t in 1990 to approximately 183 t in 2007. Recreational catches of flatfish totaled 1,445 t from 1991 to 2007, accounting for 42% of the total recreational catch. Flatfish catches increased from 1991 to 2004, when they peaked at 160 t, and then decreased to 43 t in 2007. Salmon was estimated to have contributed approximately 1.5% to total recreational catches, with a total of 54 t from 1992 to 2007, and an average yearly recreational catch of 3 t. Recreational herring catches totaled 26 t from 1991-2007.

Table 11. Total recreational catch (t) for Estonia by decade for each of the taxonomic entities considered.

Common name	1950-1989	1990-1999	2000-2007
Cod	0 [a]	0	0
Herring	0 [a]	8	18
Sprat	0 [a]	0	0
Salmon	0 [a]	19	35
Flatfishes	0 [a]	514	931
'Others'	0 [a]	578	1,318

[a] assumption based estimate.

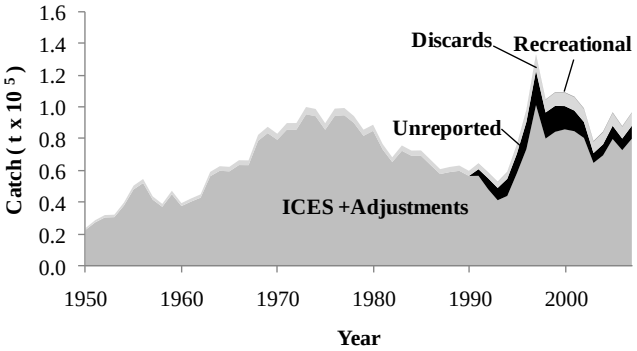

Figure 6. Area graph of Estonia's total reconstructed catch by component for 1950-2007.

Total reconstructed catches

The total reconstructed catch for Estonia from 1950-2007 was estimated to be over 4.2 million t (Figure 6; Table 12; see Appendix Tables B1-B7 for complete time series data on all additions to taxonomic catch data, by catch component). The total reconstructed catch for Estonia was estimated to have averaged 41,444 t·year^{-1} from 1950-1963. Average annual catches then increased to an estimated 81,877 t·year^{-1} from 1964-1986, with an estimated peak of 100,171 t in 1973. 1987-1994 was a period of lower catches, with an average estimate of 57,672 t·year^{-1}, with a low of 45,538 t in 1992. Reconstructed catches increased at the end of the time period, and averaged an estimated 98,562 t from 1995-2007, with an overall estimated peak of 127,739 t in 1997. In contrast to the 1,165,996 t from 1991-2007 reported by ICES landing statistics, our total reconstructed catch increased 21% to 1,474,693 t for the same period.

Table 12. Total catch (tonnes) for Estonia by decade by each component of catch reconstruction.

Component	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
ICES landing statistics	n/a	n/a	n/a	n/a	556,279	609,716
Adjustments to ICES	375,316	587,441	888,315	676,287	57,323	489
Unreported	0	0	0	0	111,924	87,926
Discards	18,184	28,258	43,328	32,790	56,974	64,101
Recreational	0	0	0	0	1,119	2,302
Total reconstructed	393,500	615,699	931,643	709,077	791,619	764,533

Approximately 62% of our reconstructed time series is due to adjustments to ICES landing statistics, the majority of which is due to disaggregating Estonia's catches from the former USSR from 1950-1990 (Table 12). Discards accounted for 5.8% of our total reconstructed time series. Unreported and recreational landings accounted for 4.9% and 0.1%, respectively, of our reconstructed catch from 1991-2007.

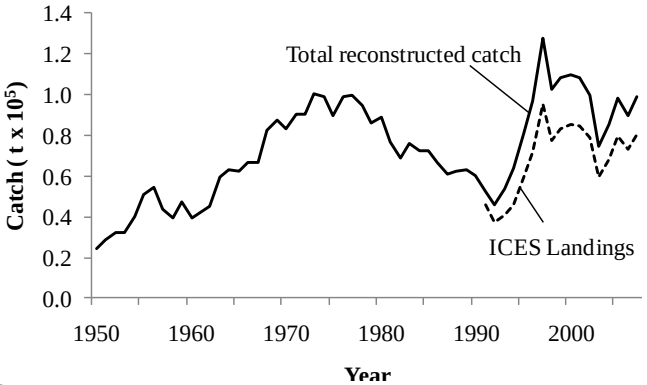

Figure 7. ICES landings statistics vs. total reconstructed catch for Estonia from 1950-2007.

Herring contributed the largest amount to the reconstructed catch, 54%, with an estimated total of 2,252,202 t from 1950-2007 (Table 13). Herring catches peaked three times during this time period, with catches of 47,651 t in 1956, 50,087 t in 1978, and 69,734 t in 1997. Herring catches averaged 29,901 t t·year^{-1} from 1950-1960, 38,100 t·year^{-1} from 1961-1992, and 46,940 t·year^{-1} from 1993-2007. Herring catches ended the time series at 32,727 t.

Sprat accounted for the next largest amount of reconstructed catches, with an estimated total of 1,488,597 t from 1950-2007 accounting for 35% of total reconstructed catch (Table 13). Sprat had two periods of high catches, and two periods of lower catches. Catches were lower at the beginning of the time series, beginning at 2,310 t in 1950, and averaged 4,130 t·year^{-1} from 1950-1961. In 1962 sprat catches began to increase, and in 1974 they peaked at 57,990 t (averaging 35,673 t from 1962-1978). From 1979-1995 catches were lower again, averaging 13,090 t·year^{-1} (with a peak of 19,578 t in 1989). The other period of higher catches was 1996-2007, when catches averaged 49,298 t·year^{-1} and peaked at 66,395 t in 2005. For the last year in the time series, sprat catches were 61,257 t.

Table 13. Total reconstructed catch (tonnes) for Estonia by decade for each of the taxonomic entities considered.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	6,041	1,151	10,555	132,411	17,825	10,801
Herring	307,499	323,042	407,120	407,752	497,658	311,131
Sprat	41,297	209,160	441,045	122,480	249,734	419,881
Salmon	187	104	78	778	454	299
Flatfishes	12,730	13,057	10,602	12,608	4,195	5,476
'Others'	25,747	71,187	62,244	33,048	21,753	16,945

Catches of the group 'others' were 5.5% of total reconstructed catches, and contributed an estimated 230,923 t from 1950-2007 (Table 13). From an estimated 1,524 t in 1950, catches of the group 'others' increased to peak at 10,137 t in 1968. Catches then decreased and leveled off to an average 2,407 t·year^{-1} from 1983-2007, ending the time period with 2,443 t in 2007.

Cod catches were 4.3% of total reconstructed catches, and contributed an estimated 178,783 t from 1950-2007 (Table 13). From 1950-1978, cod catches averaged 396 t·year^{-1} (with a range from 10 t to 1,927 t). Estimated catches were greatest from 1979-1987, averaging 15,182 t·year^{-1} with a peak of 23,217 t in 1983. For the remainder of the time period cod catches averaged 1.532 t·year^{-1} (with a range from 68 t in 2002 to 2,618 t in 1997).

Flatfish catches accounted for 1.4% of total reconstructed catches, and contributed an estimated 58,668 t from 1950-2007 (Tabel 13). Flatfish catches averaged 1,012 t·year^{-1}, with a peak of 2,831 t in 1964. Salmon catches contributed the least to total reconstructed catch in terms of weight, an estimated 0.05%, or 1,899 t, from 1950-2007. Salmon catches averaged 33 t·year^{-1}, with a peak of 120 t in 1989.

DISCUSSION

Our cumulative catch reconstruction of Estonia's fisheries in the Baltic Sea for the period 1950-2007 was estimated to be approximately 4.2 million t. We compared this total to the officially reported landings, presented here as ICES landings statistics. However, Estonia's landings are only represented in the ICES landings database from 1991 onward. Prior to 1991, Estonia's landings were reported as landings for the 'former' USSR, which also included landings for Latvia, Lithuania, and Russia. Thus to make a meaningful comparison we looked at the total reconstructed catch compared to ICES landings statistics for the period 1991-2007. ICES landings statistics reported a total of approximately 1.2 million t for Estonia from 1991-2007 while our total reconstructed catch for the same period was estimated to be approximately 1.5 million t. Our total reconstructed catch over this time period was 28% higher than total landings presented by ICES on behalf of Estonia.

The larger discrepancy, if the comparison is made over the entire study period, is mainly due to the inclusion of commercial landings data provided by LATFRA in our total reconstructed catch. These commercial landings were considered here as '*adjustments*' to ICES landings statistics as they were not presented for Estonia as a separate entity even though they may have been included in the ICES landings statistics for the USSR. The commercial landings data provided by LATFRA is potentially the first time such a comprehensive data set has been presented for Estonia's commercial landings covering the period 1950-1989.

Unreported landings are a serious concern for the sustainability of fisheries both on a global scale (Bray, 2000; Crona and Österblom, 2009) and regionally in the Baltic Sea (Menn, 2006; Anon., 2007b; ICES, 2008a). For Estonia, we considered unreported landings to be a concern only since the dissolution of the USSR, as the strict reporting procedures during the Soviet era would have prevented such activities. Our estimate of unreported landings for the period 1991-2007 was approximately 13% of the total reconstructed catch, attributed mainly to herring and sprat. Of all taxa considered in our reconstruction, herring and sprat represented over 90% of unreported landings.

Discards, also a major concern in global fisheries misreporting (Alverson *et al.*, 1994; Kelleher, 2005) were considered for Estonia over the entire study period and represented 5% of the total reconstructed catch. Estimates of discarded catches of some taxa (cod, herring, sprat, European flounder and several additional taxa included in our grouping 'others') were mostly obtained from the Estonian government but were only available for 2005. The majority of discards were of herring and sprat, which together represented almost half of the discarded catches of all taxa considered.

As recreational fishing in Estonia was illegal during the USSR period, we only considered recreational catches from 1991 onward. We obtained recreational catch data from the Estonian government, but only for selected years in the most recent decade. Recreational catches represented only a minor component of the reconstructed catch, but should be considered significant as these are not included in the ICES landings statistics. Quantifying these catches is important in an ecosystem-based management context as the species targeted recreationally are often different from those caught commercially. For instance perch, pikeperch and pike are important in Estonia's recreational fisheries, particularly since the increase in export opportunities that occurred in the early to mid-1990s (Vetemaa *et al.*, 2006). The high value of these fish in the export market encouraged recreational fishers to sell their catches as opposed to retaining them for personal consumption (Vetemaa *et al.*, 2006).

In the post-Soviet period, state-owned fisheries were converted to private enterprise. Interviews with fishers revealed that catches were often misreported in order to lower taxes (Vetemaa *et al.*, 2006). Official catches were thought to have been severely underestimated during the early to mid-1990s due to a lack of enforcement and control during the transition from a state-controlled to a market economy (Vetemaa *et al.*, 2006). Although the propensity for misreporting in Estonian fisheries has been recognized, the information necessary for quantifying these catches was limited. Unreported cod landings were estimated based on a range of values obtained from LATFRA, for which we conservatively applied the average. For all remaining taxa, we estimated unreported landings using Baltic-wide estimates presented by ICES in their stock assessment working group reports. The estimates used were based on the amount of reported discards and unreported landings as a proportion of total Baltic-wide landings. While our estimation took into account countries that are known not to report their unreported landings (e.g., Sweden), we were not able to account for all non-reporting countries as ICES did not disclose this information. ICES lacks transparency in this respect and our estimates would have been greater if we had been able to adjust the amount of landings to reflect only those countries that report their unreported landings (i.e., unreported landings totals would remain the same, but the amount of total landings would decrease leading to a larger percentage). However, we accepted the non-specific nature of these estimates, since the alternative assumption was that no data meant zero catches (Zeller and Pauly, 2007). Thus by using conservative estimates of IUU, we estimate total catches that would be closer to the truth than presenting landings data only.

A key concern with fisheries management in Estonia is the lack of data. Although the Estonian government did provide some important fisheries data, the majority of our estimates for this study relied on Baltic-wide approximations, which are most likely underestimates due to the conservative nature of our methods. To get a more accurate account of catch components, such as discards, increased monitoring is necessary. Observer coverage or Vessel Monitoring Systems (VMS) should be mandatory for all commercial vessels in Estonia. This would not only act to assess the magnitude of discards but would increase enforcement which might significantly reduce discarding and result in lower amounts of unreported landings.

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APPENDIX A

Appendix Table A1. Boat-based trout (*Salmo trutta*) discard rates for Estonia (%) used in all subdivisions except in subdivision 32 when seal-damaged discard rates, derived from FGFRI data were greater (1981-2007). Values in *italics* indicate an interpolated rate.

Year	Boat-based	Seal-damaged
1950-1980	2.0	0.0
1981	2.0	4.6
1982	2.0	9.2
1983	2.0	13.7
1984	2.0	18.3
1985	2.0	22.9
1986	2.0	27.5
1987	2.0	32.1
1988	2.0	36.7
1989	2.0	41.2
1990	2.0	45.8
1991	*9.9*	50.4
1992	*17.8*	55.0
1993	25.7	59.6
1994	25.7	64.1
1995	25.7	68.7
1996	25.7	73.3
1997	25.7	77.9
1998	25.7	82.5
1999	25.7	87.1
2000	25.7	91.6
2001	25.7	96.2
2002	25.7	85.0
2003	25.7	151.8
2004	25.7	132.9
2005	25.7	58.6
2006	25.7	78.2
2007	25.7	184.2

Appendix Table A2. Boat-based whitefish (*Coregonus lavaretus*) discard rates for Estonia (%) used in all subdivisions except in subdivision 32 when seal-damaged discard rates derived from FGFRI data were greater (1981-2007). Values in *italics* indicate an interpolated rate.

Year	Boat-based	Seal-damaged
1950-1980	2.00	0.00
1981	2.00	1.4
1982	2.00	2.9
1983	2.00	4.3
1984	2.00	5.8
1985	2.00	7.2
1986	2.00	8.7
1987	2.00	10.1
1988	2.00	11.6
1989	2.00	13.0
1990	2.00	14.5
1991	*3.41*	15.9
1992	*4.83*	17.4
1993	6.24	18.8
1994	6.24	20.3
1995	6.24	21.7
1996	6.24	23.2
1997	6.24	24.6
1998	6.24	26.1
1999	6.24	27.5
2000	6.24	29.0
2001	6.24	30.4
2002	6.24	54.5
2003	6.24	104.9
2004	6.24	120.3
2005	6.24	33.4
2006	6.24	19.5
2007	6.24	91.1

Appendix Table A3. Boat-based perch (*Perca flaviatilis*) discard rates for Estonia (%) used in all subdivisions except in subdivision 32 when seal-damaged discard rates derived from FGFRI data were greater (1981-2007). Values in *italics* indicate an interpolated rate.

Year	Boat-based	Seal-damaged
1950-1980	2.00	0.00
1981	2.00	*0.00*
1982	2.00	*0.00*
1983	2.00	*0.00*
1984	2.00	*0.00*
1985	2.00	*0.00*
1986	2.00	*0.00*
1987	2.00	*0.00*
1988	2.00	*0.00*
1989	2.00	*0.00*
1990	2.00	*0.00*
1991	*3.83*	*0.00*
1992	*5.67*	*0.00*
1993	7.67	*0.00*
1994	7.67	*0.00*
1995	7.67	*0.00*
1996	7.67	*0.00*
1997	7.67	*0.00*
1998	7.67	*0.00*
1999	7.67	*0.00*
2000	7.67	*0.00*
2001	7.67	*0.00*
2002	7.67	*0.00*
2003	7.67	0.21
2004	7.67	0.20
2005	7.67	28.45
2006	7.67	75.79
2007	7.67	7.29

Appendix Table A4. Boat-based pikeperch (*Sander lucioperca*) discard rates for Estonia (%) used in all subdivisions except in subdivision 32 when seal-damaged discard rates derived from FGFRI data were greater (1981-2007). Values in *italics* indicate an interpolated rate.

Year	Boat-based	Seal-damaged
1950-1980	2.0	0.00
1981	2.0	*0.04*
1982	2.0	*0.09*
1983	2.0	*0.13*
1984	2.0	*0.18*
1985	2.0	*0.22*
1986	2.0	*0.27*
1987	2.0	*0.31*
1988	2.0	*0.36*
1989	2.0	*0.40*
1990	2.0	*0.45*
1991	*3.41*	*0.49*
1992	*5.67*	*0.54*
1993	7.51	*0.58*
1994	7.51	*0.63*
1995	7.51	*0.67*
1996	7.51	*0.72*
1997	7.51	*0.76*
1998	7.51	*0.81*
1999	7.51	*0.85*
2000	7.51	0.90
2001	7.51	0.94
2002	7.51	0.51
2003	7.51	6.22
2004	7.51	4.71
2005	7.51	17.37
2006	7.51	44.10
2007	7.51	51.94

APPENDIX B

Appendix Table B1. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for Estonia (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	22,928	0	1,095	0	24,023
1951	N/A	27,594	0	1,326	0	28,920
1952	N/A	30,668	0	1,477	0	32,145
1953	N/A	30,881	0	1,496	0	32,377
1954	N/A	38,163	0	1,853	0	40,016
1955	N/A	48,288	0	2,355	0	50,643
1956	N/A	52,282	0	2,559	0	54,841
1957	N/A	41,880	0	2,032	0	43,912
1958	N/A	37,371	0	1,810	0	39,181
1959	N/A	45,261	0	2,180	0	47,441
1960	N/A	37,846	0	1,798	0	39,644
1961	N/A	40,628	0	1,946	0	42,574
1962	N/A	43,112	0	2,067	0	45,179
1963	N/A	56,570	0	2,743	0	59,313
1964	N/A	60,013	0	2,896	0	62,909
1965	N/A	59,631	0	2,864	0	62,495
1966	N/A	63,600	0	3,072	0	66,672
1967	N/A	63,530	0	3,029	0	66,559
1968	N/A	78,848	0	3,795	0	82,643
1969	N/A	83,663	0	4,048	0	87,711
1970	N/A	79,503	0	3,837	0	83,340
1971	N/A	85,857	0	4,204	0	90,061
1972	N/A	85,876	0	4,205	0	90,081
1973	N/A	95,496	0	4,675	0	100,171
1974	N/A	94,329	0	4,633	0	98,962
1975	N/A	85,781	0	4,189	0	89,970
1976	N/A	94,534	0	4,626	0	99,160
1977	N/A	94,903	0	4,649	0	99,552
1978	N/A	90,067	0	4,388	0	94,455
1979	N/A	81,969	0	3,923	0	85,892
1980	N/A	85,098	0	3,925	0	89,023
1981	N/A	73,392	0	3,383	0	76,775
1982	N/A	65,507	0	2,985	0	68,492
1983	N/A	72,567	0	3,345	0	75,912
1984	N/A	69,458	0	3,229	0	72,687
1985	N/A	69,464	0	3,319	0	72,783
1986	N/A	63,641	0	3,235	0	66,876
1987	N/A	57,977	0	2,990	0	60,967
1988	N/A	59,205	0	3,144	0	62,349
1989	N/A	59,978	0	3,235	0	63,213
1990	N/A	56,768	0	3,124	0	59,892
1991	45,636	43	3,523	2,898	25	52,125
1992	36,937	25	5,667	2,860	50	45,538
1993	41,161	-1	8,394	3,812	75	53,441
1994	46,076	45	12,864	4,770	99	63,855
1995	59,173	64	15,566	6,114	124	81,040
1996	71,374	-4	17,836	7,371	149	96,727
1997	95,293	250	22,243	9,779	174	127,739
1998	77,627	132	16,975	7,903	199	102,836
1999	83,002	2	16,857	8,341	224	108,426
2000	85,176	97	15,781	8,451	249	109,754
2001	84,971	50	14,668	8,515	274	108,478
2002	79,036	3	12,037	8,086	298	99,460
2003	59,385	31	8,503	6,350	323	74,592
2004	68,102	-86	9,114	7,663	348	85,141
2005	79,762	384	9,597	8,557	309	98,609
2006	73,040	10	8,633	7,874	270	89,827
2007	80,245	0	9,592	8,605	231	98,673

Appendix Table B2. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for cod (*Gadus morhua*) for Estonia (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	1,270	0	46	0	1,316
1951	N/A	960	0	35	0	995
1952	N/A	1,032	0	38	0	1,070
1953	N/A	361	0	13	0	374
1954	N/A	540	0	20	0	560
1955	N/A	542	0	20	0	562
1956	N/A	330	0	12	0	342
1957	N/A	213	0	8	0	221
1958	N/A	400	0	15	0	415
1959	N/A	180	0	7	0	187
1960	N/A	110	0	4	0	114
1961	N/A	10	0	0	0	10
1962	N/A	10	0	0	0	10
1963	N/A	200	0	7	0	207
1964	N/A	190	0	7	0	197
1965	N/A	100	0	4	0	104
1966	N/A	110	0	4	0	114
1967	N/A	140	0	5	0	145
1968	N/A	140	0	5	0	145
1969	N/A	100	0	4	0	104
1970	N/A	110	0	4	0	114
1971	N/A	10	0	0	0	10
1972	N/A	10	0	0	0	10
1973	N/A	16	0	1	0	17
1974	N/A	137	0	5	0	142
1975	N/A	296	0	11	0	307
1976	N/A	686	0	25	0	711
1977	N/A	1,027	0	37	0	1,064
1978	N/A	1,859	0	68	0	1,927
1979	N/A	6,032	0	220	0	6,252
1980	N/A	18,551	0	677	0	19,228
1981	N/A	15,813	0	577	0	16,390
1982	N/A	18,777	0	685	0	19,462
1983	N/A	22,399	0	818	0	23,217
1984	N/A	21,324	0	778	0	22,102
1985	N/A	17,886	0	653	0	18,539
1986	N/A	6,278	0	229	0	6,507
1987	N/A	4,769	0	174	0	4,943
1988	N/A	1,650	0	60	0	1,710
1989	N/A	301	0	11	0	312
1990	N/A	155	0	6	0	161
1991	1,805	5	453	95	0	2,358
1992	1,369	-1	684	98	0	2,150
1993	70	0	53	7	0	129
1994	905	47	714	89	0	1,755
1995	1,049	0	787	98	0	1,934
1996	1,392	-4	1,041	130	0	2,559
1997	1,173	247	1,065	133	0	2,618
1998	1,070	126	897	112	0	2,205
1999	1,060	2	797	99	0	1,958
2000	513	96	457	57	0	1,123
2001	755	50	604	75	0	1,484
2002	36	1	28	3	0	68
2003	560	31	443	55	0	1,089
2004	1,278	-86	894	111	0	2,197
2005	588	384	729	91	0	1,792
2006	703	4	530	66	0	1,303
2007	946	0	710	88	0	1,744

Appendix Table B3. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for herring (*Clupea harengus*) for Estonia (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	16,887	0	844	0	17,731
1951	N/A	21,594	0	1,080	0	22,674
1952	N/A	24,766	0	1,238	0	26,004
1953	N/A	25,010	0	1,251	0	26,261
1954	N/A	32,173	0	1,609	0	33,782
1955	N/A	41,464	0	2,073	0	43,537
1956	N/A	45,382	0	2,269	0	47,651
1957	N/A	32,313	0	1,616	0	33,929
1958	N/A	25,146	0	1,257	0	26,403
1959	N/A	28,121	0	1,406	0	29,527
1960	N/A	20,396	0	1,020	0	21,416
1961	N/A	24,090	0	1,205	0	25,295
1962	N/A	22,539	0	1,127	0	23,666
1963	N/A	31,746	0	1,587	0	33,333
1964	N/A	33,640	0	1,682	0	35,322
1965	N/A	29,680	0	1,484	0	31,164
1966	N/A	30,350	0	1,518	0	31,868
1967	N/A	35,610	0	1,781	0	37,391
1968	N/A	38,380	0	1,919	0	40,299
1969	N/A	39,323	0	1,966	0	41,289
1970	N/A	33,583	0	1,679	0	35,262
1971	N/A	33,852	0	1,693	0	35,545
1972	N/A	32,596	0	1,630	0	34,226
1973	N/A	37,159	0	1,858	0	39,017
1974	N/A	32,906	0	1,645	0	34,551
1975	N/A	32,774	0	1,639	0	34,413
1976	N/A	42,652	0	2,133	0	44,785
1977	N/A	46,481	0	2,324	0	48,805
1978	N/A	47,702	0	2,385	0	50,087
1979	N/A	48,028	0	2,401	0	50,429
1980	N/A	47,471	0	2,374	0	49,845
1981	N/A	43,237	0	2,162	0	45,399
1982	N/A	35,660	0	1,815	0	37,475
1983	N/A	41,539	0	2,156	0	43,695
1984	N/A	34,658	0	1,830	0	36,488
1985	N/A	35,863	0	1,926	0	37,789
1986	N/A	38,658	0	2,115	0	40,773
1987	N/A	35,035	0	1,948	0	36,983
1988	N/A	37,900	0	2,141	0	40,041
1989	N/A	37,130	0	2,135	0	39,265
1990	N/A	36,004	0	2,103	0	38,107
1991	27,034	0	1,892	1,715	0	30,642
1992	29,556	0	4,138	2,251	0	35,945
1993	32,982	0	6,695	2,968	1	42,646
1994	34,493	0	9,279	3,559	1	47,331
1995	43,482	0	11,044	4,504	1	59,031
1996	45,296	0	10,871	4,729	1	60,897
1997	52,436	0	11,798	5,498	1	69,734
1998	42,721	0	8,971	4,430	1	56,124
1999	44,039	0	8,632	4,530	2	57,202
2000	41,735	0	7,554	4,244	2	53,535
2001	41,737	0	6,970	4,369	2	53,078
2002	36,251	0	5,510	4,009	2	45,772
2003	27,360	0	3,748	3,304	2	34,414
2004	27,358	0	3,365	3,896	3	34,621
2005	22,099	0	2,475	3,293	2	27,870
2006	23,192	0	2,598	3,322	2	29,114
2007	26,108	0	2,924	3,693	2	32,727

Appendix Table B4. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for sprat (*Sprattus sprattus*) for Estonia (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	2,200	0	110	0	2,310
1951	N/A	2,020	0	101	0	2,121
1952	N/A	1,760	0	88	0	1,848
1953	N/A	2,340	0	117	0	2,457
1954	N/A	1,900	0	95	0	1,995
1955	N/A	2,410	0	121	0	2,531
1956	N/A	2,830	0	142	0	2,972
1957	N/A	4,980	0	249	0	5,229
1958	N/A	7,870	0	394	0	8,264
1959	N/A	11,020	0	551	0	11,571
1960	N/A	10,500	0	525	0	11,025
1961	N/A	10,220	0	511	0	10,731
1962	N/A	14,020	0	701	0	14,721
1963	N/A	18,460	0	923	0	19,383
1964	N/A	18,600	0	930	0	19,530
1965	N/A	21,280	0	1,064	0	22,344
1966	N/A	25,250	0	1,263	0	26,513
1967	N/A	17,000	0	850	0	17,850
1968	N/A	29,520	0	1,476	0	30,996
1969	N/A	34,350	0	1,718	0	36,068
1970	N/A	35,680	0	1,784	0	37,464
1971	N/A	45,410	0	2,271	0	47,681
1972	N/A	46,700	0	2,335	0	49,035
1973	N/A	50,920	0	2,546	0	53,466
1974	N/A	55,229	0	2,761	0	57,990
1975	N/A	45,601	0	2,280	0	47,881
1976	N/A	44,455	0	2,223	0	46,678
1977	N/A	41,265	0	2,063	0	43,328
1978	N/A	33,818	0	1,691	0	35,509
1979	N/A	20,965	0	1,048	0	22,013
1980	N/A	13,213	0	661	0	13,874
1981	N/A	8,903	0	445	0	9,348
1982	N/A	5,829	0	291	0	6,120
1983	N/A	3,993	0	200	0	4,193
1984	N/A	9,090	0	455	0	9,545
1985	N/A	11,769	0	588	0	12,357
1986	N/A	14,862	0	743	0	15,605
1987	N/A	14,472	0	724	0	15,196
1988	N/A	15,871	0	794	0	16,665
1989	N/A	18,646	0	932	0	19,578
1990	N/A	18,442	0	922	0	19,364
1991	14,124	0	989	907	0	16,019
1992	4,140	0	580	330	0	5,050
1993	5,763	0	1,170	555	0	7,488
1994	9,079	0	2,442	922	0	12,443
1995	13,051	0	3,315	1,309	0	17,675
1996	22,493	0	5,398	2,231	0	30,123
1997	39,692	0	8,931	3,890	0	52,513
1998	32,165	0	6,755	3,114	0	42,033
1999	36,407	0	7,136	3,483	0	47,026
2000	41,394	0	7,492	3,911	0	52,797
2001	40,776	0	6,810	3,807	0	51,392
2002	40,717	0	6,189	3,752	0	50,658
2003	29,366	0	4,023	2,671	0	36,060
2004	37,308	0	4,589	3,352	0	45,249
2005	55,285	0	6,192	4,918	0	66,395
2006	46,689	0	5,229	4,153	0	56,072
2007	51,007	0	5,713	4,538	0	61,257

Appendix Table B5. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for salmon (*Salmo salar*) for Estonia (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	10	0	0	0	10
1951	N/A	20	0	1	0	21
1952	N/A	40	0	1	0	41
1953	N/A	40	0	1	0	41
1954	N/A	20	0	1	0	21
1955	N/A	10	0	0	0	10
1956	N/A	10	0	0	0	10
1957	N/A	10	0	0	0	10
1958	N/A	10	0	0	0	10
1959	N/A	10	0	0	0	10
1960	N/A	10	0	0	0	10
1961	N/A	10	0	0	0	10
1962	N/A	20	0	1	0	21
1963	N/A	10	0	0	0	10
1964	N/A	10	0	0	0	10
1965	N/A	10	0	0	0	10
1966	N/A	10	0	0	0	10
1967	N/A	10	0	0	0	10
1968	N/A	10	0	0	0	10
1969	N/A	0	0	0	0	0
1970	N/A	10	0	0	0	10
1971	N/A	10	0	0	0	10
1972	N/A	0	0	0	0	0
1973	N/A	10	0	0	0	10
1974	N/A	6	0	0	0	6
1975	N/A	9	0	0	0	9
1976	N/A	8	0	0	0	8
1977	N/A	8	0	0	0	8
1978	N/A	6	0	0	0	6
1979	N/A	8	0	0	0	8
1980	N/A	23	0	1	0	24
1981	N/A	25	0	1	0	26
1982	N/A	50	0	3	0	53
1983	N/A	58	0	4	0	62
1984	N/A	98	0	9	0	107
1985	N/A	94	0	10	0	104
1986	N/A	77	0	9	0	86
1987	N/A	92	0	12	0	104
1988	N/A	80	0	12	0	92
1989	N/A	103	0	17	0	120
1990	N/A	93	0	16	0	109
1991	64	22	6	20	0	112
1992	31	1	4	12	1	49
1993	31	0	6	9	1	48
1994	5	5	2	4	2	17
1995	9	0	2	4	2	17
1996	9	0	2	6	2	20
1997	11	0	2	8	3	25
1998	8	0	2	7	3	20
1999	14	0	3	17	4	37
2000	21	1	4	26	4	56
2001	14	0	3	25	5	47
2002	16	1	3	34	5	60
2003	10	0	2	29	5	47
2004	7	0	1	19	6	33
2005	8	0	2	9	5	23
2006	6	0	1	8	4	19
2007	6	0	1	5	2	15

Appendix Table B6. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for the category 'flatfish' for Estonia (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	1,091	0	40	0	1,131
1951	N/A	1,310	0	48	0	1,358
1952	N/A	950	0	35	0	985
1953	N/A	990	0	36	0	1,026
1954	N/A	1,170	0	43	0	1,213
1955	N/A	1,752	0	64	0	1,816
1956	N/A	1,610	0	59	0	1,669
1957	N/A	1,324	0	48	0	1,372
1958	N/A	1,135	0	41	0	1,176
1959	N/A	950	0	35	0	985
1960	N/A	980	0	36	0	1,016
1961	N/A	768	0	28	0	796
1962	N/A	753	0	27	0	780
1963	N/A	1,094	0	40	0	1,134
1964	N/A	1,903	0	69	0	1,972
1965	N/A	2,731	0	100	0	2,831
1966	N/A	1,070	0	39	0	1,109
1967	N/A	1,330	0	49	0	1,379
1968	N/A	1,018	0	37	0	1,055
1969	N/A	950	0	35	0	985
1970	N/A	1,300	0	47	0	1,347
1971	N/A	1,275	0	47	0	1,322
1972	N/A	1,330	0	49	0	1,379
1973	N/A	731	0	27	0	758
1974	N/A	543	0	20	0	563
1975	N/A	607	0	22	0	629
1976	N/A	934	0	34	0	968
1977	N/A	954	0	35	0	989
1978	N/A	923	0	34	0	957
1979	N/A	1,632	0	60	0	1,692
1980	N/A	1,589	0	58	0	1,647
1981	N/A	1,854	0	68	0	1,922
1982	N/A	1,834	0	67	0	1,901
1983	N/A	1,669	0	61	0	1,730
1984	N/A	1,533	0	56	0	1,589
1985	N/A	1,103	0	40	0	1,143
1986	N/A	816	0	30	0	846
1987	N/A	733	0	27	0	760
1988	N/A	610	0	22	0	632
1989	N/A	423	0	15	0	438
1990	N/A	372	0	14	0	386
1991	248	15	18	25	11	317
1992	164	24	26	30	23	267
1993	165	-1	33	37	34	269
1994	162	-7	42	37	46	279
1995	102	64	42	39	57	304
1996	297	0	71	69	69	506
1997	334	3	76	78	80	571
1998	355	0	75	81	91	602
1999	416	0	82	94	103	694
2000	420	0	76	93	114	704
2001	482	0	80	106	126	794
2002	515	1	78	112	137	843
2003	443	0	61	95	148	747
2004	406	0	50	86	160	702
2005	403	0	45	84	121	653
2006	352	0	39	74	82	547
2007	335	0	38	70	43	485

Appendix Table B7. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for the category 'others' for Estonia (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	1,470	0	54	0	1,524
1951	N/A	1,690	0	62	0	1,752
1952	N/A	2,120	0	77	0	2,197
1953	N/A	2,140	0	78	0	2,218
1954	N/A	2,360	0	86	0	2,446
1955	N/A	2,110	0	77	0	2,187
1956	N/A	2,120	0	77	0	2,197
1957	N/A	3,040	0	111	0	3,151
1958	N/A	2,810	0	103	0	2,913
1959	N/A	4,980	0	182	0	5,162
1960	N/A	5,850	0	214	0	6,064
1961	N/A	5,530	0	202	0	5,732
1962	N/A	5,770	0	211	0	5,981
1963	N/A	5,060	0	185	0	5,245
1964	N/A	5,670	0	207	0	5,877
1965	N/A	5,830	0	213	0	6,043
1966	N/A	6,810	0	249	0	7,059
1967	N/A	9,440	0	345	0	9,785
1968	N/A	9,780	0	357	0	10,137
1969	N/A	8,940	0	326	0	9,266
1970	N/A	8,820	0	322	0	9,142
1971	N/A	5,300	0	193	0	5,493
1972	N/A	5,240	0	191	0	5,431
1973	N/A	6,660	0	243	0	6,903
1974	N/A	5,508	0	201	0	5,709
1975	N/A	6,494	0	237	0	6,731
1976	N/A	5,799	0	212	0	6,011
1977	N/A	5,168	0	189	0	5,357
1978	N/A	5,759	0	210	0	5,969
1979	N/A	5,304	0	194	0	5,498
1980	N/A	4,251	0	155	0	4,406
1981	N/A	3,560	0	130	0	3,690
1982	N/A	3,357	0	123	0	3,480
1983	N/A	2,909	0	107	0	3,016
1984	N/A	2,755	0	102	0	2,857
1985	N/A	2,749	0	101	0	2,850
1986	N/A	2,950	0	109	0	3,059
1987	N/A	2,876	0	106	0	2,982
1988	N/A	3,094	0	114	0	3,208
1989	N/A	3,375	0	125	0	3,500
1990	N/A	1,702	0	64	0	1,766
1991	2,361	1	165	136	13	2,676
1992	1,677	1	235	139	26	2,078
1993	2,150	0	436	237	39	2,862
1994	1,432	0	385	160	51	2,029
1995	1,480	0	376	159	64	2,079
1996	1,887	0	453	205	77	2,623
1997	1,647	0	371	172	90	2,280
1998	1,308	6	276	160	103	1,853
1999	1,066	0	209	118	116	1,509
2000	1,093	0	198	121	129	1,540
2001	1,207	0	202	132	141	1,682
2002	1,501	0	228	174	154	2,057
2003	1,646	0	225	196	167	2,234
2004	1,745	0	215	199	180	2,339
2005	1,379	0	154	162	181	1,876
2006	2,098	6	236	251	182	2,773
2007	1,843	0	206	211	183	2,443

BALTIC SEA FISHERIES CATCHES FOR FINLAND (1950-2007)[1]

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ABSTRACT

This study estimates total marine and brackish-water catches made by Finland in the Baltic Sea from 1950-2007. We used ICES electronic database landing statistics as the officially-reported data baseline, and then added 'adjustments' to reported landings (from various sources including the Finnish Game and Fisheries Research Institute) as well as estimates of unreported landings, discards, and recreational catches. The total of these components represents reconstructed total catches and provides a more comprehensive view of the total exploitation of marine resources. We believe these estimates are underestimates due to our conservative estimation procedures. ICES landing statistics report 4.5 million tonnes of marine landings from 1950-2007, our reconstruction estimates the total catch to be 29% higher (5.8 million tonnes). The majority of this discrepancy is due to unreported landings and discarding of herring (*Clupea harengus*), while cod (*Gadus morhua*) catches are low compared to other Baltic countries. Finland has recorded recreational fishing since 1953, although it is not known whether they submit estimates of unreported landings or discards (other than seal-induced discards). In an effort to contribute to better management of Baltic fish stocks and the Baltic Sea ecosystem, Finland could allocate more resources towards decreasing the amount of unreported catches and discards.

INTRODUCTION

The Nordic Republic of Finland has borders with Sweden, Russia and Norway, and with Estonia to the south across the Gulf of Finland (Figure 1). With a population of 5,329,000 and an area of 302,348 km^2 (Anon., 2009), Finland is the third least densely populated country in the European Union after Norway and Iceland. Finland entered into a free trade agreement with the European Community (EC) in 1973, before experiencing a significant economic recession in the early 1990s. Finland joined the European Union (EU) in 1995, however, and has since developed into a highly-industrialized free-market economy (Melender and Repo, 2006).

Finnish fisheries can be divided into five main sectors: 1) commercial marine; 2) commercial inland; 3) recreational or subsistence in both inshore marine and inland lakes; 4) small-scale marine; and 5) aquaculture. The recreational fishing sector is relatively more important in Finland than in other Scandinavian countries as about half of marine landings are accounted for by recreational fishers, when herring catches are excluded (FAO, 2005). Aquaculture also supplies a substantial portion of fish for human consumption, particularly since the late 1980s when the quality of the Baltic environment and many fish stocks began to decline (Setälä *et al.*, 1998). Our paper, however, will address only wild fisheries catches taken in marine and brackish-water.

Table 1. Percent distribution (%) of Finland's reported landings by ICES subdivision, by decade. Prior to the 1980s all landings were reported from ICES division IIId.

Percentage of catch	1980s	1990s	2000s
ICES subdivision 24	<0.1	0.2	0.39
ICES subdivision 25	<0.1	1.4	2.0
ICES subdivision 26	0.1	0.7	1.1
ICES subdivision 27	0.1	0.4	0.5
ICES subdivision 28	0.7	1.1	0.9
ICES subdivision 29	12.2	24.5	18.5
ICES subdivision 30	8.9	52.3	57.9
ICES subdivision 31	2.6	7.4	5.0
ICES subdivision 32	6.3	12.0	13.8

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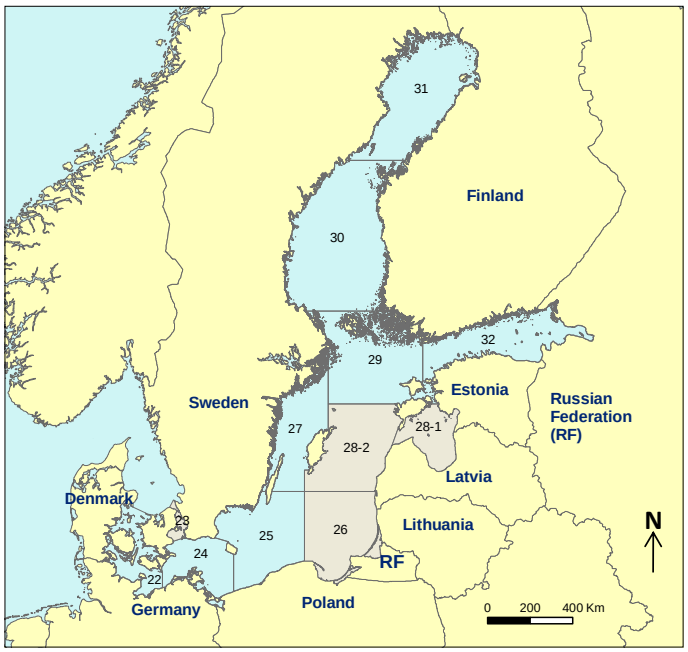

Figure 1. Map of the Baltic Sea with ICES subdivisions and surrounding countries. Finland's coastline borders ICES subdivisions 29-32.

Despite a high rate of fish consumption in Finland, marine fisheries have never contributed significantly to the economy. In 2000, the industry accounted for approximately 0.1% of the GDP (FAO, 2005). The bulk of fish for human consumption are usually imported from Norway, Denmark, Iceland or Sweden (Setälä *et al.*, 1998). Finnish catches are used mainly for industrial purposes, and as a result, the processing sector in Finland is substantial. In 2001, 1,265 people were employed by some 228 plants processing 35,000 tonnes of fish (FAO, 2005). Small-scale fisheries account for 65% of those employed by fisheries, and consequently are more important in economic terms than vessels acquiring the greatest volumes of catches offshore. Small-scale fisheries are especially important in sparsely populated areas where there are few alternative opportunities for employment (FGFRI, 2009).

The three main species caught by Finland according to landings reported by the International Council for the Exploration of the Sea (ICES), are herring (*Clupea harengus*), sprat (*Sprattus sprattus*) and cod (*Gadus morhua*). The majority are caught by pelagic trawlers less than 24 meters long (a fleet of about 65 vessels in 2002). Herring and sprat landings account for approximately 90% of the total Finnish reported landings, and the majority of herring are usually caught during the spring spawning period (May-June). There are no significant fisheries targeting cod, and the majority of this species is caught as bycatch in herring trawls (~60%), in mixed fisheries operating with gillnets, or as bycatch on salmon (*Salmo salar*) longlines (Sjöblom and Parmanne, 1975). Some herring and sprat are frozen or filleted for human consumption, but about 80% of the total catch is sold as fishmeal to the fur farming industry (FAO, 2005). Annual catches are highly dependent on consumer demands for these products, as in the late 1980s, when animal welfare awareness was on the rise, herring landings experienced a significant depression.

A fleet of trawlers greater than 24 meters in length (about 21 vessels in 2002) catch a higher quality and more diversified catch for human consumption (as compared to pelagic trawlers <24m targeting herring for industry [see above]). Targeted species include herring, sprat, salmon, whitefish (*Coregonus lavaretus*), smelt (*Osmerus eperlanus*) and cod. Salmon are also caught by gill- and trap-net, but increasing damage to trap-nets in traditional sites have caused a significant decrease in their use. Approximately 35% of the commercial salmon catch in 2004 had to be discarded due to seal damage (ICES, 1995). Some flounder (*Platichthys flesus*) is also targeted by gill-net (ICES, 1993). Small-scale fisheries target mainly non-quota species, the most important being whitefish.

Prior to the 1990s, herring were mainly caught by trap-net, but by 2004, the fraction obtained by commercial trawl had increased to 90% (Rahikainen *et al.*, 2004). The most important trawling sites in Finland are the southern and southwestern coasts, as the majority of Finland's catches are reported in ICES subdivisions 29, 30 and 32 (Figure 1; Table 1). Trap netting sites are more evenly distributed along the coast, with some concentration in the Archipelago Sea (subdivision 29; Sjöblom and Parmanne, 1975). More than 50% of Finland's total landings have been reported in subdivision 30 (the Bothnian Sea) since the early 1990s (Table 1).

In early periods of reporting, landings were recorded by ICES divisions IIIb, IIIc and IIId. Division IIIb represents the Sound, IIIc the Belt Sea (located between the Kattegat and Baltic Sea [collectively known as the transition zone]), and IIId the Baltic Sea (Table 2). These divisions were segregated into subdivisions by ICES in the late 1970s (ICES, 1987). In Finland, all reporting prior to the 1980s occurred in ICES

division IIId, which was followed by reporting in the corresponding subdivisions (24-32) beginning in the 1980s (Table 1; Table 2).

Table 2. ICES divisions and corresponding subdivisions representing the Danish Sound, Belt and Baltic Sea. Source: (ICES, 1987).

ICES Division	ICES Subdivision
IIIb- Sound	23
IIIc- Belt Sea	22
IIId- Baltic Sea	24-32

Fisheries management in Finland has traditionally been the responsibility of the Ministry of Agriculture and Forestry, Department of Fish and Game. Before joining the EU, Finland had the most centralized fisheries management system of any Nordic country. Commercial and recreational fishers were marginally represented in management agencies and rarely involved in governmental decisions (Jentoft and McCay, 1995). This changed slightly when Finland joined the EU in 1995, as the overarching principles of the Common Fisheries Policy (CFP) became the basis of fisheries governance. Though structural and market-oriented activities are set by this policy, there is some subjectivity as to how the Department of Fish and Game can interpret EU rules [e.g., at what time of year to enforce particular closures (FAO, 2005)]. Total Allowable Catches (TACs) are key elements of management in Finland, and reflect advice from ICES. The five key species in Finland subject to TACs are herring, salmon, sprat, cod, and plaice (FAO, 2005).

National and EU authorities mainly govern offshore waters and marine reserves, while coastal waters (a distance of 500m from the 2m depth line) are privately owned and managed. The Fishery Act requires stakeholders to design management plans for the fisheries in their area of water, including aspects on utilization, conservation and restoration. Owners form associations which collect revenue from license sales which are invested in management. All privately owned waters are also part of nationally administrated fisheries regions which provide opportunity for cooperation between owners and commercial fishers. Commercial fishers are heavily dependent on access to private waters and these associations address issues of minimum mesh and fish landing sizes as well as temporal closures. Recent developments and urbanization have fragmented private waters triggering complications in management which has initiated requests for re-evaluation of protocol.

On a larger scale, Finland shares many of the management challenges with other EU countries whose resource policies now fall under the CFP. Fishing fleet overcapacity is estimated to be 60% in the EU, and Finland struggles to balance the size and capacity of its fleet with available resources (FAO, 2005). In 2004, the offshore fleet was reduced from 47 to 16 vessels (ICES, 2005b).

The purpose of the present study is to provide an estimate of total fisheries catches in the Baltic Sea by Finland (1950-2007) and contrast these total catches with officially reported data. The ICES catch statistics database offers time series data on marine fisheries landings for this time period, but there has been no apparent effort to fully represent total catches (including Illegal, Unreported and Unallocated catches [IUU]) in contrast to landings. Therefore, for the purposes of our study, the ICES electronic database will be referred to as the 'ICES landings statistics', to better reflect the nature of the data presented, and represents the officially reported data. Sources of IUU include data source adjustments to reported landings data, unreported landings, discards, and recreational catches. Our approach utilizes data by the Finnish Game and Fisheries Research Institute (FGRI), a review of the academic and grey literature, as well as correspondence with local fishers and authorities.

METHODS

Reported landings extracted from the ICES landings statistics database (ICES, 2009) were used as the reported data baseline for our reconstruction of Finland's total catches in the Baltic Sea from 1950-2007. ICES landings statistics were used as the reported data foundation as they are the only publicly available data that present all countries' landings for all taxa and years (since 1950) in all areas of the Baltic Sea.

All catches that are not included in the ICES landings statistics were considered part of IUU. Here, IUU catches were considered in four components: a) '*adjustments*' to ICES landings statistics based on time series data from reliable sources (e.g., ICES stock assessment working group data, national government agencies); b) '*unreported*' landings (referred to as 'unallocated' catches by ICES); c) '*discards*' being catches or mortality caused by fishing but where fish are not landed or utilized; and d) '*recreational*' catches. The sum of these components plus the officially reported ICES landings statistics provided our total reconstructed catch for Finland from 1950-2007.

Using all available data and information, anchor points were derived or formed through an assumption-based approach (see 'Methods' in Zeller *et al.*, this volume). From these anchor points, a complete time series of data from 1950-2007 was constructed using linear interpolations and extrapolations for years when data were not available.

Here, our reconstruction presents the main commercially targeted species for Finland including cod (*Gadus morhua*); herring (*Clupea harengus*); sprat (*Sprattus sprattus*); salmon (*Salmo salar*); a flatfish grouping, which included plaice (*Pleuronectes platessus*), European flounder (*Platichthys flesus*), and turbot (*Psetta maxima*); and an additional 18 individual taxa grouped here for reporting as 'others'.

Illegal, Unreported and Unregulated (IUU) catches

Illegal, Unreported and Unregulated (IUU) catches are a major source of underreporting in many country's fisheries catches (Zeller and Pauly, 2007) and are also of concern in the Baltic Sea (Menn, 2006; Anon., 2007b; Crona and Österblom, 2009). Below, we present the methods and data sources used to estimate the four IUU components defined above: a) '*adjustments*'; b) '*unreported*' landings; c) '*discards*'; and d) '*recreational*' catches.

Estimates of IUU catch components were based on information obtained through a range of primary and secondary sources. Information was primarily obtained through interviews and collaborations with fisheries experts at the Finnish Game and Fisheries Research Institute (FGFRI) who provided national fisheries catches (commercial landings and recreational catches; A. Ahvohenen and P. Söderkultalahti, pers. comm., FGFRI), although we also searched sources such as the European Union's Directorate-General for Maritime Affairs, the ICES library, and the archives of Finnish newspapers, magazines and fisheries-related organizations.

Adjustments to ICES landings statistics

The reported ICES landings statistics were adjusted using Finnish landings data provided by FGFRI for the period from 1953-2007, for most taxa including cod, herring, sprat, salmon, flatfishes and 'others'. For some species in our group flatfishes and 'others', FGFRI data were available for slightly different periods of time (Table 3). Landings reported by FGFRI were considered more reliable than the ICES landings statistics for two reasons. Firstly, Finland is unique among the Baltic countries in that recreational catches have been estimated and reported nationally since the late 1950s. Secondly, Finland updated its national catch estimation methods in 1988, which led to a revision of reported landings for Finland from 1980-1986 (Ahvonen, 2001); yet, the ICES landings statistics database was not amended retroactively to account for these updated landings estimates (E. Aro, pers. comm., FGFRI). Thus, negative adjustments to ICES landings statistics were made to account for the inclusion of recreational catches and also to account for the new catch estimation methods by Finland. These adjustments made to ICES landings statistics to account for the inclusion of Finland's recreational catches made Finland's landings data comparable to all other Baltic countries by reflecting commercial fisheries landings only.

Table 3. Years when landings data provided by FGFRI were used as adjustments to the ICES landings statistics for some taxa included in our grouping of flatfishes and 'others'.

Common name[a]	Scientific Name	Years
Ide	*Leuciscus idus*	1969-2007
Flounder	*Platichthys flesus*	1974-2007
Trout	Salmonidae	1974-2007
Eel	*Anguilla anguilla*	1976-2007
Roach	*Rutilus rutilus*	1979-2007
Freshwater species nei	-	1980-2007
Turbot	*Psetta maxima*	1996-2007
European plaice	*Pleuronectes platessa*	2006-2007
Whiting	*Merlangius merlangus*	2006-2007
Other (various)	-	1953-1979

[a]as defined by FGFRI

Adjustments were made for all taxa in years when FGFRI data indicated that catches were different than what was presented in the ICES landings statistics. However, careful attention was paid to not adjust landings for taxa that may have been included in another taxon or group. For example, a gap in cod data from 1959-1961 was not interpolated, as Finnish cod catches were so small during this period that they

Table 4. Anchor points (%) used for estimating unreported landings for cod, salmon and other taxa from 1950-2007 based on sources (Tables 2.3.1 and 2.4.1 in ICES, 2007; Table 2.1.2. in ICES, 2008a). Dashed lines (-) indicate years when linear interpolations were used.

Year	Western cod	Eastern cod	Salmon	Other taxa[a]
1950	5.0	5.0	5.0	5.0
1951-1979	-	-	-	-
1980	20.1	43.9	19.9	12.3
1981	-	-	6.4	-
1982	-	-	6.5	-
1983	-	-	7.1	-
1984	-	-	6.4	-
1985	-	-	5.8	-
1986	-	-	7.0	-
1987	-	-	6.5	-
1988	-	-	7.1	-
1989	-	-	7.1	-
1990	-	-	7.2	-
1991	-	-	5.8	-
1992	-	-	5.6	-
1993	40.2	87.7	5.9	24.6
1994	39.6	123.6	5.9	30.3
1995		29.7	6.2	-
1996	5.3	13.1	6.4	-
1997	-	-	6.5	-
1998	-	-	6.7	-
1999	-	-	6.6	-
2000	-	46.0	6.8	-
2001	-	47.5	6.6	-
2002	-	47.5	6.5	-
2003	-	59.8	6.7	-
2004	0.1	52.9	6.0	12.3
2005	0.0[b]	46.4	6.2	11.2
2006	0.0[b, c]	46.9	6.0	11.2[c]
2007	0.0[b, c]	43.2	6.5	11.2[c]

[a] includes all taxa except cod and salmon. [b] less than 0.05. [c] rate from 2005 carried forward.

may have been included as part of the grouping 'others'. Trout were not adjusted either, as they were reported as a component of salmon catches from 1953-1973. Thus, our aim was to not risk double counting catches in order to remain conservative when making adjustments on a taxonomic basis.

Unreported landings

Percentage rates for unreported landings were applied to the sum of ICES landings statistics plus adjustments to estimate total unreported landings for each respective taxon or group. Despite a dearth of information on Finnish unreported landings, it is likely that Finland did have some unreported landings between 1950 and 2007. For example, Finnish fishers are known to have been involved in large-scale operations to catch and sell unreported cod caught and sold in Sweden in the 1980s (P.-O. Larsson, pers. comm., Swedish Board of Fisheries). We estimated unreported landings from ICES stock assessment working group for cod (ICES, 2007; 2008a) and salmon data (ICES, 2008b); and for all other taxa using our assumed default approach (Table 4; see 'Methods' in Zeller *et al.*, this volume). Other data sources also suggest that Finland has unreported landings. For example, when comparing import/export data and consumption patterns with landings, Ahvonen (1998) found that the unreported landings of salmon were approximately 16-33%. Ahvonen's method for estimating unreported catches was not used here, because unfortunately Finland's trade statistics for fisheries products have become much more aggregated since joining the EU in 1995. Unreported landings in the Baltic Sea have mainly focused on cod, and Finland has traditionally caught very little relative to the other Baltic countries. For this reason, the EU did not include Finland in its recent evaluation of the reliability of Baltic countries in reporting cod catches (Anon., 2007a).

Table 5. Anchor points (%) for estimating underwater discards for Finnish herring and sprat catches adjusted to reflect all landings based on Rahikainen *et al.* (2004)

Year	Underwater discard
1950-1979	2.50[a]
1980	2.54
1981	2.06
1982	2.90
1983	3.86
1984	5.18
1985	5.59
1986	6.29
1987	5.36
1988	5.78
1989	6.70
1990	6.61
1991	7.23
1992	7.52
1993	7.21
1994	7.77
1995	8.12
1996	8.00
1997	8.30
1998	8.10
1999	8.50
2000	8.46
2001-2007	8.46[b]

[a] 1980-1982 average carried back to 1950; [b]2000 rate carried forward unaltered to 2007.

Discards

Discards were considered as four separate categories, each calculated as a rate by estimating discard tonnage as a proportion of reported landings from the respective sources. The four discard categories considered for Finland were: a) '*underwater discards*', which accounted for the mortality of fish lost from actively fishing gear prior to being brought on board; b) '*ghostfishing*' due to lost or abandoned fishing gear that continues to fish; c) '*boat-based discards*' usually resulting from fishers' catch retention behavior; and d) '*seal-damaged discards*' representing the fraction of catch discarded because of seal damage. To avoid the chance of double counting, seal discard data were used in place of boat-based discards when estimated seal-damaged discards where higher than boat-based discards. Rates for each

category were applied to the estimated total landings of each respective taxon (i.e., ICES landings statistics + adjustments + unreported landings), giving an estimated total discard amount for each category. The sum of the discard amounts for each category gave us a total discards amount for Finland from 1950-2007.

'*Underwater discards*': An underwater discard rate for herring of approximately 9% was estimated for catches from Finland's trawl fisheries in subdivision 32 from 1980-2000 based on Rahikainen *et al.* (2004). We applied this rate to all of herring landings by trawl for all years and subdivisions.

Data on the proportion of Finnish landings that were caught in trawl fisheries were only available from 1980-2000. The rate from 2000 was carried forward to 2007. To estimate the rate from 1950-1979, we used the average rate from 1980-1982. We used the same rates for sprat as both herring and sprat are pelagic species that are caught in a mixed fishery using similar gear-types. We adjusted the above rates to reflect landings by all gear-types (Table 5).

'*Ghostfishing*': Ghostfishing is a worldwide problem that was highlighted in recent work by Macfadyen *et al.* (2009). Our estimate of Finland's ghostfishing discards was derived from a study by Tschernij and Larsson (2003), which estimated the amount of cod caught by lost gear in Sweden, and related these ghostfishing discards to commercial landings in Sweden. Estimates from this source were converted by Brown *et al.* (2005) into a range of ghostfishing rates. Here, we used the average of this range, which was estimated to be 1.65%. This rate was then applied to all taxa, except herring and sprat, for all years. Ghostfishing is mostly associated with lost gear that ends up on the bottom of the ocean so it is not a major concern for pelagic species such as herring and sprat.

'*Boat-based discards*': Finland specific boat-based discard data were not available. Therefore, we relied on information from ICES stock assessment working group reports to estimate boat-based discards for salmon (ICES, 2008b) and cod (ICES, 2007; 2008a), and information from a Danish study (Anon., 2006) to derive estimates for the flatfishes and the group 'others' (see 'Methods' in Zeller *et al.*, this volume). For herring and sprat, we assumed a boat-based discard rate of 0% for herring and sprat during the entire study period, based on an ICES reports that indicates that boat-based discards for herring and sprat were almost non-existent (ICES, 2005a; 2007; 2008a).

'*Seal-damaged discards*': Seal-damaged discards have been a political concern in the Baltic Sea since the 1980s when seal populations increased again from a previously depleted state (Österblom *et al.*, 2007). We assumed seal-damaged discards to be mostly a commercial fishing issue; therefore, we applied seal-discard rates to total landings data (ICES landings statistics + adjustments + unreported landings), but not to recreational catches. It is likely that a proportion of seal-damaged discards may have been included in accounts of boat-based discards for species targeted by seals. To avoid the possibility of double counting, seal-damaged discard rates replaced the boat-based discard rate in years when the seal-discard rate was higher.

Table 6. Anchor points (%) used for estimating for seal-damaged discard rates for herring based on sources (FGFRI, 2009; Königson, 2005). Boat-based discards were assumed to be zero from 1950-2007. Dashed line (-) indicates interpolated rates.

Year	Seal-damaged discard
1980	0.00
1981-1999	-
2000	0.09
2001	0.33
2002	0.10
2003	0.51
2004	0.06
2005	0.16
2006	0.25
2007	0.39

Estimates of Finland's yearly seal-damaged discard tonnage were made available by FGFRI from 2000-2007 for herring, salmon, trout, whitefish, perch, pikeperch and vendace in ICES subdivisions 24-32. However, these estimates do not account for fish that are completely removed from fishing nets by seals prior to gear retrieval. A separate study investigating the removal of fish by seals from fixed gear in Sweden (Königson *et al.*, 2005; Anon., 2005) quantified this loss as 7.4 times the seal-damaged discards that were retained in the gear and brought to the surface. Thus, to account for total seal discards in coastal waters of Finland (Subdivisions 29-32) by fixed-gears, the reported discards provided by FGFRI were raised by a factor of 7.4. These discards were then transformed into a percentage of FGFRI reported commercial landings for the respective species or groups. We assumed a zero percent seal-damaged discarding rate for years prior to 1980, and interpolated rates linearly between 1980 and 2000 (Table 6). For herring, seal-damaged discard rates replaced boat-based discard rates from 1980-2007, as we assumed conservatively that boat-based discarding for these taxa was likely zero for the entire study period (see above).

Seal-damaged discard rates for salmon, derived from FGFRI data, were compared to the boat-based salmon discard rates derived from ICES stock assessment working group data (see 'Methods' in Zeller *et al*., this volume) for the period 1980-2007 (Table 7). To avoid potential double accounting due to damage caused by seals, only the higher discard rate between the two categories was used.

Table 7. Salmon discard rates (%) for boat-based discards derived from ICES stock assessment working group data (ICES, 2008b) and seal-damaged discards derived from FGFRI. Only the highest rate of the two discard categories was used. Values in *italics* indicate an interpolated rate.

Year	Discards		
	Boat-based	Seal-damaged	Rate used
1950-1980	14.44	0.00	14.44
1981	8.31	4.2	8.31
1982	8.29	8.46	8.46
1983	9.00	*12.68*	12.68
1984	8.14	*16.91*	16.91
1985	7.73	*21.14*	21.14
1986	8.77	*25.37*	25.37
1987	8.47	*29.59*	29.59
1988	8.61	*33.82*	33.82
1989	8.91	*38.05*	38.05
1990	10.17	*42.28*	42.28
1991	7.95	*46.50*	46.50
1992	7.83	*50.73*	50.73
1993	8.52	*54.96*	54.96
1994	7.80	*59.19*	59.19
1995	8.36	*63.42*	63.42
1996	8.99	*67.64*	67.64
1997	8.58	*71.87*	71.87
1998	8.58	*76.10*	76.10
1999	8.83	*80.33*	80.33
2000	5.76	84.55	84.55
2001	9.10	103.21	103.21
2002	9.61	95.66	95.66
2003	9.77	127.51	127.51
2004	9.10	94.37	94.37
2005	8.76	83.22	83.22
2006	10.02	95.97	95.97
2007	10.02	79.91	79.91

Species specific, seal-damaged discard rates for trout, whitefish, perch, pikeperch, and vendace were derived from FGFRI data and compared to the default boat-based discard rates for these species derived from a Danish study (Anon., 2006). The higher discard rate was chosen to avoid double accounting, in cases where seal-discards may have already been accounted for in the boat-based discards.

Recreational catches

Estimates of Finland's recreational catches from the Baltic Sea were provided by our collaborators at FGFRI. FGFRI has undertaken studies to estimate recreational catches throughout most of the time period considered here (FGFRI, 2009). Recreational catches were estimated by FGFRI starting in 1953 and since 1986 these estimates have been done every other year with the exception of 1955-1958 and 1960-1961 when recreational catch surveys were not carried out. In years when recreational catch surveys were not done, FGFRI provided estimates of recreational catches for the non-surveyed years. For the period 1950-1952, we estimated annual recreational catches based on the average catch from 1953-1955 as reported by FGFRI.

Overall, our total reconstructed catch was the sum of ICES landings statistics, reported landings adjustments and estimates of unreported landings, discards and recreational catches. The estimated total reconstructed catch was then compared to the officially reported data, defined here as the ICES landings statistics.

RESULTS

ICES landing statistics for Finland totaled 4,468,766 t over the 1950-2007 time period (Figure 2). Landings according to ICES showed a steady increase over the study period from around 20,000 t in 1950 to approximately 100,000 t·year^{-1} in the late 1970s. A significant decline in reported landings occurred in the early 1990s to roughly 75,000 t·year^{-1}, followed by an increase from the mid-1990s to the early 2000s, with the highest reported landings of almost 130,000 t in 2007 (Figure 2).

Illegal, Unreported and Unregulated (IUU) catches

Catches that were not presented in the ICES landings statistics were considered components of IUU. These included data source adjustments to ICES landings, unreported ('unallocated') landings, discards and recreational catches.

Adjustments to ICES landings statistics

Negative adjustments of 180,437 t were made to the ICES landings statistics for Finland using national data sources. These adjustments were, in part, due to recreational catches being included in the ICES landings for some years over the period 1950-2007. Given that we accounted for recreational catches separately (see below), we excluded the recreational component from reported landings here, resulting in negative adjustments. Adjustments to landings were greatest in the late 1970s and throughout the 2000s (Table 8; Appendix Table A1). The most substantial adjustments to landings were for the group 'others'.

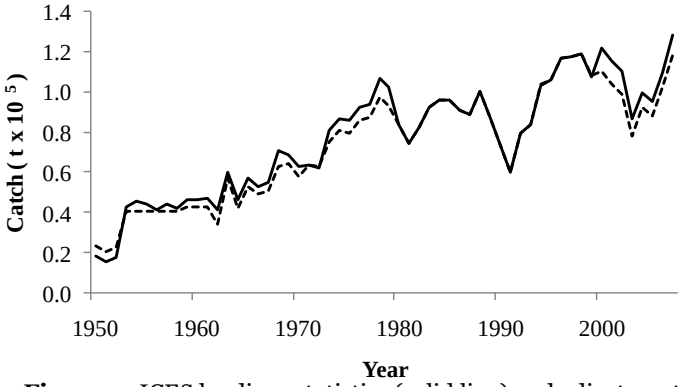

Figure 2. ICES landings statistics (solid line) and adjustments to ICES landings (dashed line) for Finland from 1950-2007

Table 8. Total adjustments (tonnes) to ICES landings statistics for Finland from 1950-2007.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	216	-167	-3,390	-2	1	-38
Herring	-2,910	-10,246	-5,894	-1	-2	-5,532
Sprat	3,060	-107	-385	1	-2	-407
Flatfishes	0	0	-914	1	-6	-1,588
Salmon	127	-504	-473	3	1	-832
'Others'	-4,520	-35,333	-43,994	304	-157	-66,745

Table 9. Total estimated unreported landings (tonnes) of commercially targeted species in Finland from 1950-2007.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	60	17	650	13,660	4,792	3,593
Herring	16,061	36,046	76,596	135,787	203,381	86,074
Sprat	1062	1,365	2,362	1,293	20,678	20,206
Flatfishes	0	0	49	92	199	72
Salmon	242	408	937	562	814	221
'Others'	4,777	5,354	6,683	4,917	10,452	4,053

Unreported landings

Estimated unreported landings for all taxa from 1950-2007 totaled approximately 663,500 t. Unreported landings increased steadily over the study period from about 1,000 t·year^{-1} in 1950 to almost 21,000 t·year^{-1} in 1988. After this, there was a slight decline before unreported landings increased again to a likely peak of over 31,000 t·year^{-1} in 1994 (Figure 3; Appendix Table A1). Unreported landings declined steadily after that to about 13,000 t·year^{-1} in 2007.

Herring represented the largest component of unreported landings, which were estimated to be about 29,600 t·year^{-1} in 1994. Estimated unreported landings of herring increased steadily from 675 t·year^{-1} in 1950 to about 29,600 t·year^{-1} in 1994 and then decreased to an average of approximately 8,700 t·year^{-1} from 2003-2007. During the period 1950-2007, unreported landings of herring totaled over 550,000 t.

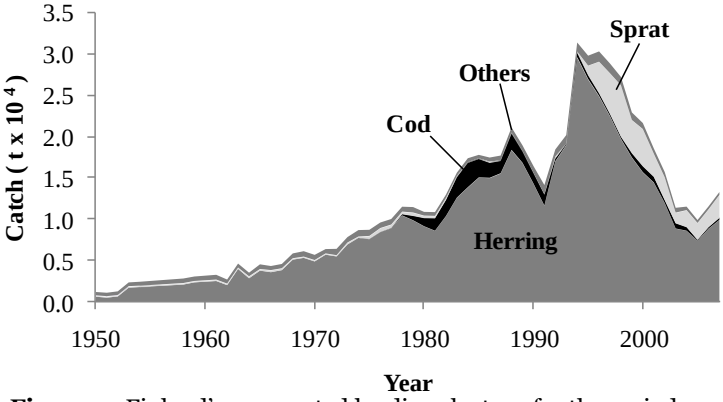

Figure 3. Finland's unreported landings by taxa for the period 1950-2007.

Unreported landings of cod were highest in 1984 adding approximately 3,000 t to the reported landings of 2,137 t for that year. Unreported landings of sprat were low from 1950-1994, averaging 146 t·year^{-1}. After this period, a dramatic increase occurred during which unreported landings averaged approximately 3,100 t·year^{-1} from 1995-2007 (Figure 3, Appendix Table A4. Unreported landings of salmon were relatively low over the entire study period, ranging from approximately 20 t·year^{-1} to 150 t·year^{-1} (Figure 3). Unreported landings of

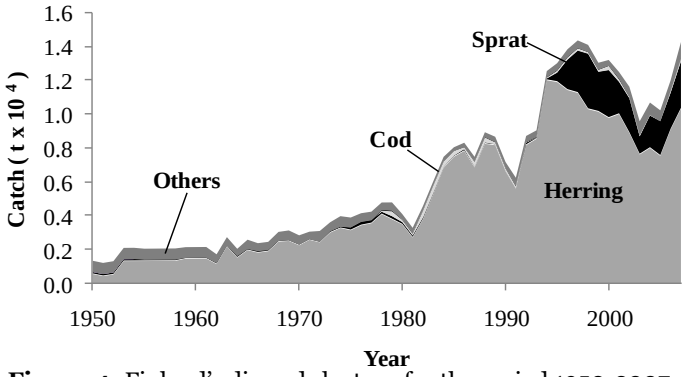

Figure 4. Finland's discards by taxa for the period 1950-2007.

flatfishes were minimal totaling about 400 t over the time period 1974-2007. The group of flatfishes, which included European flounder, European plaice and turbot, represented a very small proportion of estimated unreported landings due in part to our assumption that from 1950-1973 landings of flatfishes were reported as one of the 'miscellaneous' categories included within the group 'others'. From 1950-2007, unreported landings of 'others' totaled approximately 36,000 t (Appendix Table A7).

Discards

Estimated total discards for all species from 1950-2007 were approximately 372,800 t (Figure 4). Discards increased steadily over the study period from about 1,400 t·year^{-1} in 1950 to a peak of over 15,000 t·year^{-1} in 1997. Discards were highest throughout the 1990s and into the 2000s. Herring accounted for the largest amount of discards and totaled approximately 291,000 t over the study period, with a peak in 1994 of over 12,000 t·year^{-1} (Appendix Table A3). Over the study period, cod discards totaled 5,000 t. Salmon discards were substantial in comparison to reported salmon landings, adding nearly 16,000 t to the total reported ICES landings for salmon of 37,625 t from 1950-2007 . Sprat discards were low throughout the first four decades of the study period, increasing dramatically in the mid-1990s and remaining substantial throughout the 2000s (Table 10). Flatfish discards were quite low, totaling around 1,300 t over the study period (Figure 4).

Table 10. Total estimated discards (tonnes) of commercially targeted species in Finland from 1950-2007.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	90	13	445	2,414	789	850
Herring	11,267	18,810	31,922	61,142	96,551	71,694
Sprat	770	723	973	526	10,517	16,513
Flatfishes	0	0	237	318	492	258
Salmon	587	595	1,019	1,897	8,120	3,514
'Others'	6,569	5,402	5,362	2,747	4,165	5,158

Table 11. Total recreational catches (t) for Finland, 1950-2007.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	72	168	3,528	12,667	646	30
Herring	1,390	15,658	9,321	10,532	12,798	5,176
Sprat	132	390	475	433	30	340
Flatfishes	-	-	1,001	3,338	5,922	1,366
Salmon	141	513	629	1,293	1,736	644
'Others'	17,015	37,053	52,704	64,920	128,01	66,786

Recreational catch

Total catches for Finland's recreational fisheries in the Baltic Sea from 1950-2007 were reported as 456,679 t (Figure 5). Note that Finland reports recreational catches nationally and that the national data set provided by FGRI had separate accounting for commercial landings and for recreational catches.

Recreational catches increased steadily from around 1,600 t·year^{-1} in 1950 to between 10,000 t·year^{-1} and 20,000 t·year^{-1} in the 1990s (Figure 5, Appendix Table A1). The majority of recreational catches were of 'other species', which represented 80% of the total recreational

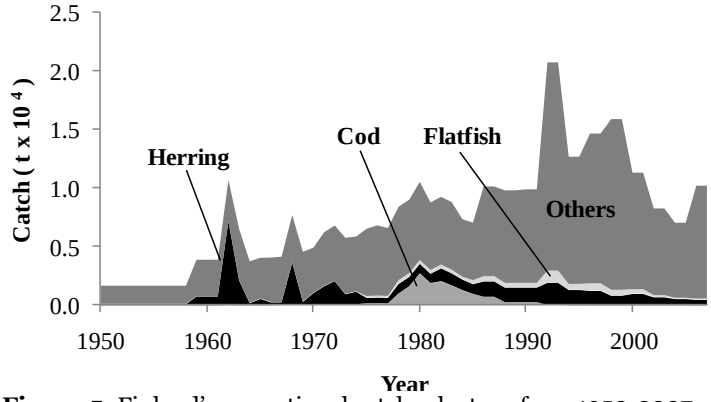

Figure 5. Finland's recreational catches by taxa from 1950-2007.

catch for Finland from 1950-2007. Herring represented 12%, cod 4%, salmon 1%, and sprat contributed less than 0.4% of total recreational catches over the entire study period (Figure 5). Recreational catches of 'others' totaled over 366,000 t from 1950-2007 and were most substantial during the 1990s (Table 11).

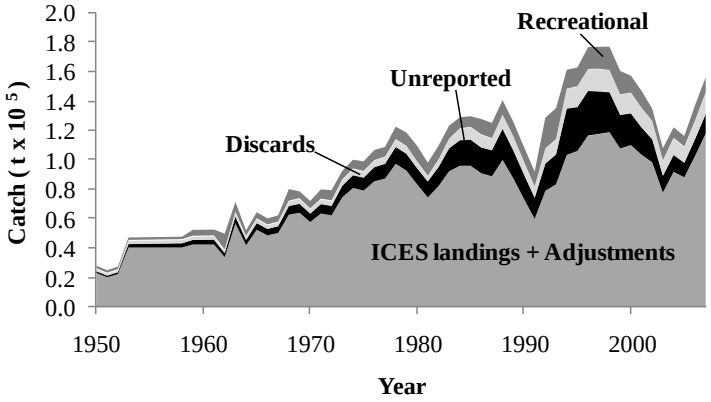

Figure 6. Finland's total reconstructed catch by component from 1950-2007.

Total reconstructed catches

The total catch for Finland as reconstructed here combined reported ICES landings statistics, adjustments, unreported landings, discards and recreational catches, (Table 12, Figure 6). The total reconstructed catch was estimated to be 5,781,000 t for the period 1950-2007 (Appendix Table A1). This compares to the 4,468,766 t that was reported in the ICES landings statistics for the same period (Figure 7).

This discrepancy of over 29% between officially reported landings and estimated total catches was due to significant quantities of unreported landings and discards (since recreational catches were included, at least partially, in the data reported by ICES on behalf of Finland). Unreported landings and discard estimates added over 1 million t to the reported landings (Figure 7). The majority of unreported landings and discards were attributed to fisheries involving herring. Recreational fisheries, dominated by the group 'others', accounted for approximately 500,000 t from 1950-2007. The cod fishery in Finland was modest compared to those in other Baltic countries; however, unreported landings, discards and recreational catches of cod together totaled approximately 45,000 t between 1950 and 2007, an increase of 67% to data reported in the ICES landings statistics (Figure 7). Overall, unreported landings, discards and recreational catches represented 12%, 6% and 8% of the total reconstructed catch for Finland, respectively (Figure 6).

Table 12. Total reconstructed catches (tonnes) of commercially targeted species in Finland from 1950-2007.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	924	290	6,839	61,978	19,866	12,916
Herring	284,129	487,684	810,368	1,020,216	1,123,617	769,876
Sprat	19,450	18,528	24,887	11,028	117,288	180,182
Flatfishes	0	0	1,714	4,298	7,409	2,154
Salmon	4,374	4,806	7,984	11,107	23,735	7,812
'Others'	106,839	110,913	126,018	102,481	184,960	104,331

DISCUSSION

Our reconstruction of Finland's total catch, including reported landings from ICES landings statistics (ICES, 2009), adjustments to landings, unreported landings, discards, and recreational catches, totaled approximately 5.8 million tonnes for the period 1950 to 2007. Finland's annual landings data as reported by ICES total approximately 4.5 million tonnes for the same period (1950-2007). The difference of approximately 1.3 million tonnes (29%) between ICES data and our total catch reconstruction suggests the magnitude of IUU catches in

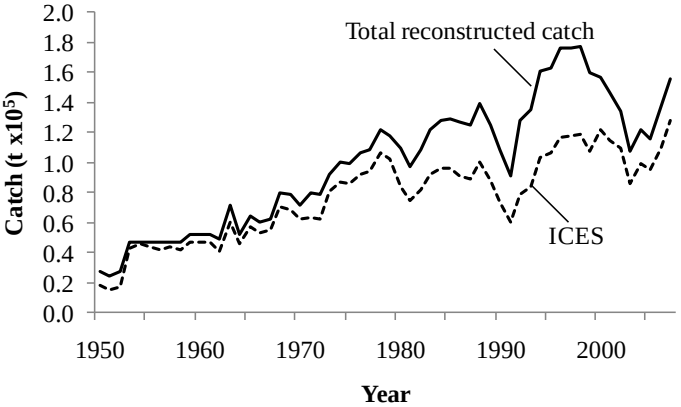

Figure 7. Total reconstructed catch and ICES landings statistics for Finland from 1950-2007.

Finland between 1950 and 2007. The discrepancy between these datasets (estimating landings versus estimating catches) displays the significant mortality rates and impacts on the Baltic ecosystem that are not accounted for. This discrepancy can mislead the public and complicates the decision making process for policy makers who are forced to rely on incomplete or underestimated catch records when setting TACs or deciding upon other management strategies (closures, gear restrictions, etc.).

Our estimates of IUU catches were based on conservative methods and our catch reconstruction is thought to underestimate the total catch between 1950 and 2007. However, it undoubtedly provides a more accurate baseline than current statistics available from ICES which assume zero IUU catches. Even though our catch reconstruction presents a 29% increase in catches between 1950 and 2007 (as compared to ICES landings statistics), Finland's total estimate of IUU was one of the lowest of all Baltic countries. This is due in part because of Finland's exemplary efforts at accounting for the recreational fishing sector since 1953. Landings reported to ICES since this time have included recreational catches, meaning the majority of IUU catches unaccounted for in Finland were comprised of unreported landings and discards. The Finnish Game and Fisheries Research Institute (FGFRI) provided us with all commercial and recreational landings data from 1953 to present. FGFRI data were more comprehensive than data presented by ICES on behalf of Finland. Adjustments were made to ICES data with a national dataset that displayed a greater degree of transparency and accountability in Finnish fisheries management compared to other Baltic countries.

Our catch reconstruction showed herring to be the species most affected by IUU fishing in Finland since 1950. This is due in part to the fact that herring is the most important species fished in Finland by volume. Unreported landings of herring were estimated to be about 560,000 tonnes, and discards of herring were estimated to total approximately 300,000 tonnes between 1950 and 2007. Unreported landings of cod in Finland were only 4%of the amount of unreported landings of herring when summed over the period of study (1950-2007). The Finish Ministry of Agriculture and Forestry reports that the majority of cod fishing occurs outside of the Finnish EEZ and that in 2005, most cod landings were made in Swedish and Danish ports, with zero cod landings in Finnish ports (Anon., 2007b). Finland's unreported landings of cod still represented about 37% of cod landings reported to ICES between 1950 and 2007 (i.e., catch volumes of cod are low, but the rate of underreporting is relatively high.

As a Member of the EU, Finland is required to enforce the regulations of the Common Fisheries Policy (CFP), and to report details on serious infringements to the European Commission (EC; the legislative arm of the EU). These rules were formed in an effort to encourage transparency and consistency between Member States with regards to CFP enforcement. In 2003, 18 serious infringements were reported by Finland (50% of the total number of infringements in Finland) and the average fine was a low €282. This is compared to already low Baltic-wide average fine of €464. However, little direct comparison can be made between these figures, since there are no standards for evaluating fishers' behaviors among EU members. When a Member state is believed to be in noncompliance with Community laws, the Commission can issue a request for a written description of the country's observations relating to the subject of investigation. If the opinion of the Community remains unchanged after receiving this written report, court proceedings can be initiated. In 2004, two procedures were initiated against Finland for exceeding catch quotas, and one procedure was initiated for failing to provide catch or fishing effort data to the EC (Anon., 2007b).

Little information regarding discards in Finland was available from national or ICES datasets. However, estimates of discards caused by seal-induced damages were available from the FGFRI. These records were augmented using a Swedish study to include the mortalities of fish removed completely from nets by seals. The most significantly affected species by seal-induced damages was salmon, as approximately 26% of the total reconstructed salmon catch was discarded (this proportion includes boat-based, ghostfishing and seal-induced discards). Some progress has been made in modified gear designs and the choice of netting material used to build trap-nets to protect fish from seal damage. Three out of five modified gear models examined by Siira, (2007) were considered to be successful. The pontoon trap was noted as the most successful of those tested, where seal-induced damages were practically non-existent (Hemmingsson *et al.*, 2008). Protection from seal damage is necessary, as coastal salmon fishers in the Gulf of Bothnia have been severely challenged by related socio-economic factors in recent decades. Salmon populations were considered to have recovered in the early 1990s after reductions were made in the Baltic TAC for the species, and strict seasonal closures were enforced. However, drastic increases in recreational fishing of salmon since this time, in addition to vast increases in grey seal populations have left commercial salmon fishers with inadequate stock sizes to maintain their livelihoods. Less vulnerable trapping methods will

lessen the pressures induced by fisheries on salmon stocks, as well as allow more accurate accounting of salmon catches, as estimates of salmon taken by seals from set trap-nets would be unnecessary.

Discards of herring were the most substantial by volume. The total discards of herring accounted for almost 80% of the discards of all taxa between 1950 and 2007. Though discards of herring were substantial by volume, they accounted for only 8% of the total reported landings of herring by ICES, and 6.5% of the overall reconstructed catch of herring between 1950 and 2007. This emphasizes how little economic incentive there is to high-grade fish destined for industrial purposes. The second most affected species by discards was sprat, which is due to it being caught as bycatch in the pelagic herring fishery. Discards of flatfishes were the least severe (by volume) out of all Finnish fisheries, but represented about 25% of the total landings of flatfishes reported to ICES and the responsible fishing behaviors may be of significant concern. Flatfishes also represented a fairly large portion of the recreational catches, with over 11,000 tonnes reported over the period of study.

Recently, ICES reported some improvement of the eastern Baltic cod stock and recommended an increase of the TAC by 15%. This is the maximum amount allowed under the EU's management plan for Baltic cod fishing (Veem, 2009). The observed improvement in stock size, however, has not elevated cod abundance beyond what are considered historically low levels, which are still far from what would be considered sustainable in the long-term. Historically, ICES' scientifically-recommended TAC levels for the management of cod stocks have been increased due to so-called socio-economic factors within the fishing industry. It has been commonplace for ICES TAC recommendations to be increased by a factor of 3 during negotiations with the European Council of Ministers (WWF, 2006) and Russia.

Our methods used all the information available to combine reported landings with estimates of IUU catches. Apart from the adjustments to commercial landings and recreational catches that were obtained from the dataset provided by the FGFRI, the majority of our estimates were derived from Baltic-wide data presented in ICES stock assessment working group reports. The number of countries whose discards or unreported ('unallocated') landings are included in these Baltic-wide estimates is unknown due to publicly non-transparent confidentiality agreements. Thus, in some sense, under current regulations, countries are able to remain anonymous and relatively unaccountable for IUU fishing. Though some of these data are available to the stock assessment community within ICES, the 'true' level of catches lacks transparency to the public who are the ultimate beneficiaries and owners of a common resource.

Increased transparency with regard to all fisheries catches is necessary in order for all stakeholders to be informed and to become involved in the future well-being of the Baltic Sea ecosystem. In addition to increased accountability and transparency of IUU catches of target species, regulations should require accountability for all species caught by fishing gear whether or not they are economically valuable, or whether they are discarded or brought to port. When all catches resulting from fishing gear are accounted for, management can begin to evolve towards an ecosystem-based management system that considers the whole ecosystem rather than focusing on single species in isolation from their environment. Records of these catches will facilitate the modeling of Baltic Sea ecosystems and key ecosystem processes governing some of the observed issues. Such baseline data would also provide the tools required to generate scenarios illustrating various management protocols and allow decision-makers and the public to make decisions based upon various biological, social and economic factors that incorporate both short- and long-term goals. An ecosystem-based management system will also require the cooperation of all Baltic countries to contribute such data, so the ecosystem can be considered in its entirety.

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APPENDIX A

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

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	18,838	4,756	1,180	1,394	1,643	27,811
1951	15,725	5,037	1,090	1,268	1,643	24,763
1952	17,705	5,178	1,258	1,368	1,643	27,152
1953	42,669	-1,780	2,346	2,155	1,643	47,033
1954	45,800	-4,911	2,447	2,160	1,643	47,139
1955	44,100	-3,211	2,547	2,166	1,643	47,245
1956	41,500	-611	2,648	2,171	1,643	47,351
1957	44,100	-3,211	2,748	2,176	1,643	47,456
1958	42,200	-1,311	2,849	2,181	1,643	47,562
1959	46,871	-3,963	3,089	2,245	3,963	52,204
1960	46,700	-3,792	3,193	2,250	3,964	52,315
1961	46,900	-3,992	3,298	2,255	3,965	52,426
1962	41,361	-7,019	2,728	1,830	10,711	49,611
1963	60,349	-3,198	4,671	2,846	6,576	71,244
1964	46,230	-3,819	3,577	2,174	3,791	51,953
1965	56,958	-4,092	4,581	2,693	4,093	64,233
1966	52,909	-3,831	4,371	2,479	4,106	60,034
1967	54,834	-4,160	4,641	2,581	4,161	62,057
1968	70,820	-7,765	5,927	3,173	7,764	79,919
1969	69,002	-4,689	6,202	3,262	4,651	78,429
1970	62,814	-4,704	5,745	2,958	5,100	71,913
1971	63,798	13	6,464	3,187	6,298	79,761
1972	62,615	0	6,500	3,239	6,879	79,233
1973	80,638	-5,842	7,950	3,769	5,842	92,356
1974	86,928	-5,900	8,824	4,161	5,900	99,913
1975	85,626	-6,250	8,846	4,069	6,591	98,882
1976	92,166	-6,591	9,736	4,324	6,875	106,510
1977	94,057	-6,646	10,165	4,418	6,646	108,640
1978	106,655	-9,271	11,597	4,921	8,462	122,364
1979	102,671	-9,859	11,449	4,912	9,065	118,238
1980	83,558	-1	10,739	4,241	10,601	109,137
1981	74,663	42	10,493	3,395	8,866	97,459
1982	82,229	37	12,465	4,637	9,348	108,715
1983	92,337	37	15,001	6,124	8,879	122,377
1984	96,031	43	16,630	7,684	7,497	127,885
1985	96,074	31	17,237	8,263	7,194	128,800
1986	91,016	21	17,049	8,593	10,393	127,072
1987	88,914	55	17,374	7,775	10,393	124,511
1988	100,002	38	20,644	9,197	9,916	139,797
1989	87,619	2	18,679	9,137	9,916	125,353
1990	73,716	12	16,275	8,178	10,003	108,184
1991	60,249	-15	13,907	7,268	10,003	91,412
1992	79,143	-31	18,511	9,802	20,991	128,416
1993	83,570	37	20,308	10,066	20,991	134,971
1994	103,420	0	31,479	13,269	12,784	160,952
1995	106,093	-35	29,996	13,862	12,784	162,701
1996	116,597	-32	30,420	14,599	14,843	176,428
1997	117,619	-25	29,004	15,229	14,843	176,671
1998	118,829	-55	27,367	14,740	15,951	176,831
1999	107,711	-23	23,049	13,622	15,951	160,309
2000	121,643	-11,621	21,773	13,797	11,542	157,134
2001	115,268	-11,746	18,681	13,038	11,542	146,784
2002	110,030	-11,628	15,791	12,128	8,273	134,595
2003	86,314	-8,326	11,463	10,105	8,273	107,828
2004	99,163	-7,169	11,597	11,257	7,111	121,959
2005	95,476	-7,180	9,964	10,692	7,111	116,062
2006	109,780	-7,162	11,602	12,377	10,245	136,842
2007	128,164	-10,311	13,360	14,611	10,245	156,068

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

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	0	78	4	10	8	100
1951	0	78	5	10	8	100
1952	0	78	5	10	8	101
1953	86	-8	6	10	8	102
1954	100	-22	7	10	8	103
1955	100	-22	7	10	8	103
1956	100	-22	8	10	8	104
1957		78	9	10	8	105
1958	100	-22	9	10	8	106
1959	0	0	0	0	0	0
1960	0	0	0	0	0	0
1961	0	0	0	0	0	0
1962	27	-13	2	2	14	32
1963	12	-5	1	1	5	14
1964	16	-9	1	1	9	18
1965	23	-3	4	3	3	29
1966	26	-12	3	2	12	30
1967	27	-21	1	1	21	29
1968	70	-54	3	2	54	75
1969	58	-50	2	1	50	61
1970	70	-50	4	2	50	77
1971	3	0	1	0	50	54
1972	8	0	2	1	68	79
1973	95	-77	5	2	77	102
1974	160	-90	18	11	90	189
1975	298	-170	34	20	182	364
1976	278	-182	27	5	190	317
1977	310	-183	36	5	183	351
1978	1,446	-1,013	127	96	1,013	1,669
1979	2,938	-1,625	397	302	1,625	3,637
1980	2,317	-1	720	160	2,724	5,921
1981	3,249	0	1,088	142	1,892	6,371
1982	3,904	0	1,400	398	2,054	7,756
1983	4,677	0	1,789	410	1,699	8,575
1984	5,257	0	2,137	296	1,302	8,992
1985	3,793	0	1,632	258	980	6,663
1986	2,917	0	1,325	122	732	5,097
1987	2,309	-1	1,104	256	732	4,399
1988	2,903	0	1,457	269	276	4,905
1989	1,913	1	1,007	104	276	3,300
1990	1,667	1	917	121	276	2,983
1991	1,662	1	954	102	276	2,995
1992	460	2	276	38	27	803
1993	203	0	126	17	27	373
1994	521	-1	533	39	10	1,102
1995	1,851	1	540	97	10	2,499
1996	3,133	0	320	106	7	3,565
1997	1,537	-1	294	102	7	1,939
1998	1,034	0	288	69	3	1,393
1999	1,571	-2	543	99	3	2,214
2000	1,825	-7	762	227	7	2,813
2001	1,725	-8	729	133	7	2,586
2002	1,052	-7	376	75	5	1,500
2003	1,168	-6	678	90	5	1,937
2004	889	-3	454	48	3	1,391
2005	287	-3	130	20	3	436
2006	673	-3	201	118	0	989
2007	853	0	273	140	0	1,265

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

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	13,454	0	673	586	72	14,785
1951	10,669	0	559	466	72	11,766
1952	12,759	0	700	559	72	14,089
1953	31,000	-187	1,765	1,352	72	34,002
1954	32,600	-1,787	1,840	1,355	72	34,080
1955	31,700	-887	1,915	1,358	72	34,158
1956	30,000	813	1,989	1,361	72	34,236
1957	31,300	-487	2,064	1,365	72	34,314
1958	29,900	913	2,139	1,368	72	34,391
1959	34,939	-1,288	2,418	1,497	742	38,308
1960	34,400	-749	2,499	1,500	743	38,394
1961	34,400	-749	2,581	1,504	744	38,480
1962	31,140	-4,866	2,079	1,177	7,122	36,652
1963	48,632	942	4,043	2,225	2,112	57,954
1964	34,904	-225	2,912	1,560	162	39,313
1965	44,916	-532	3,835	2,001	532	50,752
1966	41,141	-96	3,646	1,855	224	46,770
1967	42,931	-221	3,898	1,934	220	48,762
1968	58,700	-3,527	5,169	2,504	3,575	66,421
1969	56,252	-223	5,385	2,549	224	64,187
1970	51,205	-984	4,949	2,290	979	58,438
1971	57,188	0	5,774	2,613	1,557	67,132
1972	53,758	0	5,558	2,462	1,980	63,758
1973	67,071	-850	7,007	3,039	850	77,117
1974	73,066	-1,060	7,794	3,312	1,060	84,172
1975	69,581	-560	7,639	3,182	436	80,277
1976	75,581	-436	8,499	3,472	455	87,570
1977	78,051	-440	8,966	3,593	440	90,610
1978	89,792	-788	10,498	4,130	788	104,420
1979	83,130	-776	9,913	3,829	776	96,873
1980	74,852	0	9,192	3,521	795	88,361
1981	65,389	0	8,648	2,752	775	77,564
1982	73,501	0	10,415	3,824	1,076	88,816
1983	83,679	0	12,647	5,319	1,009	102,654
1984	86,545	0	13,898	6,880	877	108,200
1985	88,702	0	15,082	7,536	810	112,130
1986	83,800	0	15,041	7,878	1,285	108,003
1987	82,522	-1	15,591	6,908	1,285	106,304
1988	92,824	0	18,414	8,302	1,220	120,760
1989	81,122	0	16,859	8,223	1,220	107,424
1990	66,078	0	14,357	6,681	1,220	88,335
1991	51,546	0	11,686	5,648	1,220	70,100
1992	72,171	-1	17,044	8,226	1,880	99,320
1993	77,353	0	18,998	8,595	1,880	106,826
1994	97,674	-1	29,617	12,071	1,285	140,646
1995	94,613	-1	26,980	11,962	1,285	134,839
1996	93,337	1	24,931	11,492	1,210	130,971
1997	90,334	0	22,498	11,316	1,210	125,358
1998	85,545	0	19,760	10,356	804	116,465
1999	82,237	0	17,511	10,204	804	110,756
2000	81,648	-951	15,726	9,835	951	107,209
2001	82,867	-951	14,484	10,062	951	107,413
2002	76,530	-950	11,999	8,945	663	97,187
2003	64,021	-663	8,915	7,672	663	80,607
2004	71,073	-521	8,653	8,054	520	87,779
2005	66,978	-521	7,442	7,593	520	82,012
2006	79,955	-522	8,895	9,149	454	97,932
2007	89,392	-453	9,960	10,384	454	109,737

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

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	552	1,227	89	78	5	1,950
1951	693	1,086	93	78	5	1,955
1952	522	1,257	98	78	5	1,959
1953	1,797	-18	102	78	5	1,964
1954	1,900	-121	106	78	5	1,968
1955	1,700	79	111	78	5	1,973
1956	1,600	179	115	79	5	1,977
1957	1,800	-21	119	79	5	1,982
1958	2,300	-521	123	79	5	1,986
1959	1,562	-87	106	66	87	1,734
1960	1,500	-25	110	66	87	1,737
1961	1,600	-125	113	66	87	1,741
1962	1,557	5	124	70	19	1,775
1963	1,399	-23	112	62	21	1,571
1964	2,111	12	178	96	17	2,414
1965	1,637	-40	138	72	40	1,847
1966	2,048	189	199	101	20	2,557
1967	1,896	-11	172	85	11	2,153
1968	1,291	-42	117	57	42	1,465
1969	1,118	-47	103	49	46	1,269
1970	1,265	-90	116	54	90	1,434
1971	994	0	100	45	24	1,164
1972	972	0	100	45	35	1,152
1973	1,854	-38	192	83	38	2,130
1974	1,035	-40	108	46	40	1,188
1975	2,854	-20	314	131	49	3,327
1976	3,778	-49	422	172	51	4,374
1977	3,213	-49	366	146	49	3,725
1978	2,373	-50	274	108	50	2,755
1979	3,125	-49	370	143	49	3,638
1980	2,137	0	262	101	53	2,554
1981	1,895	0	251	80	57	2,282
1982	1,468	0	208	76	70	1,822
1983	828	0	125	53	47	1,053
1984	374	0	60	30	47	511
1985	364	0	62	31	47	504
1986	705	0	126	66	56	953
1987	287	0	54	24	56	421
1988	495	0	98	44	0	638
1989	222	0	46	22	0	291
1990	162	0	35	16	0	214
1991	99	0	22	11	0	132
1992	893	-1	211	101	0	1,204
1993	206	-1	50	23	0	278
1994	497	-1	151	61	0	708
1995	4,103	1	1,170	515	0	5,790
1996	14,351	0	3,833	1,754	0	19,939
1997	19,852	-1	4,944	2,468	0	27,263
1998	27,014	0	6,240	3,244	15	36,513
1999	18,886	0	4,021	2,324	15	25,246
2000	23,242	-108	4,508	2,795	108	30,545
2001	15,849	-107	2,783	1,873	108	20,506
2002	17,354	-109	2,738	2,020	12	22,015
2003	8,961	-12	1,259	1,032	12	11,253
2004	16,584	-8	2,033	1,881	6	20,497
2005	17,894	-11	2,003	2,010	6	21,902
2006	19,020	-7	2,129	2,137	44	23,324
2007	24,626	-45	2,753	2,763	44	30,142

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

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	399	0	20	67	12	498
1951	352	0	19	60	12	443
1952	383	0	23	65	12	483
1953	350	-15	22	57	12	426
1954	300	35	23	58	12	428
1955	300	35	25	58	12	430
1956	300	35	27	58	12	432
1957	300	35	28	58	12	434
1958	300	35	30	59	12	436
1959	293	-33	25	46	33	363
1960	300	-40	26	46	33	365
1961	300	-40	27	46	33	366
1962	265	41	34	55	36	430
1963	368	-60	35	55	61	460
1964	465	-58	49	73	61	590
1965	339	-40	37	54	41	431
1966	324	-70	33	46	57	390
1967	425	-42	52	70	43	547
1968	513	-115	56	73	67	594
1969	495	-80	60	76	81	632
1970	450	-124	49	60	124	559
1971	401	0	62	74	77	614
1972	456	0	73	85	83	697
1973	640	-87	91	104	87	835
1974	747	-40	120	133	40	1,000
1975	703	-50	114	123	44	934
1976	686	-44	115	122	46	925
1977	699	-44	121	125	44	945
1978	532	-41	93	94	41	719
1979	558	-43	100	99	43	757
1980	550	-2	109	106	51	814
1981	658	0	42	70	66	836
1982	505	-3	32	54	66	654
1983	544	0	39	84	66	732
1984	946	0	61	187	143	1,337
1985	815	0	47	197	143	1,202
1986	843	-1	59	243	234	1,378
1987	817	9	53	275	234	1,388
1988	653	0	46	248	145	1,093
1989	1,021	0	73	434	145	1,673
1990	2,058	0	148	969	145	3,320
1991	1,935	0	112	986	145	3,178
1992	1,886	-2	105	1,042	288	3,319
1993	1,619	2	96	972	288	2,978
1994	1,049	0	62	676	139	1,926
1995	1,160	0	71	801	139	2,172
1996	975	0	62	719	217	1,973
1997	1,051	0	68	823	217	2,159
1998	720	0	49	597	79	1,445
1999	612	0	40	535	79	1,266
2000	744	-153	40	544	152	1,327
2001	596	-152	29	496	152	1,122
2002	594	-153	29	457	33	960
2003	377	-34	23	473	33	872
2004	607	-102	30	514	103	1,153
2005	562	-101	29	416	103	1,008
2006	413	-104	19	320	34	682
2007	372	-33	22	294	34	689

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

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	0	0	0	0	0	0
1951	0	0	0	0	0	0
1952	0	0	0	0	0	0
1953	0	0	0	0	0	0
1954	0	0	0	0	0	0
1955	0	0	0	0	0	0
1956	0	0	0	0	0	0
1957	0	0	0	0	0	0
1958	0	0	0	0	0	0
1959	0	0	0	0	0	0
1960	0	0	0	0	0	0
1961	0	0	0	0	0	0
1962	0	0	0	0	0	0
1963	0	0	0	0	0	0
1964	0	0	0	0	0	0
1965	0	0	0	0	0	0
1966	0	0	0	0	0	0
1967	0	0	0	0	0	0
1968	0	0	0	0	0	0
1969	0	0	0	0	0	0
1970	0	0	0	0	0	0
1971	0	0	0	0	0	0
1972	0	0	0	0	0	0
1973	0	0	0	0	0	0
1974	55	0	6	30	0	91
1975	100	-50	6	28	131	214
1976	194	-131	7	35	137	242
1977	203	-132	8	39	132	251
1978	390	-303	10	48	303	449
1979	399	-298	12	56	298	467
1980	52	0	6	29	304	392
1981	78	0	10	44	304	437
1982	50	0	7	28	310	396
1983	39	0	6	22	286	353
1984	43	0	7	25	224	299
1985	37	0	6	22	310	375
1986	52	0	9	31	426	518
1987	58	0	11	34	426	529
1988	70	0	14	41	374	499
1989	70	0	15	42	374	501
1990	59	-1	13	35	374	481
1991	76	-1	17	46	374	512
1992	65	0	15	40	1,009	1,128
1993	85	-1	21	52	1,009	1,166
1994	79	-1	24	51	486	638
1995	89	0	25	57	486	657
1996	99	0	26	62	617	804
1997	85	1	21	53	617	777
1998	82	-3	18	48	475	621
1999	83	0	18	49	475	624
2000	454	-373	16	47	374	518
2001	504	-373	23	76	374	603
2002	452	-375	12	44	155	289
2003	200	-157	6	24	155	227
2004	121	-84	5	20	79	141
2005	106	-79	3	15	79	124
2006	103	-72	3	16	75	125
2007	107	-74	4	16	75	128

Appendix Table A7. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for the category 'others' for Finland (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	4,433	3,451	394	653	1,546	10,477
1951	4,011	3,873	413	655	1,546	10,498
1952	4,041	3,843	432	656	1,546	10,519
1953	9,436	-1,552	452	658	1,546	10,539
1954	10,900	-3,016	471	659	1,546	10,560
1955	10,300	-2,416	490	661	1,546	10,581
1956	9,500	-1,616	509	662	1,546	10,601
1957	10,700	-2,816	528	664	1,546	10,622
1958	9,600	-1,716	547	665	1,546	10,643
1959	10,077	-2,555	540	636	3,101	11,800
1960	10,500	-2,978	559	638	3,101	11,819
1961	10,600	-3,078	577	639	3,101	11,839
1962	8,372	-2,186	489	527	3,520	10,722
1963	9,938	-4,052	480	502	4,377	11,245
1964	8,734	-3,539	436	444	3,542	9,618
1965	10,043	-3,477	567	563	3,477	11,173
1966	9,370	-3,842	491	475	3,793	10,287
1967	9,555	-3,865	519	490	3,866	10,565
1968	10,246	-4,027	583	537	4,026	11,364
1969	11,079	-4,289	653	587	4,250	12,280
1970	9,824	-3,456	627	552	3,857	11,404
1971	5,212	13	528	454	4,590	10,796
1972	7,421	0	767	646	4,713	13,547
1973	10,978	-4,790	655	540	4,790	12,173
1974	11,865	-4,670	779	629	4,670	13,273
1975	12,090	-5,400	740	586	5,749	13,766
1976	11,649	-5,749	667	518	5,996	13,081
1977	11,581	-5,798	668	509	5,798	12,758
1978	12,122	-7,076	595	445	6,267	12,353
1979	12,521	-7,068	656	482	6,274	12,865
1980	3,650	1	448	323	6,674	11,097
1981	3,394	42	454	307	5,772	9,969
1982	2,801	41	403	256	5,772	9,272
1983	2,570	37	394	237	5,772	9,010
1984	2,866	42	467	266	4,904	8,546
1985	2,363	31	407	221	4,904	7,925
1986	2,699	22	488	253	7,660	11,123
1987	2,921	49	561	279	7,660	11,470
1988	3,058	38	614	293	7,901	11,904
1989	3,271	1	680	312	7,901	12,165
1990	3,691	12	805	356	7,988	12,851
1991	4,931	-15	1,114	476	7,988	14,494
1992	3,669	-29	860	355	17,787	22,641
1993	4,103	36	1,017	407	17,787	23,349
1994	3,600	4	1,093	371	10,864	15,931
1995	4,277	-36	1,209	430	10,864	16,744
1996	4,702	-32	1,247	467	12,792	19,176
1997	4,760	-23	1,180	467	12,792	19,175
1998	4,434	-52	1,012	426	14,575	20,394
1999	4,322	-21	916	412	14,575	20,203
2000	13,731	-10,028	722	349	9,950	14,723
2001	13,728	-10,154	632	398	9,950	14,554
2002	14,048	-10,033	637	588	7,405	12,645
2003	11,586	-7,454	581	815	7,405	12,933
2004	9,889	-6,451	422	739	6,400	10,998
2005	9,649	-6,465	357	639	6,400	10,580
2006	9,616	-6,454	354	637	9,638	13,792
2007	12,814	-9,706	348	1,012	9,638	14,106

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

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ABSTRACT

Total fisheries catches by Germany in the Baltic Sea from 1950-2007 were estimated using a method called 'catch reconstruction' that used ICES landing statistics as a baseline, then adjusted these data based on data available from other sources such as ICES stock assessment working group reports and national data, unreported landings, discards, and recreational fishing. Cod (*Gadus morhua*) contributed the largest proportion of unreported landings, discards, and recreational catches, although herring (*Clupea harengus*) is also an important commercial species. The reconstructed catch from 1950-2007 was approximately 36% higher than catches attributed to Germany by ICES landing statistics for the same time period. We believe that this reconstruction remains a conservative estimate. Overexploitation of marine resources, either legally or illegally, is a serious problem in many areas of the world including the Baltic Sea. Comprehensive accounts of total catches (in contrast to reported commercial landings only) as well as full public transparency of all data collection, the scientific advice and political decision process will be crucial in any efforts to move towards ecosystem-based management of the Baltic Sea.

INTRODUCTION

The Federal Republic of Germany has coastlines both along the Baltic and North Seas (Figure 1). With an area of approximately 357,000 km^2, and a population of 82.6 million (UN, 2009), Germany is not only Europe's second most populous nation, but its strongest economically. After World War II, Germany was divided into the Federal Republic of Germany (FRG) also known as 'West Germany' and the German Democratic Republic (GDR) also known as 'East Germany'. The western state (FRG) became involved with western economic and security organizations, and was a founding member of the European Commission (EC) in 1957 (which became the European Union [EU] in 1993). The GDR was part of the Soviet aligned eastern bloc. At the end of the Cold War in the early 1990s, the country was re-unified under the banner of the Federal Republic of Germany. Though the marine fishing industry has never contributed significantly to the GDP (0.13%), Germany runs substantial deep-sea operations in the North Atlantic and North Sea, as well as small-scale fisheries in the Baltic Sea (Anon., 2007b). German fishers mainly target sprat (*Sprattus sprattus*), herring (*Clupea harengus*), cod (*Gadus morhua*), and flounder (*Platichthys flesus*) in the Baltic Sea, with reported landings in 2007 totaling approximately 73,000 tonnes (t) annually (UN, 2009).

The German Baltic fleet is comprised of cutters and coastal fishing boats. The total number of vessels doubled after reunification in the 1990s, but capacity (gross tonnage) has since been decreased by about 40%. In 2004, there were a total of 445 cutter and coastal vessels targeting herring (a mixture of fixed and trawl gear), 27 vessels targeting sprat (trawls), and 573 vessels targeting cod (gillnet and trawl). In 2003, there were approximately 2,200 registered vessels and 4,000 commercial fishers (Anon., 2007b). Though there is little information in the literature about recreational fishing in Germany, angling for cod, flounder and herring is well-established (Anon., 2007a). Authorities have since 2005 been in the process of conducting surveys to obtain quantitative information on these fisheries (ICES, 2005). In addition, marine

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recreational fishers also target mackerel (*Scomber scombrus*) and garfish (*Belone belone*; Pawson *et al.*, 2007). It is estimated that there are approximately 113,000 to 147,000 active anglers along the coastal waters of the Baltic (Anon., 2007a).

Cod was the main species fished commercially by Germany until the late 1980s, but with declines in cod stock abundance and more restrictive management quotas, herring and sprat have become the main species landed by Germany in the most recent decade. However, German fishers still account for approximately 32% of cod landings in the western Baltic (Menn, 2006). The western stock is targeted primarily by trawl and gillnets while the eastern cod stock is mainly fished by trawl. Prior to the 1990s, the majority of cod was taken by gillnet, but a change in stock age composition has resulted in more predominant trawl use since the early 2000s (Anon., 2007b). Though most flounder is caught as bycatch in the cod fishery, Germany also has a flounder-directed fishery (ICES, 1991).

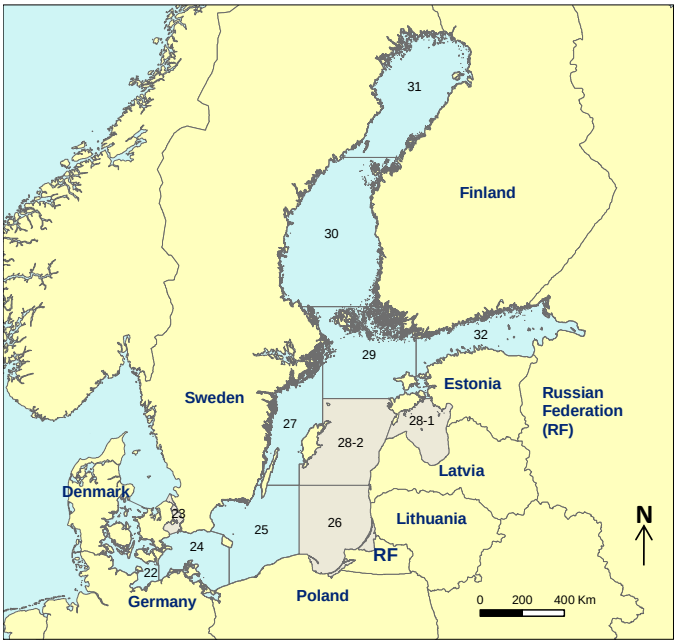

Figure 1. Map of the Baltic Sea with ICES subdivisions and surrounding countries. Germany's coastline borders ICES subdivisions 22 and 24.

The only fishery which appears not to have peaked, as of 2007, is the sprat fishery. Though Germany's landings of sprat have fluctuated greatly since the 1950s, reported landings in the 2000s exceed those of any other decade for the period 1950-2007. In comparison, herring and cod landings in the 2000s are below average and less than half what they were in the 1960s. The reunification of Germany caused many difficulties for fishers from East Germany who were accustomed to an industry based on public property and subsidies. Reduction of fisheries production was one of the primary goals for integration, and as fleet capacity was reduced under the EU Common Fisheries Policy (CFP), unemployment escalated. A unified Germany also inherited an economically inefficient, over-sized, and ageing fleet from East Germany which did little to aid a smooth transformation in market structure (Cannarella, 1997).

Management efforts for commercial species have been somewhat complicated since reunification in the early 1990s. Fishers from West Germany became authorized to fish in East Germany's fishing areas, resulting in significant overfishing of local cod stocks. Harmful fishing behaviors have also developed since this time. Prior to reunification, there were very low discards or Illegal, Unreported and Unregulated fishing (IUU) due to strict regulation by national authorities in East Germany. Most fish species had similar financial values, and all were delivered to national authorities prior to being sold on the market (R. Oeberst and J. Heinrich, pers. comm., Johann Heinrich von Thünen-Institut). Since reunification and transformation to a market economy and the rules of the CFP, unreported catches and discards have become an economic reality.

As in all EU member states, CFP policies and TAC shares are administered nationally. Germany's Sea Fisheries Act dictates a national management strategy, which has generally aimed to reduce overall fishing effort in recent years. One of the primary rules states that an individual or organization may only be issued a fishing license if the vessel was already in service in 1986 or 1987. New vessels require consent of the Federal Ministry of Food, Agriculture and Consumer Protection, and must replace a vessel which is larger, more powerful, or less efficient. There are two types of fishing licenses issued by the German ministry: 1) general fishing licenses; and 2) individual fishing licenses. A general fishing license permits a license holder for a given fishery to fish with no restrictions (within the national TAC share), until permission is revoked. This is generally used for species for which the national TAC share is not expected to quickly be exhausted. An individual license is more restrictive and is generally used for more vulnerable species such as Baltic cod and saithe (*Pollachius virens*). This license permits a catch of a set amount from a set fishing

area. One other type of common management strategy is the specification of a weekly or monthly total allowable catch which is usually delineated per fisher, per fishing journey. The intent of this strategy is to prevent early exhaustion of national quota shares (Anon., 1997).

Monitoring of the German quota follows the rules set for all EU member states. Every vessel greater than 10 meters must keep a logbook with details of the species, amount, area and time fished. As in other countries, there is no independent confirmation of logbooks or reported catches, such as compulsory onboard observer programs. Individuals who are responsible for the marketing of landed fishery products are required to deliver invoices to the authorities (Anon., 1997). Though there is no management strategy for marine recreational fishing in Germany, anglers require a permit to go fishing for any commercially targeted quota species in coastal or offshore waters, and all sales of recreationally caught fish are illegal. The species targeted by recreational fishers which are subject to EU quotas are mainly cod and herring. Rules vary slightly between coastal states, but generally speaking, minimum age and ticketing qualifications are set on top of mandatory compliance with minimum mesh size and effort regulations set for commercial fishers (Pawson *et al.*, 2007).

The purpose of this study is to provide an estimate of the total fisheries catches (reported landings + IUU) in the Baltic Sea by Germany for the period from 1950-2007. The ICES catch statistics database (ICES, 2009) (which we will refer to here as the 'ICES landings statistics') offers time series data on marine landings for Germany from 1950-2007. The title, 'ICES landings statistics', seeks to represent the true nature of the data presented, as no apparent effort has been made to fully represent total catches (which would include IUU as opposed to reported landings only). Our reconstruction attempts to estimate four main components of IUU including: a) data source adjustments to reported landings; b) unreported landings; c) discards; and d) recreational catches. Our approach utilizes previously reported data by ICES, a review of the peer-reviewed and grey literature, and correspondence with local experts.

METHODS

Germany was treated as two separate entities for the time period 1950-1990 to reflect the existence of East and West Germany as two distinct jurisdictions during this time period. Here we present information concerning the two Germanys separately for the earlier time period (1950-1990), and after re-unification in 1991, the two former states are treated as 'Germany'.

The general method involved adding Illegal, Unreported and Unregulated (IUU) estimates of various kinds to the 'ICES landings statistics', which are treated here as representing the 'officially reported data set' that is publicly available, covers all reported taxa, all countries, all Baltic Sea statistical areas, and all years of concern (1950-2007) . We thus treat anything not part of ICES landings statistics as IUU. The various IUU components as applied here are: a) *adjustments:* these were made to account for other known landings as reported by national data sources or stock assessment sources; we undertake 'Adjustments to ICES landings data' from these alternate data sources in certain years, with the result being what we consider to be the best estimate of commercial landings; b) *unreported* landings (referred to by ICES as 'unallocated' catches): which were estimated separately during the period when Germany existed as two entities; c) *discards*: which were estimated as rate and then applied to the estimated total landings (i.e., ICES landings statistics + landings adjustments + unreported catches); and *recreational* catches: which were also estimated separately. Thus, reconstructed total catch estimates include more comprehensive accounting of reported landings, unreported landings (commercial as well as recreational), as well discarding than the officially reported data made readily available to the general public via the ICES landings statistics.

ICES landings statistics

ICES landings statistics for Germany (ICES, 2009) for the time period 1950-1972 are reported separately for East Germany and for West Germany. ICES landings data for West Germany begin in 1950 and continue until 1990. ICES landings statistics for East Germany cover the time period 1961 to 1990, with the 1973-1990 period being reported as Germany (Neue Länder)[2]. Since 1991, Germany's landing statistics are reported to ICES as a single country because of the re-unification of the two former separate countries.

[2] Neue Länder (="new states") refers to the fact that upon incorporation into the Federal Republic of Germany, the former East Germany was split into states (Germany is a federation) or Länder.

Illegal, Unreported and Unregulated (IUU) catches

Illegal, Unreported and Unregulated (IUU) catches are here considered entirely with respect to the ICES landings statistics, and included: a) *Adjustments* are made to the ICES landings statistics to account for more detailed data on commercial landings available from other highly recognized sources, such as stock assessment reports or national datasets; b) Estimates of *unreported* catches (in ICES terminology 'unallocated' catches), which are derived using ratio information based on ICES landings statistics plus 'adjustments'; c) *Discard* rates are applied to the sum of ICES landings statistics plus adjustments plus unreported catches; and d) *Recreational* catches are estimated separately. Thus, total reconstructed catches are formed from the sum of ICES landings statistics and the four estimates outlined above.

Table 1. Anchor points (%) used for estimating unreported landings for eastern and western cod stocks for West Germany (1950-1990), and for Germany (1991-2007) based on sources (Tables 2.3.1 and 2.4.1 in ICES, 2007; Tables 2.3.1 and 2.4.1 in ICES, 2008a). Dashed (-) lines indicate years when linear interpolations were used.

Year	Cod stocks	
	western	Eastern
1950	5.00[a]	5.00[a]
1951-1979	-	-
1980	20.10[b]	31.10[b]
1981-1992	-	-
1993	40.20	62.20
1994	39.64	102.55
1995	-	29.68
1996	5.34	10.30
2000	-	46.00
2001	-	47.55
2002	-	46.62
2003	-	61.46
2004	0.07	52.91
2005	0.04	46.41
2006	0.04[c]	46.91
2007	0.04[c]	43.17

[a] assumed discard rate; [b] assumption of one-half the 1993 rate; [c] 2005 value

Adjustments to ICES landings statistics

Adjustments were made to ICES landings statistics in order to present the best estimate of commercial landings. Adjustments to ICES landings statistics are based on unpublished data provided by our co-author from Germany (C. Hammer, unpl. data) and from ICES stock assessment working group data. Adjustments were made to the landings data throughout the study period, but were more substantial in the earlier time periods.

East Germany's landings data for all taxa are not presented in ICES landings statistics for the period 1950-1960, except salmon landings which are not presented in ICES landings statistics until 1963. Thus, adjustments during this early time period accounted for the landings of all taxa by the former East Germany. Adjustments for herring, sprat, salmon, flatfishes, and 'others' were based on the average of the first three years of reported data. Adjustments for cod during this early time period were based on information from our collaborator in Germany who provided data regarding landings of cod, and we used this data as a source of adjustments for 1950-1964 (Hammer *et al.*, 2008). After the 1950s and early 1960s, adjustments were only made to ICES landings of cod, flatfishes and taxa in our group 'others' for East Germany originated from ICES stock assessment working group data (ICES, 2007; 2008a).

Adjustments to ICES landings statistics for West Germany for cod (from 1965 onwards) as well as flatfishes (mostly from the 1990s onwards), were based on ICES stock assessment working group data (ICES, 2007; 2008a).

Unreported landings

Unreported landings were estimated separately for East Germany and West Germany. After reunification, Germany's unreported landings were estimated by continuing the methodology used for West Germany.

When East Germany was a part of the eastern bloc (1950- 1990) and had a state-controlled economy, we assumed that there were no unreported landings because of the consequences of non-compliance and a similar price was paid for whatever was landed. For West Germany (1950-1990) and Germany (1991-2007), estimates of unreported landings were formed from what ICES refers to as 'unallocated' catches, and also from assumed values. The general approach was to convert unreported landings into a percent of the landings reported for the respective taxa, and to apply this unreported landings percent to the sum of ICES landings and adjustments. In order to expand to time periods and to taxa that were not covered by ICES, we used an assumption-based method. ICES reports unreported landings of cod (ICES, 2007; 2008a), and salmon (ICES, 2008b), and we use these to estimate unreported landings for all other taxa.

Table 2. Anchor points in % used for estimating unreported landings for salmon for West Germany (1950-1990), and for Germany (1991-2007) based on sources (ICES, 2008b). Dashes (-) indicate years when linear interpolations were used.

Year	Anchor point	Year	Anchor point
1950	5.0[a]	1994	18.7
1951-1980	-	1995	19.5
1981	20.4	1996	20.4
1982	20.7	1997	20.8
1983	22.6	1998	20.1
1984	20.7	1999	20.4
1985	19.7	2000	19.9
1986	22.0	2001	20.4
1987	21.4	2002	20.5
1988	22.2	2003	20.1
1989	22.6	2004	20.6
1990	24.4	2005	20.7
1991	19.5	2006	22.2
1992	20.1	2007	21.4
1993	19.4		

[a] assumed default.

Cod: Some estimates of unreported ('unallocated') landings were reported in ICES stock assessment working group data (ICES, 2007) separately for both the western and eastern cod stocks. Unreported landings of cod from the western cod stock are reported for the years 1993, 1994, 1996, 2004 and 2005. Unreported landings of the eastern cod stock were reported for the periods 1993-1996 and for 2000-2007 (Table 1). The anchor points for 1950 and 1980 were assumption-based anchor points. The 1950 value was our assumed default rate, and the 1980 anchor point was assumed to be half the 1993 value, which was based on information from ICES stock assessment working group data. All anchor points were transformed into rates based on the unreported totals as a proportion of landings from the same ICES working group reports.

Salmon: Unreported landings of salmon were reported in ICES working group data from 1981 to 2007 (ICES, 2008b). The data provides information on Baltic-wide unreported landings of salmon, and these were transformed into rates as a percentage of the reported landings presented in the same report (see 'Methods' in Zeller *et al.*, this volume). We used our assumed default rate of 5 % for 1950 and interpolated linearly to the 1981 anchor point (Table 2).

Table 3. Anchor points in % used for estimating unreported landings of other taxa for West Germany (1950-1990), and for Germany (1991-2007) based on sources (Tables 2.3.1 and 2.4.1 in ICES, 2007; Table 2.1.2. in ICES, 2008a). Dashed lines (-) indicate years when linear interpolations were used.

Year	Anchor point
1950	5.0[a]
1951-1993	-
1994	20.3
1995	26.9
1996-2003	-
2004	12.3
2005	11.2
2006-2007	11.2[b]

[a] assumed default value; [b] 2005 value

Other taxa: Other taxa, which here comprise sprat, herring, flatfishes, and the group 'others' had unreported landings estimated as well. We used our assumed default rate of 5 % for 1950, and derived anchor points in 1993 and 1994, and for 2004 and 2005 from years when there were anchor points of unreported landings for each cod stock and salmon. We averaged the rates for these years and then reduced this rate by 50 % to derive anchor points in 1993, 1994, 2004, and 2005 (Zeller *et al.*, this volume). The rate for 2005 was used to estimate unreported landings for the last two years (Table 3).

Discards

Discards were divided into four categories, with each assessed individually: 1) underwater discards account for the mortality of fish lost from gear while it is actively deployed for fishing; 2) fish caught as a result of ghostfishing by gear that is lost; 3) boat-based discards usually resulting from fishers' behavior after the catch is brought on board; and 4) discards estimated to account for fish damaged by seals. Seal damage is considered to be not an important issue in Germany and thus, here we estimate the first three categories (1-3).

Underwater discards: Underwater discards were applied to the sum of ICES landings, adjustments, and unreported landings from 1950-2007 for all German catches of herring and sprat only. Sprat and herring are caught by the same fleet (ICES, 2007). Inaccurate catch composition data due to the mixed nature of this fishery, and the fact that these two species are targeted by the same fleet, led us to apply the underwater discard rate to both species combined.

Our estimates for underwater discards of herring and sprat were based on a Finnish trawl study by Rahikainen (2004) from which we derived an underwater discard rate for herring of approximately 9% (see 'Methods' in Zeller *et al.*, this volume). However, we applied a more conservative rate of 5% to their estimated catches (ICES landings + adjustments + unreported catches) of herring and sprat because German catches by gear type were not available.

Ghostfishing: Catches (mortality) of fish due to ghostfishing were treated as discards. Tschernij and Larsson (2003) studied the capture of cod due to the loss of fishing gear (gillnets) in Sweden's marine waters and related it to commercial landings. Here we use the mean value (1.65%) between the low (0.01%) and high (3.2%) estimates as presented in Brown (2005). Ghostfishing rates were applied to the catches of all species, excluding herring and sprat, during the entire time period, 1950-2007 and were applied to ICES landings statistics + adjustments + unreported catches.

Boat-based discards: Boat-based discards usually resulting from fishers' behavior were also estimated. However, during the period before re-unification, estimates of East and West Germany's discarding rates were treated in a different manner because of political and economic differences. In East Germany it was assumed that discarding was minimal due to the lack of economic incentives for discarding as it was officially illegal to discard and same price was paid for all edible species, hence it is likely that only damaged or unpalatable fish were discarded (R. Oerberst, pers. comm., Johann Heinrich von Thünen-Institut). Therefore, we assumed a discard rate of 2% for the 1950-1990 time period, applied to all species. We linearly interpolated from 2% to the first anchor point established in 1993. This is conservative in comparison with discard rates of 6% observed in Norway, where it is illegal to discard (Krog, 2001).

Table 4. West Germany's anchor points (%) used for estimating boat-based discards of eastern and western cod stocks from 1950-2007 based on sources (Tables 2.3.6, 2.4.1, and 2.4.5b in ICES, 2007; Tables 2.3.1, 2.3.6, 2.4.1, 2.4.5b, 2.4.20, and Figure 2.3.1 in ICES, 2008a). Dashed lines (-) indicate years when linear interpolations were used. East Germany's discard rates were 2 % from 1950-1990 and were then linearly interpolated to the first anchor point presented here in 1993.

Year	Cod stocks		Year	Cod stocks	
	Western	Eastern		Western	Eastern
1950-1965	65.1	10.21	1987	20.8	5.9
1966	65.1	9.4	1988	10.2	4.5
1967	65.1	12.6	1989	7.8	1.9
1968	65.1	8.6	1990	7.9	3.0
1969	65.1	9.8	1991	9.6	2.2
1970	71.5	6.8	1992	19.2	3.5
1971	57.0	4.9	1993	14.5	3.5
1972	66.9	12.7	1994	10.6	2.1
1973	21.3	8.9	1995	11.3	1.7
1974	42.6	10.5	1996	15.7	1.2
1975	22.4	10.4	1997	10.0	3.9
1976	18.3	2.3	1998	17.4	3.4
1977	25.6	1.6	1999	11.6	2.5
1978	27.5	15.5	2000	12.5	6.8
1979	10.8	16.0	2001	11.2	3.2
1980	17.1	3.6	2002	10.4	2.2
1981	13.8	1.6	2003	15.8	2.8
1982	35.3	5.9	2004	10.1	1.8
1983	40.7	4.5	2005	18.6	3.0
1984	17.9	2.4	2006	8.6	13.2
1985	7.2	3.1	2007	8.3	11.4
1986	15.3	1.2			

Boat-based discard rates for West Germany were considered to be higher than those for East Germany due to its market-oriented economy, and associated discarding incentives. Discard rates of the eastern and western cod stocks, and salmon followed the assumption-based approach as outlined in Zeller *et al.* (this volume), with anchor points being developed from ICES working group data (Table 4, 5). Taxa that formed part of our groups 'others' and flatfish were assigned discard rates according to taxa-specific information from a Danish study which documented the discarding practices over a one-year period for the entire Danish fleet (Anon., 2006a), and here we use these rates throughout the time period (1950-2007). Rates of discards for brill and turbot had the average rate (38.5%) from dab (33.4%), European flounder (48.0%) and European plaice (34.0%) applied, and we also used this average rate for our flatfish group (Zeller *et al.*, this volume). Whiting, which formed part of our group 'others', had a species-specific discard rate of 36.1% and all other taxa had a discard rate of 6.2%.

Table 5. West Germany's anchor points (%) used for estimating boat based discards for salmon from 1950-2007 based on Table 2.1.2 in ICES (2008b). East Germany's discard rates were 2% from 1950-1990 and were then linearly interpolated to the first anchor point presented here in 1993.

Year	Anchor point	Year	Anchor point
1950-1980	14.4	1994	12.9
1981	13.9	1995	13.9
1982	14.0	1996	15.1
1983	15.3	1997	14.9
1984	13.9	1998	14.2
1985	13.3	1999	14.8
1986	14.9	2000	10.3
1987	14.5	2001	15.0
1988	14.7	2002	15.8
1989	15.1	2003	15.4
1990	17.3	2004	15.6
1991	13.6	2005	15.2
1992	14.1	2006	17.4
1993	14.1	2007	14.2

Recreational catches

Recreational catches were not estimated for East Germany since it was illegal to participate in this activity (R. Oerberst, pers. comm., Johann Heinrich von Thünen-Institut). Thus, for 1950-1990, recreational catches were estimated for West Germany only, and for the reunified Germany from 1991-2007. The approach taken here is based on the number of fishers and catch rates (i.e., catch·fisher^{-1}) for the two states (Länder) bordering the Baltic Sea (Schleswig-Holstein and Mecklenburg-Vorpommern). In 2005 and 2006, the numbers of fishers and the catch of cod, flounder and herring were reported by the Institut für Ostseefischerei Rostock (Anon., 2007a) for the coastal states of Schleswig-Holstein (a state in former West Germany) and Mecklenburg-Vorpommern (a state in former East Germany). The numbers of fishers in Schleswig-Holstein reported for the two years were averaged (63,500 fishers) and we assumed that the number of fishers in West Germany in 1980 was half this average determined for 2005 and 2006, and in 1950, the numbers of fishers was assumed to be 25% of the average. For the state that was a part of East Germany, the numbers of fishers was also determined (73,500) from the two years of reported data, and for 1990 we set the number of fishers to zero and linear interpolations were done between years. Annual catch rates were held constant and were 23.4 kg·fisher^{-1} for cod, 0.5 kg·fisher^{-1} for flounder, and 1.8 kg·fisher^{-1} for herring.

RESULTS

ICES landings statistics, which here incorporate the landings of East Germany, West Germany, and reunified Germany, reported a total of 4,221,739 t between 1950 and 2007 (Figure 2; Appendix Table 1). Reported landings were, on average, 40,000 t·year^{-1} until 1960, after which there was a substantial increase to over 100,000 t·year^{-1} by the mid-1960s, and were maintained at this level throughout most of the 1970s and 1980s. Reported landings decreased dramatically in the early 1990s to an average of approximately 30,000 t·year^{-1}, and remained at that level until the early 2000s when reported landings increased again to approx. 72,000 t by 2007 (Figure 2).

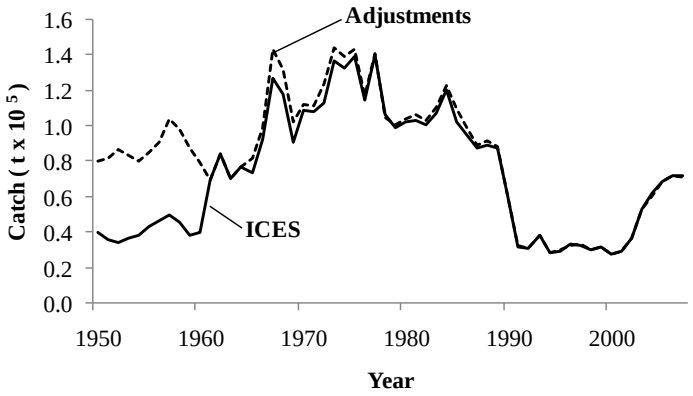

Figure 2. ICES landings statistics and adjustments to ICES landings statistics for Germany from 1950-2007.

Illegal, Unreported and Unregulated (IUU) catches

All catches that were not reported in the publicly available ICES landings statistics (ICES, 2009) were considered either Illegal, Unreported or Unregulated catches. The components included in our estimates of IUU catches were: a) '*adjustments*' to ICES landings statistics for reported commercial landings from other reliable sources such as ICES stock assessment working group data or national data sources; b) '*unreported*' ('unallocated') landings; c) '*discards*'; and d) '*recreational*' catches. Combined, these components formed the basis for our reconstruction.

Table 6. Total reported data adjustments (tonnes) to ICES landings statistics for Germany from 1950-2007.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	173,646	65,331	25,430	29,435	-137	-1,932
Herring	91,560	9,156	0	0	0	0
Sprat	115,677	11,568	0	0	0	0
Flatfishes	35,597	3,708	1,478	20	2,357	19
Salmon	178	53	1	0	0	0
'Others'	51,623	5,162	8,680	0	0	0

Adjustments to ICES landings statistics

ICES landings statistics were adjusted using information obtained from ICES stock assessment working group data and from national sources (see methods for details). The largest adjustments to the ICES

landings statistics were in the first two decades of the study period, with over half of the overall adjustments occurring in the 1950s (Figure 2, Table 6). These adjustments were primarily due to the large proportion of cod landings taken by Germany in the Baltic Sea that were not represented in ICES landings statistics, but were reported in the ICES stock assessment working group reports. Herring and sprat also contributed substantially to the adjustments, particularly in the 1950s. From 1950-2007, adjustments to ICES landings statistics totaled 794,052 t (Figure 2).

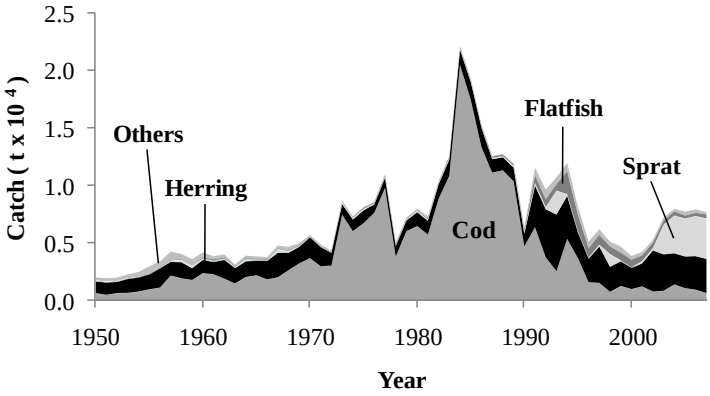

Figure 3. Germany's unreported landings by taxa, 1950-2007.

Unreported landings

Unreported landings totaled 342,486 t over the 1950-2007 time period (Figure 3). Unreported landings increased from about 2,000 t·year^{-1} in 1950 to a peak of approximately 16,700 t·year^{-1} in 1984, thereafter declining to an average of around 7,000 t·year^{-1} throughout the 1990s and 2000s. The greatest proportion of unreported landings was of cod, which represented roughly 58% of all unreported landings over the study period (Table 3). Herring, sprat, flatfishes, 'others' and salmon represented 27%, 6%, 4%, 4% and less than 1% of the total unreported landings for the period 1950-2007, respectively. The unreported landings of herring increased over the study period, with the highest levels in the early 1990s (Table 7). Unreported landings of sprat were, on average, 120 t·year^{-1} until the early 2000s, after which unreported landings increased dramatically to over 3,000 t·year^{-1}. During the study period, unreported landings of flatfishes increased from 22 t·year^{-1} in 1950 to the highest estimated level of over 1,800 t·year^{-1} in 1994. Unreported salmon landings were highest in the 1960s with a total of 271 t for that period (Table 7).

Table 7. Total unreported landings (tonnes) of commercially targeted species in Germany from 1950-2007.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	10,110	19,780	47,008	87,287	27,148	8,021
Herring	11,591	12,886	9,403	10,836	25,508	21,600
Sprat	698	713	500	698	3,382	16,153
Flatfishes	448	712	696	872	7,988	3,245
Salmon	24	271	120	83	84	48
'Others'	3,984	2,238	689	729	4,946	2,287

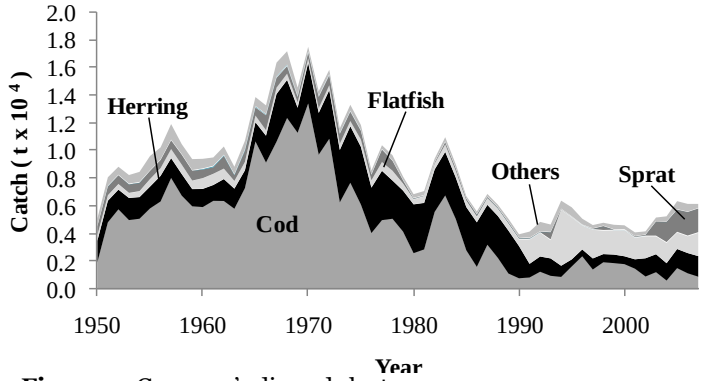

Figure 4. Germany's discards by taxa, 1950-2007.

Discards

Total discards of all species for Germany from 1950-2007 were estimated at 494,694 t (Figure 4). Discards were substantial throughout the study period, but were highest from the mid-1960s to the early 1970s with an average of approximately 15,000 t·year^{-1}. Cod represented the largest proportion (56%) of discards and were highest in the 1965-1972 time period when

Table 8. Total discards (tonnes) of commercially targeted species in Germany from 1950-2007.

Common Name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	56,071	86,358	71,918	33,064	14,403	10,111
Herring	15,234	17,890	33,818	31,209	9,257	9,383
Sprat	6,411	6,561	6,192	1,044	1,017	7,651
Flatfishes	4,666	5,601	4,666	4,242	19,033	11,678
Salmon	70	411	137	77	80	46
'Others'	7,557	6,770	3,122	2,176	3,984	2,784

average discards of cod were roughly 11,000 t·year^{-1} (Figure 4). Cod discards decreased from 1990-2007, but remained high compared to overall cod landings (Appendix Table A2). Herring and sprat discards represented 24% and 6% of the total discards over the study period, respectively. Herring discards peaked in the 1970s and 1980s with an average of over 2,500 t·year^{-1} (Figure 4) Salmon discards were highest from 1960 to 1972, with an average of 37 t·year^{-1} and a total of 477 t over that period (Figure 4). Salmon discards were much lower in subsequent years with an average of 8 t·year^{-1} in the period from 1973-2007. Flatfish discards peaked at over 3,900 t·year^{-1} in 1994 and remained high throughout the 1990s and 2000s. Discards of 'others' accounted for 26,517 t from 1950-2007, with an average of approximately 450 t·year^{-1} (Figure 4).

Recreational catches

Here, recreational catches included cod, herring and flatfishes. Cod made up the majority of recreational catches for Germany in the Baltic Sea. Recreational catches in Germany from 1950-2007 totaled 70,740 t (Appendix Table A1). Recreational catches increased from 410 t·year^{-1} in 1950 to over 3,500 t·year^{-1} by 2006, with the most significant increase in the early 1990s (Figure 5, Appendix Table A1). With reunification in 1990, recreational fishing in the eastern parts of Germany was permitted and this corresponds to the sharp increase in recreational catches that appears from 1990 onward (Figure 5).

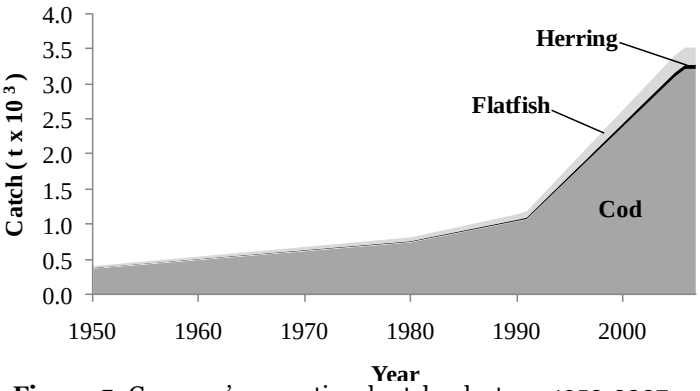

Figure 5. Germany's recreational catches by taxa, 1950-2007.

Overall, cod represents over 91% of the total recreational catch for Germany, with herring and flatfishes making up 2% and 7%, respectively (Figure 5). Recreational catches of cod, herring and flatfishes all increased steadily and substantially over the study period. Recreational catches of cod increased from 373 t·year^{-1} in 1950 to 3,219 t·year^{-1} in 2007, adding a total of 64,210 t to the reported landings over the 1950-2007 study period. Herring catches in Germany's recreational fisheries increased from 8 t·year^{-1} in 1950 to 69 t·year^{-1} in 2007 (Figure 5). Recreational fisheries for flatfish increased from 29 t·year^{-1} in 1950 to 250 t·year^{-1} in 2007. From 1950-2007, recreational catches of herring added an additional 1,408 t to reported landings and flatfishes added an extra 5,122 t (Figure 5).

Table 9. Total recreational catches (tonnes) for Germany

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	4,289	5,532	6,775	8,802	15,929	22,883
Herring	92	118	145	188	362	504
Flatfishes	333	430	526	684	1,318	1,831

Total reconstructed catch

The total reconstructed catch for Germany included 'adjustments', estimates of unreported landings, discards and recreational catches in addition to the officially reported ICES landings statistics, were estimated to be 5,758,267 t for the period 1950-2007 (Figure 6). Reconstructed catch totals were 36% higher than those presented for Germany in the ICES landings statistics, which were 4,221,739 t during the same time period (Figure 7, Appendix Table A1). This difference is due, in part, to the additional

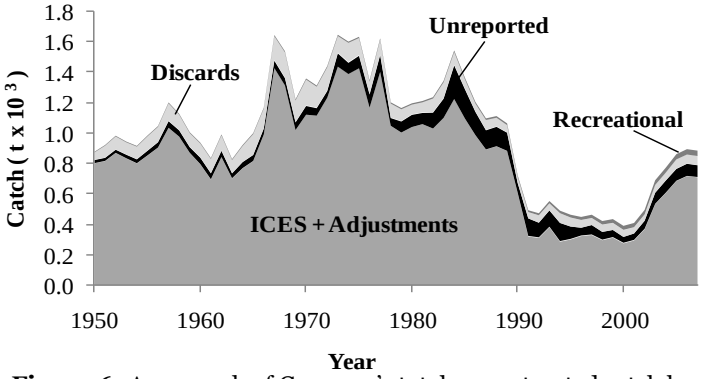

Figure 6. Area graph of Germany's total reconstructed catch by component from 1950-2007.

landings derived from ICES stock assessment working group data and from national sources, which added adjustments of almost 630,000 t to the ICES landings statistics. The other major contributors to the reconstructed catch were the large proportion of unreported landings (Figure 3) and discards (Figure 4), mainly of cod, herring, sprat and flatfishes. Cod represented the greatest proportion of taxa that were unreported (58%) and the greatest proportion discarded (55%) (Appendix Table A1 and A2). Recreational fisheries, also dominated by cod, added another 64,210 t to the total reported landings (Appendix Table A2). When considering both reported and unreported catch components, cod and herring fisheries dominated throughout the study period, with the highest estimated catches for both these species during the 1970s (Table 10).

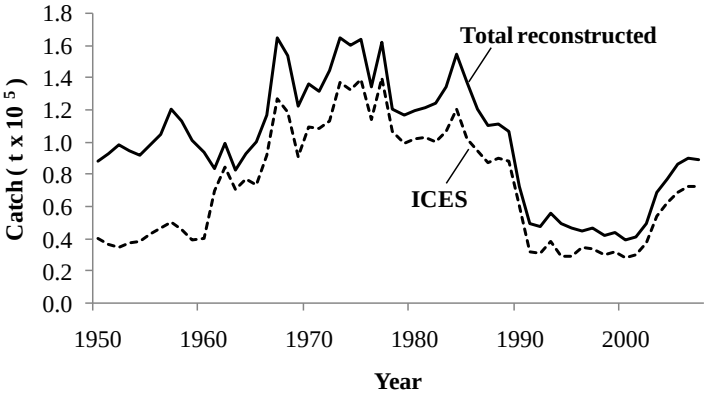

Figure 7. Total reconstructed catch and ICES landings statistics for Germany, 1950-2007.

Table 10. Total reconstructed catch (tonnes) for commercially targeted species in Germany from 1950-2007.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	364,957	385,208	465,431	435,343	169,917	118,252
Herring	320,000	375,805	710,328	655,567	194,763	197,555
Sprat	134,639	137,778	130,035	21,920	21,359	160,672
Flatfishes	48,603	50,026	45,435	46,470	65,159	40,182
Salmon	645	3,034	1,014	576	580	328
'Others'[a]	131,002	153,905	70,801	47,061	31,842	22,078

[a]detailed taxonomic breakdown of this grouping is available in the electronic data being used by the *Sea Around Us* Project.

Of the total reconstructed catch from 1950-2007, adjustments, unreported landings, discards and recreational catches represented 11%, 6%, 9% and 1%, respectively (Appendix Table A1). Adjustments were most significant in the 1950s, adding over 100% to what was reported in the ICES landings statistics for that decade. Discards were highest in the 1960s unreported landings were greatest in the 1980s. Recreational catches have been increasing since the 1950s with the highest levels in the 2000s (Table 11).

Table 11. Total Reconstructed catch (t) by component for all taxa for Germany from 1950-2007.

Component	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
ICES landings	409,989	844,508	1,201,737	995,492	347,259	422,754
Adjustments	468,280	94,978	35,589	29,455	2,220	-1,913
Unreported	26,855	36,600	58,417	100,505	68,757	51,354
Discards	90,009	123,591	119,854	71,812	47,775	41,654
Recreational	4,714	6,080	7,446	9,673	17,609	25,218

DISCUSSION

Our total reconstructed catch for Germany for the period 1950-2007 was estimated to be approximately 6 million tonnes (t). Separate methodologies were used for estimating catch components for East and West Germany. The estimated reconstructed catch, calculated for each were then combined to represent the total reconstructed catch for Germany. This reconstructed catch total was 36% higher than the amount presented in the ICES landings statistics on behalf of Germany, which was approximately 4.2 million t over the same time period. This difference was due, in part, to the additional landings derived from ICES stock assessment working group data and from national sources, which were considered to be '*adjustments*' to landings. These adjustments were mainly to account for the fact that East Germany's landings were not presented in the ICES landings statistics prior to 1961. Additional data concerning cod landings for former East and West Germany were contributed by our German co-author (C. Hammer, unpubl. data). To estimate discards and unreported landings we relied on Baltic-wide rates, which are likely to be conservative.

Besides adjustments, the other major contributors to the reconstructed catch total were discards and unreported landings, mainly of cod. Discards have been identified as a major concern for fisheries

worldwide (Alverson *et al.*, 1994; Kelleher, 2005; Zeller and Pauly, 2005). For fisheries in Germany, we estimated discards to be 9% of the total reconstructed catch with cod representing the greatest proportion of taxa that were discarded (55%). Unreported landings are also a serious concern for fisheries globally and are considered a significant problem in the Baltic Sea (Menn, 2006; Anon., 2007b). Germany's unreported landings were estimated to be 6% of the total reconstructed catch, and cod was the major contributor, representing 58% of all taxa that were unreported.

Our estimates of discards and unreported landings for Germany were mostly based on Baltic-wide estimates, which may be under-estimates. Rates used were derived from Baltic-wide discards or unreported landings (based on ICES stock assessment working group reports) as a proportion of the total Baltic-wide landings. We made corrections for countries that are known to not report their unreported landings (e.g., Sweden). As ICES did not disclose which countries did not report amounts of unreported landings, we could not make all the appropriate adjustments in order to make accurate country-specific estimates of these catch components. If ICES had been more transparent in disclosing country-specific information, the rates would have been higher as we would have subtracted the landings for non-reporting countries from the total Baltic-wide landings, while the amount of unreported landings remained the same. Thus, accounts of unreported landings were likely under-estimates and therefore conservative. While Germany has made some attempts at reducing discards through the use of logbooks and Vessel Monitoring Systems (VMS), these mechanisms have not significantly reduced discarding (Pramod *et al.*, 2008).

Recreational fisheries were only a small contributor to the total reconstructed catch, representing approximately 1%. Recreational fisheries were dominated by cod, which constituted over 90% of Germany's recreational catches. In Germany, cod from the eastern and western stock are caught; however, eastern cod was only considered to have been available recreationally in Germany since reunification in 1990. Prior to 1990, catches of eastern cod were restricted because they were mostly located in East German territory where recreational fishing was illegal, and we considered that West Germans did not have access to this stock. Surveys were conducted in recent years to estimate the amount of cod, herring and flounder caught by recreational anglers in Germany. However, recreational catches are currently not included in stock assessments, which results in under-estimates of TACs (Pramod *et al.*, 2008). In the most recent survey year (2006), recreational catches of cod were a third of the commercial cod catches as presented by ICES landings statistics. To accurately represent the amount of fish being removed from the Baltic Sea, recreational catches must be included in estimations used to allocate catches, particularly for commercially important taxa such as cod.

Cod stocks in the Baltic Sea have been significantly depleted over the past three decades (Menn, 2006). While there are signs of some recovery for the eastern cod stock, populations of both stocks remain low compared to historic levels (Anon., 2006b; Veem *et al.*, 2009). In a study of over 230 fish populations Hutchings and Reynolds (2004) found that rates of recovery were linked to life history characteristics and cod exhibit a much slower rate of recovery, if they recover at all, compared to other taxa such as herring. Even when quotas are severely reduced, recovery of depleted stocks can be threatened by illegal fishing, misreporting and discarding of catches (Hutchings and Reynolds, 2004). Unreported landings of cod are known to be high throughout the Baltic, estimated at 40-60% of reported catches (Anon., 2006b). While cod fisheries in Germany had a lower average rate of unreported landings over the entire time period, unreported landings were in the higher range in some years. The recovery of cod stocks in the Baltic Sea requires immediate action to reduce the amount of unreported cod landings.

Illegal, Unreported and Unregulated (IUU) fishing is a concern for fisheries globally (Bray, 2000; Crona and Österblom, 2009). Our assessment of IUU fishing in Germany since 1950 reveals that there are considerable catches that are not being reported and represented in the publicly available ICES landings statistics database. Germany, among other Baltic countries, is a member of the European Union (EU), and as an EU member state, Germany is subject to the Common Fisheries Policy (CFP), which includes a code of conduct for all EU fisheries. Despite regulations in place to reduce IUU fishing, the CFP has failed to prevent IUU catches by its member states. Unreported landings and discards continue to be a serious concern in the Baltic Sea and unless a revised CFP, due in 2012, is able to implement stricter regulations, fisheries in the Baltic Sea will continue to be threatened by IUU fishing. Revisions to the CFP should include improved data collection, quality and transparency (Lutchman, 2009; Richartz, 2009). In a global assessment of the core features in the management process that determine the sustainability of a fishery, transparency ranked as the most important factor when compared to other factors such as scientific

robustness, implementation and enforcement of regulations, fishing capacity, subsidies and access to foreign fishing (Mora *et al.*, 2009). Currently much of the data needed for effective management of Germany's fisheries are not widely available. Increasing the availability of good quality fisheries data will facilitate better management decisions, encourage public involvement and allow for greater accountability.

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APPENDIX A

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

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	40,174	40,204	2,009	5,064	410	87,861
1951	36,290	45,572	1,926	8,060	424	92,272
1952	34,418	52,753	1,923	8,817	437	98,348
1953	37,086	46,516	2,173	8,216	451	94,441
1954	38,054	42,259	2,352	8,441	465	91,571
1955	43,080	42,368	2,796	9,588	478	98,310
1956	46,696	43,995	3,131	10,203	492	104,517
1957	49,899	53,803	3,803	11,867	506	119,878
1958	45,750	52,138	3,588	10,421	519	112,417
1959	38,544	48,668	3,155	9,331	533	100,232
1960	40,003	39,732	3,587	9,334	547	93,203
1961	69,703	18	3,324	9,440	560	83,045
1962	84,375	19	3,530	10,242	574	98,740
1963	70,419	0	2,771	8,792	587	82,569
1964	77,094	0	3,441	10,662	601	91,798
1965	73,606	8,224	3,516	13,847	615	99,808
1966	92,381	6,908	3,436	13,245	628	116,598
1967	127,050	16,076	4,343	16,345	642	164,456
1968	118,492	13,195	4,261	17,178	656	153,782
1969	91,385	10,806	4,391	14,505	669	121,757
1970	109,364	2,999	5,002	17,440	683	135,488
1971	108,646	3,076	4,355	14,244	697	131,017
1972	113,015	10,574	3,850	15,774	710	143,922
1973	137,336	6,769	7,022	11,427	724	163,278
1974	133,030	6,191	5,918	13,138	738	159,014
1975	139,613	3,407	6,665	11,665	751	162,101
1976	114,503	2,534	6,910	8,467	765	133,179
1977	140,288	342	8,550	10,283	779	160,241
1978	106,649	-1,595	4,318	9,541	792	119,704
1979	99,294	1,293	5,829	7,876	806	115,099
1980	102,161	2,049	6,223	6,733	820	117,986
1981	102,929	3,200	6,100	7,005	853	120,086
1982	100,617	2,613	8,103	9,235	885	121,452
1983	107,180	3,103	9,779	10,770	918	131,750
1984	120,321	2,399	16,737	8,767	951	149,175
1985	102,400	7,599	14,319	6,450	984	131,752
1986	94,751	4,179	11,294	5,452	1,017	116,693
1987	87,731	1,689	9,465	6,611	1,049	106,545
1988	89,626	1,918	9,590	5,863	1,082	108,079
1989	87,777	706	8,894	4,927	1,115	103,419
1990	60,326	529	4,994	3,850	1,148	70,847
1991	31,500	806	9,111	3,958	1,192	46,567
1992	30,931	452	7,945	4,674	1,351	45,354
1993	38,210	193	9,044	4,497	1,510	53,455
1994	28,905	-9	10,596	6,194	1,670	47,356
1995	29,097	1,258	7,676	5,781	1,829	45,641
1996	33,846	-1,249	4,576	4,996	1,988	44,157
1997	33,043	230	5,667	4,530	2,148	45,617
1998	29,861	5	4,717	4,715	2,307	41,605
1999	31,541	5	4,429	4,579	2,466	43,021
2000	27,782	18	3,676	4,546	2,626	38,648
2001	29,688	1	4,080	4,046	2,785	40,599
2002	37,045	-1	5,080	4,122	2,944	49,190
2003	53,530	5	7,111	5,129	3,104	68,879
2004	61,955	-1,097	8,005	5,231	3,263	77,357
2005	68,749	-5	7,749	6,324	3,422	86,240
2006	71,965	-17	7,945	6,128	3,537	89,558
2007	72,040	-817	7,708	6,127	3,537	88,596

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

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	13,151	10,741	658	2,001	373	26,923
1951	8,771	16,109	495	4,893	385	30,653
1952	10,080	23,290	633	5,830	398	40,230
1953	9,181	17,053	637	5,049	410	32,331
1954	9,623	12,796	730	5,145	423	28,716
1955	10,981	12,905	902	5,890	435	31,113
1956	11,644	14,532	1,028	6,390	448	34,042
1957	18,690	24,340	1,868	8,060	460	53,417
1958	15,364	22,675	1,643	6,795	472	46,949
1959	13,356	19,205	1,518	6,019	485	40,582
1960	15,867	10,269	1,963	5,943	497	34,539
1961	22,137	0	1,912	6,400	510	30,959
1962	19,897	1	1,643	6,403	522	28,466
1963	17,847	0	1,314	5,857	535	25,552
1964	18,197	0	1,801	7,339	547	27,883
1965	17,989	8,224	2,069	10,724	559	39,566
1966	16,512	6,908	1,756	9,207	572	34,955
1967	18,909	16,059	1,956	10,723	584	48,231
1968	28,186	13,125	2,500	12,437	597	56,845
1969	32,666	10,745	2,867	11,325	609	58,211
1970	34,600	2,943	3,285	13,428	622	54,878
1971	24,149	3,076	2,743	9,752	634	40,353
1972	25,351	3,885	2,752	10,869	646	43,504
1973	36,349	6,765	6,020	6,175	659	55,967
1974	29,114	4,086	4,836	7,593	671	46,300
1975	36,223	3,399	5,471	6,019	684	51,796
1976	32,644	2,534	6,124	4,050	696	46,048
1977	42,527	-754	7,618	4,971	709	55,070
1978	26,263	-1,796	3,325	5,055	721	33,568
1979	27,080	1,292	4,836	4,006	733	37,947
1980	23,769	2,044	4,991	2,582	746	34,132
1981	28,020	3,197	4,788	2,899	776	39,680
1982	30,615	2,613	6,819	5,490	806	46,343
1983	32,572	3,103	8,372	6,667	835	51,550
1984	49,518	2,399	15,427	4,929	865	73,138
1985	30,792	7,599	12,846	2,650	895	54,781
1986	21,422	4,179	9,720	1,569	925	37,815
1987	22,241	1,689	8,279	3,054	955	36,218
1988	21,022	1,907	8,438	2,135	985	34,486
1989	16,784	705	7,607	1,091	1,014	27,201
1990	8,855	520	3,666	797	1,044	14,882
1991	8,637	806	4,835	846	1,074	16,198
1992	6,668	-219	3,083	1,284	1,219	12,035
1993	5,127	-1	2,290	1,010	1,364	9,790
1994	7,088	-9	4,728	922	1,509	14,238
1995	14,681	11	3,699	1,698	1,654	21,743
1996	20,607	-1,249	1,397	2,428	1,799	24,982
1997	14,483	1	1,436	1,475	1,944	19,338
1998	10,989	3	748	2,004	2,089	15,833
1999	15,439	0	1,266	1,940	2,234	20,879
2000	13,079	1	1,006	1,868	2,379	18,333
2001	12,738	0	1,243	1,540	2,524	18,045
2002	8,768	-1	775	976	2,669	13,186
2003	8,125	4	882	1,289	2,813	13,113
2004	8,407	-1,097	1,410	686	2,958	12,364
2005	9,346	-5	1,089	1,580	3,103	15,113
2006	9,558	-17	953	1,208	3,219	14,920
2007	9,148	-817	663	964	3,219	13,177

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

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	20,777	9,156	1,039	1,549	8	32,528
1951	20,755	9,156	1,079	1,550	8	32,548
1952	18,107	9,156	960	1,411	8	29,642
1953	21,416	9,156	1,178	1,587	9	33,346
1954	20,713	9,156	1,181	1,552	9	32,611
1955	20,888	9,156	1,232	1,564	9	32,850
1956	25,928	9,156	1,556	1,832	10	38,481
1957	18,026	9,156	1,118	1,415	10	29,724
1958	20,439	9,156	1,308	1,545	10	32,458
1959	14,475	9,156	941	1,229	10	25,811
1960	15,794	9,156	1,058	1,300	11	27,319
1961	21,641	0	976	1,131	11	23,758
1962	29,825	0	1,472	1,565	11	32,873
1963	27,458	0	1,194	1,433	11	30,096
1964	24,063	0	1,210	1,264	12	26,549
1965	26,204	0	1,130	1,367	12	28,713
1966	36,873	0	1,405	1,914	12	40,205
1967	66,413	0	1,860	3,414	12	71,699
1968	53,141	0	1,326	2,723	13	57,203
1969	34,343	0	1,255	1,780	13	37,391
1970	56,417	0	1,545	2,898	13	60,873
1971	58,318	0	1,420	2,987	14	62,738
1972	68,813	0	950	3,488	14	73,265
1973	74,384	0	781	3,758	14	78,938
1974	80,301	0	860	4,058	14	85,233
1975	81,873	0	944	4,141	15	86,972
1976	64,650	0	624	3,264	15	68,553
1977	70,110	0	735	3,542	15	74,403
1978	54,069	0	765	2,742	15	57,591
1979	58,027	0	779	2,940	16	61,762
1980	69,060	0	997	3,503	16	73,576
1981	65,767	0	995	3,338	17	70,116
1982	59,796	0	1,045	3,042	17	63,900
1983	61,264	0	1,159	3,121	18	65,562
1984	58,239	0	1,086	2,966	18	62,310
1985	60,686	0	1,271	3,098	19	65,074
1986	62,443	0	1,389	3,192	20	67,043
1987	56,236	0	967	2,860	20	60,084
1988	59,238	0	935	3,009	21	63,202
1989	60,605	0	994	3,080	22	64,700
1990	45,339	0	922	2,313	22	48,597
1991	16,022	0	2,996	951	25	19,994
1992	17,746	0	3,460	1,060	28	22,295
1993	20,143	0	4,089	1,212	32	25,475
1994	12,367	0	3,327	785	35	16,513
1995	7,898	0	2,006	495	38	10,437
1996	7,737	0	1,857	480	41	10,114
1997	12,755	0	2,870	781	44	16,450
1998	9,514	0	1,998	576	47	12,135
1999	10,115	0	1,983	605	50	12,753
2000	9,475	0	1,715	559	53	11,803
2001	11,447	0	1,912	668	56	14,083
2002	22,661	0	3,444	1,305	59	27,470
2003	22,637	0	3,101	1,287	63	27,088
2004	22,244	0	2,736	1,249	66	26,295
2005	24,754	0	2,772	1,376	69	28,972
2006	26,206	0	2,935	1,457	69	30,667
2007	26,644	0	2,984	1,481	69	31,178

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

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	1,636	11,568	82	664	0	13,950
1951	1,091	11,568	57	636	0	13,351
1952	1,071	11,568	57	635	0	13,330
1953	778	11,568	43	619	0	13,008
1954	532	11,568	30	606	0	12,736
1955	301	11,568	18	594	0	12,481
1956	196	11,568	12	589	0	12,364
1957	1,006	11,568	62	632	0	13,268
1958	2,610	11,568	167	717	0	15,062
1959	2,632	11,568	171	719	0	15,089
1960	892	11,568	60	626	0	13,145
1961	9,450	0	43	475	0	9,967
1962	18,465	0	42	925	0	19,432
1963	8,499	0	37	427	0	8,962
1964	16,239	0	117	818	0	17,173
1965	11,685	0	39	586	0	12,311
1966	21,540	0	28	1,078	0	22,647
1967	13,916	0	231	707	0	14,855
1968	10,612	0	85	535	0	11,232
1969	7,639	0	31	384	0	8,054
1970	8,134	0	14	407	0	8,555
1971	16,237	0	10	812	0	17,059
1972	14,346	0	26	719	0	15,091
1973	14,151	0	102	713	0	14,966
1974	13,370	0	79	672	0	14,121
1975	12,420	0	54	624	0	13,098
1976	7,942	0	43	399	0	8,384
1977	17,954	0	68	901	0	18,924
1978	14,280	0	56	717	0	15,053
1979	4,508	0	49	228	0	4,785
1980	857	0	71	46	0	975
1981	583	0	55	32	0	670
1982	1,667	0	68	87	0	1,822
1983	3,243	0	69	166	0	3,477
1984	3,404	0	85	174	0	3,664
1985	2,588	0	89	134	0	2,811
1986	2,906	0	58	148	0	3,112
1987	1,700	0	61	88	0	1,849
1988	1,488	0	42	76	0	1,606
1989	1,742	0	99	92	0	1,933
1990	1,423	0	162	79	0	1,664
1991	736	0	138	44	0	917
1992	608	0	119	36	0	763
1993	8,267	0	1,678	497	0	10,442
1994	374	0	101	24	0	498
1995	230	0	58	14	0	303
1996	161	0	39	10	0	210
1997	428	0	96	26	0	551
1998	4,551	0	956	275	0	5,782
1999	182	0	36	11	0	229
2000	22	0	4	1	0	27
2001	792	0	132	46	0	970
2002	950	0	144	55	0	1,149
2003	18,023	0	2,469	1,025	0	21,517
2004	26,354	0	3,242	1,480	0	31,075
2005	28,975	0	3,245	1,611	0	33,831
2006	30,779	0	3,447	1,711	0	35,938
2007	30,973	0	3,469	1,722	0	36,164

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

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	0	18	0	1	0	19
1951	142	18	8	25	0	192
1952	7	18	0	2	0	27
1953	82	18	5	15	0	120
1954	117	18	8	21	0	164
1955	0	18	0	1	0	18
1956	4	18	0	1	0	23
1957	7	18	1	2	0	27
1958	7	18	1	2	0	27
1959	7	18	1	2	0	27
1960	226	18	23	41	0	307
1961	359	18	38	64	0	479
1962	222	18	24	40	0	304
1963	190	0	21	33	0	245
1964	325	0	36	55	0	415
1965	238	0	29	42	0	309
1966	203	0	26	37	0	266
1967	186	0	25	34	0	245
1968	214	0	30	39	0	283
1969	136	0	20	25	0	181
1970	152	0	23	28	0	203
1971	97	0	15	18	0	130
1972	107	1	17	20	0	145
1973	100	0	16	19	0	135
1974	78	0	11	11	0	100
1975	71	0	12	13	0	96
1976	59	0	10	11	0	80
1977	38	0	7	7	0	52
1978	19	0	3	3	0	26
1979	34	0	6	6	0	47
1980	48	0	9	9	0	67
1981	22	0	4	4	0	30
1982	17	0	3	3	0	23
1983	23	0	5	4	0	32
1984	35	0	7	6	0	48
1985	35	0	7	6	0	47
1986	64	0	14	13	0	90
1987	36	0	7	7	0	50
1988	56	0	12	11	0	79
1989	80	0	14	14	0	108
1990	57	0	13	13	0	83
1991	87	0	17	16	0	120
1992	56	0	11	11	0	78
1993	55	0	11	10	0	76
1994	13	0	2	2	0	18
1995	13	0	3	2	0	18
1996	28	0	6	6	0	39
1997	35	0	7	7	0	49
1998	42	0	8	8	0	58
1999	29	0	6	6	0	41
2000	44	0	9	6	0	59
2001	38	0	8	8	0	53
2002	29	0	6	6	0	41
2003	29	0	6	6	0	41
2004	35	0	7	7	0	50
2005	24	0	5	5	0	34
2006	18	0	4	4	0	26
2007	17	0	4	3	0	24

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

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	433	3,560	22	316	29	4,359
1951	513	3,560	27	352	30	4,481
1952	561	3,560	30	370	31	4,551
1953	473	3,560	26	327	32	4,418
1954	630	3,560	36	390	33	4,648
1955	894	3,560	53	510	34	5,050
1956	896	3,560	54	530	35	5,075
1957	1,100	3,560	68	643	36	5,407
1958	1,095	3,560	70	650	37	5,412
1959	965	3,560	63	578	38	5,203
1960	1,344	3,560	90	740	39	5,773
1961	4,849	0	104	776	40	5,769
1962	4,746	0	94	725	41	5,606
1963	4,713	0	57	516	42	5,328
1964	5,537	0	67	585	42	6,231
1965	3,130	0	68	488	43	3,730
1966	3,507	0	50	397	44	3,999
1967	4,162	17	62	481	45	4,767
1968	4,378	70	62	485	46	5,042
1969	3,210	61	57	407	47	3,782
1970	2,863	56	51	365	48	3,383
1971	3,081	0	48	355	49	3,532
1972	3,743	112	48	379	50	4,332
1973	4,075	4	58	434	51	4,622
1974	3,019	0	57	381	52	3,509
1975	3,110	8	87	517	53	3,775
1976	3,637	0	79	489	54	4,260
1977	4,339	1,096	92	607	55	6,189
1978	5,142	201	109	672	56	6,179
1979	5,062	1	67	466	57	5,653
1980	3,747	5	47	337	58	4,193
1981	3,736	3	77	449	60	4,325
1982	4,152	0	64	389	63	4,667
1983	4,709	0	94	518	65	5,386
1984	3,836	0	88	448	67	4,439
1985	4,833	0	76	413	70	5,391
1986	3,974	0	73	355	72	4,474
1987	3,214	0	118	427	74	3,833
1988	3,987	11	125	466	76	4,664
1989	4,467	1	111	440	79	5,097
1990	2,543	9	149	450	81	3,232
1991	3,055	0	571	1,681	92	5,400
1992	2,287	671	577	1,637	104	5,276
1993	2,157	194	477	1,263	115	4,206
1994	6,635	0	1,785	3,903	126	12,449
1995	5,146	1,247	1,624	3,062	137	11,217
1996	3,135	0	752	1,665	149	5,701
1997	3,312	229	797	2,015	160	6,512
1998	2,955	2	621	1,648	171	5,397
1999	3,239	5	636	1,708	182	5,770
2000	3,475	17	632	1,838	194	6,156
2001	2,919	1	488	1,525	205	5,138
2002	3,011	0	458	1,559	216	5,243
2003	2,614	1	358	1,272	227	4,473
2004	3,082	0	379	1,452	239	5,152
2005	2,489	0	279	1,176	250	4,194
2006	2,541	0	285	1,196	250	4,271
2007	3,277	0	367	1,660	250	5,554

Appendix Table A7. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for the category 'others' for Germany (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	4,177	5,162	209	535	0	10,082
1951	5,018	5,162	261	605	0	11,046
1952	4,592	5,162	243	570	0	10,568
1953	5,155	5,162	284	618	0	11,219
1954	6,439	5,162	367	727	0	12,695
1955	10,017	5,162	591	1,029	0	16,799
1956	8,028	5,162	482	860	0	14,531
1957	11,070	5,162	686	1,116	0	18,034
1958	6,235	5,162	399	712	0	12,508
1959	7,109	5,162	462	786	0	13,519
1960	5,880	5,162	394	684	0	12,120
1961	11,267	0	253	594	0	12,114
1962	11,220	0	255	584	0	12,059
1963	11,712	0	147	526	0	12,385
1964	12,733	0	210	603	0	13,546
1965	14,361	0	180	640	0	15,180
1966	13,746	0	170	611	0	14,527
1967	23,464	0	209	986	0	24,658
1968	21,961	0	258	958	0	23,177
1969	13,391	0	163	585	0	14,139
1970	7,199	0	84	312	0	7,595
1971	6,764	0	120	320	0	7,204
1972	655	6,576	58	298	0	7,586
1973	8,277	0	43	329	0	8,650
1974	7,148	2,105	76	422	0	9,751
1975	5,917	0	97	351	0	6,364
1976	5,571	0	29	254	0	5,854
1977	5,320	0	29	254	0	5,604
1978	6,876	0	60	352	0	7,287
1979	4,583	0	93	230	0	4,905
1980	4,680	0	108	256	0	5,043
1981	4,801	0	181	283	0	5,265
1982	4,370	0	104	224	0	4,698
1983	5,368	0	80	294	0	5,743
1984	5,289	0	44	243	0	5,576
1985	3,466	0	31	150	0	3,646
1986	3,942	0	41	175	0	4,158
1987	4,305	0	33	175	0	4,512
1988	3,835	0	39	166	0	4,041
1989	4,100	0	69	210	0	4,379
1990	2,109	0	83	197	0	2,389
1991	2,963	0	554	421	0	3,938
1992	3,566	0	695	646	0	4,908
1993	2,462	0	500	505	0	3,467
1994	2,428	0	653	559	0	3,640
1995	1,129	0	287	508	0	1,923
1996	2,178	0	525	407	0	3,110
1997	2,030	0	460	225	0	2,716
1998	1,810	0	385	205	0	2,400
1999	2,537	0	504	310	0	3,351
2000	1,687	0	309	273	0	2,269
2001	1,754	0	297	258	0	2,309
2002	1,626	0	252	221	0	2,100
2003	2,102	0	295	251	0	2,648
2004	1,833	0	231	358	0	2,422
2005	3,161	0	359	576	0	4,096
2006	2,863	0	321	552	0	3,735
2007	1,981	0	222	296	0	2,499

CATCH RECONSTRUCTION FOR LATVIA IN THE BALTIC SEA FROM 1950–2007[1]

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ABSTRACT

Total marine fisheries catches by Latvia in the Baltic Sea (or its equivalent entity prior to separation from the USSR in 1991) were estimated from 1950-2007 using an approach called 'catch reconstruction'. ICES landing statistics (which only report commercial landings) formed the baseline of the reconstruction, to which we added 'adjustments to ICES landing statistics' (particularly disaggregated data from when Latvia was part of the USSR), estimates of unreported landings, estimates of discards, and estimates of recreational catches. The reconstructed catch from 1950-2007 is approximately 4.7 million tonnes, attributing an additional 3.5 million tonnes to Latvia above catches reported by ICES for independent Latvia. From 1991-2007 when ICES landing statistics were reported for Latvia independently, our reconstructed catch was 28% higher than their reported 1.2 million tonnes. The most commercially important species are herring (*Clupea harengus*), sprat (*Sprattus sprattus*), and cod (*Gadus morhua*). We believe that this reconstruction represents a conservative estimate.

INTRODUCTION

Latvia is on the eastern edge of the Baltic Sea, located between Estonia and Lithuania, and is bordered on the east by Russia and Belarus (Figure 1). Latvia declared its independence from the USSR in 1991, and joined NATO and the European Union in 2004. In 2007, the estimated Latvian population was 2,292,000 (UN, 2008). Latvia has an area of 64,589 km² with a 12 nautical mile territorial limit in the Baltic Sea, although Latvian fishers have access to areas beyond this boundary (FAO, 2009). The main species caught are herring (*Clupea harengus*), sprat (*Sprattus sprattus*), and Atlantic cod (*Gadus morhua*).

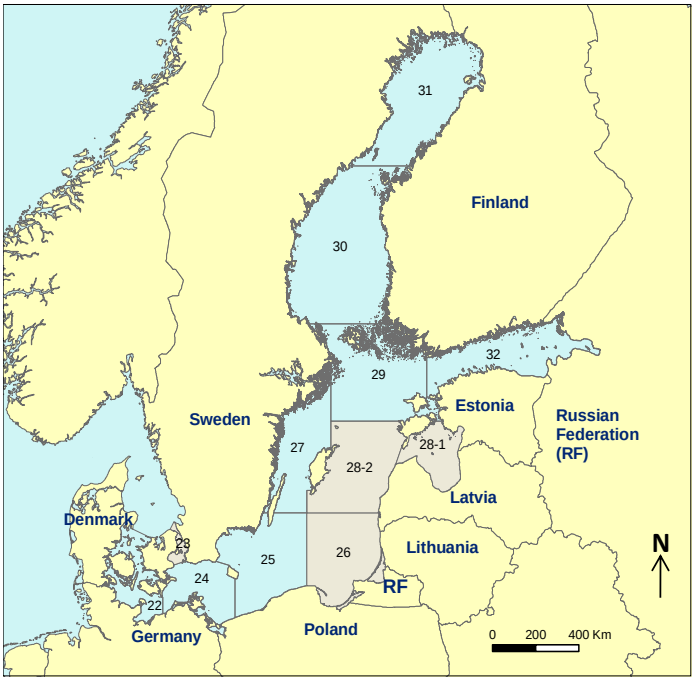

Figure 1. Map of the Baltic Sea with ICES subdivisions and surrounding countries. Latvia's coastline borders ICES subdivisions 26, 28-1 and 28-2.

Latvia's fisheries can be divided into four sectors: 1) a Baltic Sea and Gulf of Riga fleet; 2) coastal vessels; 3) a high seas fleet; and 4) inland waters.

1) In 2006, there were 115 trawlers and 48 gillnet vessels fishing in the Baltic Sea and

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the Gulf of Riga outside of coastal areas (Anon., 2008). Fishing in this area accounts for approximately 55% of annual total landings by Latvia (Anon., 2008). When Latvia was part of the USSR, it fished in most parts of the Baltic Sea. Since the 1990s, Latvia has reported its landings independent of the former USSR. The trawlers target herring all year round (with a mesh size of 28 mm), except during a 30-day ban in May/June (during the peak spawning time for herring), or if there is ice coverage in the Gulf of Riga. The trawlers also target sprat (with a mesh size of 16 mm) in the Baltic Sea year-round, with a lower intensity during the summer months. The number of trawlers and the total engine power has not been allowed to increase since the end of the 1990s, and the number of trawlers is now decreasing due to de-commissioning of vessels. The gillnet vessels target mainly cod (using bottom gillnets), and in 2006 contributed approximately 57% of total Latvian cod landings (Anon., 2008). The trap-net fishery targets spawning herring from mid-April through July. The number of nets has been stable since the mid-1990s, and contributes much less to total landings than the trawler fleet (e.g., 15% of herring landings are taken with trap-nets, and 85% with trawlers, ICES, 2007a). Atlantic salmon (*Salmo salar*) has also been targeted with drift gillnets by 9 vessels. Drift gillnets have been prohibited for use in the Baltic Sea by the EU since January 2008.

2) The coastal fishery consisted of approximately 740 boats under 12 m in 2003, and mainly targets herring, trout (*Salmo trutta*), vimba-bream (*Vimba vimba*), flounder (*Platichthys flesus*), European eel (*Anguilla anguilla*), and pikeperch (*Sander lucioperca*), small catches of sprat and cod, and Atlantic salmon. However, landing and selling of Atlantic salmon was banned in 2005 (ICES, 2007b). This fishery uses mainly passive gears such as trapnets, poundnets, gillnets, and hooks, although Danish seines are used to catch flatfishes (Anon., 2008). Coastal catches only account for approximately 4-6 % of the total reported landings for the Baltic Sea and the Gulf of Riga, yet they are important to coastal dwellers.

3) The high seas fleet is comprised of approximately 13 vessels that fish in the Northern and Central Atlantic Ocean under three international conventions (NAFO, NEAFC, and CACAF), and in 2006 contributed 45% to total Latvian landings (Anon., 2008). The high seas fleet is not considered further in this report.

4) There are approximately 800 lakes over 10 hectares within Latvia (with a total area of 91,500 ha), as well as rivers and reservoirs that are available for inland fishery exploitation. The commercial landings from these inland waters are between 500 and 600 t annually (FAO, 2009), approximately 0.5% of total landings. The inland fishery is not considered further in this report.

Although Latvia accounts for only approximately 0.8% of the total population in Baltic coastal countries, recent landings accounted for approximately 10% of the total Baltic landings. The fisheries administration in Latvia is through the National Board of Fisheries of the Ministry of Agriculture, which is responsible for overall management of the fisheries sector, quota management, sector development, strategies and legislation (FAO, 2009). The Latvian portion of the total Baltic quota has since 2004 been allocated by the EU's Common Fisheries Policy (CFP), and then distributed to Latvian fishers by the government. Latvia's utilization of their allocated quota has been increasing, and reached 99.6% in 2003 (FAO, 2009).

The objective of the present work is to estimate total catches (in contrast to reported landings) for Latvia, from 1950 – 2007. ICES landings statistics were taken here to represent officially reported data. Hence, all other additions and modifications are deemed Illegal, Unreported and Unregulated (IUU) data. Four IUU components were addressed: 1) reported landings data source adjustments from sources such as ICES stock assessment working group reports, national data and published scientific papers; 2) unreported landings; 3) discards; and 4) recreational catches. The focus was on utilizing available knowledge and information sources to derive estimated complete catch time series for all components, for Baltic Sea waters. The general methodology used relies heavily on previously described approaches for catch data reconstruction (Zeller *et al.*, 2006; Zeller *et al.*, 2007; Zeller and Pauly, 2007).

METHODS

ICES landings statistics (ICES, 2009) were used as the baseline for our reconstruction of Latvia's fisheries catches in the Baltic Sea from 1950-2007. However, landings data for Latvia are presented in ICES landings statistics only from 1991 onward. Prior to 1991, Latvia's fisheries catches were presented as a component of ICES landings statistics for the USSR, which combined landings for Latvia, Estonia, Lithuania, and Russia. Thus, for the time period 1950-1989, landings data were obtained from the Latvian

Fish Resource Agency (M. Plikshs, unpubl. data), which provided the 'former' USSR landings disaggregated by country, for each of the former Baltic States (Latvia, Estonia, and Lithuania) and Russia. While these landings were previously reported to ICES as landings by USSR, ICES has not retroactively adjusted its earlier landings statistics to create separate landings data for each country. Thus, landings obtained from LATFRA for the time period 1950-1989 were considered as '*adjustments*' to ICES landings statistics since there are no separate ICES landings statistics for Latvia for this time period. Other adjustments to ICES landings included taxa specific information contained within ICES stock assessment working group reports (ICES, 2009). In order to account for total catches (as opposed to landings), unreported landings (referred to as 'unallocated' catches by ICES), discards, and recreational catches were estimated. The resulting sum of ICES landings statistics, adjustments, unreported landings, discards, and recreational catches represents total reconstructed catches for Latvia from 1950-2007.

Our reconstruction represented the main taxa targeted by Latvia including cod (eastern and western stocks; *Gadus morhua*); herring (*Clupea harengus*); sprat (*Sprattus sprattus*); salmon (*Salmo salar*); flatfishes, which included European flounder (*Platichthys flesus*), European plaice (*Pleuronectes platessa*), and turbot (*Psetta maxima*); and another 30 taxonomic groups included in a grouping called 'others'.

Illegal, Unreported and Unregulated (IUU) catches

Catches that were not included in the ICES landings statistics for Latvia were considered as Illegal, Unreported or Unregulated (IUU) catches. Components included in our estimates of IUU catches were: a) '*adjustments*' to ICES landings statistics from other reliable sources such as ICES stock assessment working group data or national data sources; b) '*unreported*' landings (referred to by ICES as 'unallocated'); c) '*discards*', which included four categories; and d) '*recreational*' catches. When combined with ICES landings statistics, these components formed our catch reconstruction for Latvia.

Adjustments to ICES landings statistics

ICES landings statistics were adjusted using data obtained from LATFRA and information contained in ICES stock assessment working group reports (Table 1). As ICES landings data for Latvia were not available prior to the 1990s, the national landings data provided by LATFRA for the period 1950-1989 were considered adjustments to ICES data. From 1991-2007, ICES stock assessment working group data provided information to make adjustments to landings of cod (ICES, 2007a; 2008a) and flatfishes (ICES, 2008a). The ICES working group data provided better accounting for cod, since landings were reported for the eastern and western stocks separately. Flatfish data, rather than being grouped together, were presented by individual species.

Table 1. Sources of adjustments to ICES landings statistics for Latvia from 1950-2007.

Common name	Years	Source
Cod	1950-1990	LATFRA
	1994-2007	ICES (2007, 2008a)
Herring	1950-1990	LATFRA
Sprat	1950-1990	LATFRA
Salmon	1950-1990	LATFRA
Flatfishes	1950-1990	LATFRA
	1991-2005	ICES (2008a)
'Others '	1950-1990	LATFRA

Unreported landings

Unreported landings were estimated as a rate (%) for all taxa, which was applied to ICES landings statistics + adjustments from 1990 to 2007. Rates of unreported landings for Latvia from 1950-1989 were assumed to be 0%, following our assumption for all eastern bloc countries (see 'Methods' in Zeller *et al*., this volume). For the period from 1993-2007, unreported landings were based on information provided by LATFRA for cod and ICES stock assessment working group data for salmon, herring and other taxa (ICES, 2007a; 2008a; 2008b). To estimate unreported landings for 1991 and 1992, which reflected the transition from a state-controlled economy to a market-based economy, a linear interpolation was done between the assumed rate of 0% in 1990 and the first anchor point in 1993 (Table 2).

Anonymous sources within LATFRA provided an estimated range (50-100% of reported landings) for unreported landings of cod. We applied the average of this range (75%) for all years between 1993 and 2007 (Table 2). Unreported landings of salmon, herring, and other taxa for the period 1993-2007 were

derived from ICES stock assessment working group data using our default, assumption based methodology (Table 2; see 'Methods' in Zeller *et al.*, this volume).

From 1993 to 2007, unreported landings of herring caught in the Gulf of Riga were presented by ICES as a combined total tonnage for Latvia and Estonia (ICES, 2008a). However, sources indicated that these unreported landings were from Latvian fisheries only (Anon., pers. comm.).[2] The rate was determined by dividing all of the unreported landings from ICES (2008a) by Latvia's catches in subdivision 28-2. To estimate rates for 1991 and 1992, a linear interpolation was done between 0% in 1990 and the 1993 rate. We applied this rate to all herring catches in Latvia.

Table 2. Anchor points (%) for unreported landings of cod (LATFRA), herring (Table 6.3.1a in ICES, 2008a), salmon (Table 2.1.1. in ICES, 2008b) and all other taxa (Tables 2.3.1 and 2.4.1 in ICES, 2007; Table 2.3.1. and 2.4.1 in ICES, 2008a; and Table 2.1.1 in ICES, 2008a). The dashed lines (-) indicate years when the rates were derived through linear interpolation.

Year	Cod	Salmon[a]	Herring	Other taxa[b]
1950-1990	0.00[c]	0.0[c]	0.0[c]	0.0[c]
1991-1992	-	-	-	-
1993	75.0	19.4	25.4	20.3
1994	75.0	18.7	25.0	26.9
1995	75.0	19.5	20.0	-
1996	75.0	20.4	21.6	-
1997	75.0	20.8	20.0	-
1998	75.0	20.1	20.0	-
1999	75.0	20.4	15.0	-
2000	75.0	19.9	15.0	-
2001	75.0	20.4	15.0	-
2002	75.0	20.5	15.0	-
2003	75.0	20.1	15.0	-
2004	75.0	20.6	15.0	12.3
2005	75.0	20.7	15.0	11.2
2006	75.0	22.2	15.0	11.2[d]
2007	75.0	21.4	15.0	11.2[d]

[a] based on the reported mode value by ICES. [b] derived from the default values for cod and salmon (Zeller et al., this volume) [c] default assumption based rate. [d] rate carried forward.

Discards

Discards for Latvia were considered as four separate categories; each estimated as a rate and then applied to total landings (i.e., ICES landings + adjustments + unreported landings) for each respective species or group. The sum of discards in all categories gave us the total discarded catches for Latvia. The four categories considered were: 1) underwater discards accounting for the mortality of fish lost from gear while deployed and actively fishing; 2) ghostfishing due to lost gear; 3) boat based discards usually resulting from fisher's behavior after the catch is brought to the surface/on board; and 4) seal-damaged discards representing the fraction of catch discarded because of seal-damage. Seal-damaged discard data were used in place of boat based discards in subdivisions where seal-discard data were available and only when the seal-discard rates were higher than the boat-based discard rates. This was done to avoid the possibility of double accounting, as we could not determine whether seal-discards had already been included in estimates of boat based discards.

'*Underwater discards*': An underwater discard rate was applied to herring and sprat only. Our estimate of underwater discards for herring and sprat was based on a Finnish trawl study from which we estimated an underwater discard rate for herring of approximately 9% (Rahikainen *et al.*, 2004). Herring and sprat are both pelagic species that are caught in a mixed fishery using similar gear-types. This led us to apply the same underwater discard rate to both species. Since herring and sprat landings for Latvia are not reported by gear type, the estimated rate of 9% was reduced to a more conservative estimate of 5% and then applied to all years between 1950 and 2007.

'*Ghostfishing*': Estimates of ghostfishing discards were based on a Swedish study by Tschernij and Larsson (2003) that estimated the amount of cod caught in Sweden by lost gear and related it to commercial landings in Sweden. Using these data, Brown *et al.* (2005) estimated the range of ghostfishing rates by lost gear to be between 0.01% and 3.2%. Here, we used the average of 1.65% applied to all taxa, except herring and sprat, for all years during the period of study (1950-2007).

'*Boat-based discards*': A boat-based discard rate of 2% was applied to all taxa, except herring and sprat, from 1950-1990. For the period 1993-2007, boat-based discard data for western and eastern cod stocks

[2] This reliable source was interviewed personally by the lead author, and wished to remain unnamed due to personal considerations.

(ICES; 2007a; 2008a), and for salmon (ICES, 2008b) were obtained from ICES stock assessment working group data (Table 3). Discards rates for eastern and western cod were our default values calculated as Baltic wide-estimates (see 'Methods' in Zeller *et al.*, this volume). For salmon, the Baltic-wide, boat-based discard rate based on the mode estimate presented in ICES (2008b) was used, as it was the default assumption for countries whose recreational catches of salmon were not reported to ICES (see 'Methods' in Zeller *et al.*, this volume).

Table 3. Boat-based discard rates (%) of reported landings for the eastern cod stock (Tables 2.4.1, 2.4.5b in ICES, 2007; Tables 2.4.1, 2.4.5b and 2.4.20 in ICES, 2008), the western cod stock (Tables 2.3.6 in ICES, 2007; Tables 2.3.1, 2.3.6 and Figure 2.3.1 in ICES, 2008a) and salmon (Table 2.1.2 in ICES, 2008b). Dashed lines (-) indicate interpolated rates.

Year	Western cod	Eastern cod	Salmon
1950-1990	2.0[a]	2.0[a]	2.0[a]
1991-1992	-	-	-
1993	14.5	3.4	14.1[b]
1994	10.6	2.1	12.9[b]
1995	11.3	1.7	13.9[b]
1996	15.7	1.2	15.1[b]
1997	10.0	3.9	14.9[b]
1998	17.3	3.4	14.2[b]
1999	11.6	2.5	14.8[b]
2000	12.5	6.8	10.3[b]
2001	11.2	3.2	15.0[b]
2002	10.4	2.2	15.8[b]
2003	15.8	2.8	15.4[b]
2004	10.1	1.8	15.6[b]
2005	18.6	3.0	15.2[b]
2006	8.6	13.2	17.4[b]
2007	8.3	11.3	14.2[b]

[a] assumed default rate for eastern bloc countries (see 'Methods' in Zeller *et al.*, this volume); [b] based on the reported mode value from ICES (see 'Methods' in Zeller *et al.*, this volume).

For all other taxa, excluding cod and salmon, boat-based discards were derived from a Danish government study (Anon., 2006a) that examined boat-based discard practices for their entire fleet over a one year period. Discards were estimated from the discard tonnages presented for flounder (48%), plaice (34%), turbot (39%), whiting (36%), and 'others' (6%). The Danish study provided information for a species-specific discard rate for whiting (normally group with 'others') of 36% (see 'Methods' in Zeller *et al.*, this volume). These rates were applied to total landings (ICES landings statistics + adjustments + unreported landings) of flatfishes, whiting, and 'others' in all years between 1993 and 2007, while linear interpolation estimated discards between 1990 (2%) and 1993 (our first anchor point).

Seal-damaged discards have been a concern in the Baltic Sea since the 1980s, when seal populations started to recover from a previously depleted state (Österblom *et al.*, 2007). Seal-damaged discard data were only calculated and applied to herring caught in pound nets by Latvia in subdivision 28. Prior to the 1980s, our assumed default rate for seal-damaged discards was zero. To estimate seal-discards from 1980 onwards, we calculated an anchor point for seal-damaged discards based on the Estonian data for 2005. Since the proportion of herring caught in pound nets relative to other gear-types for Latvian fisheries was not known, we assumed the same value as that of Estonia. The proportion of herring caught in pound nets in Estonia relative to Estonia's total herring catch for subdivision 28, was estimated to be 45%. Seal-damaged discard rates for herring caught in subdivision 28 were estimated to be up to 50% of catches taken using pound nets. Here, we used half of Estonia's discard rate (25%) in combination with the assumption that 45% of herring in Latvia is caught with pound nets, to estimate seal-damaged discards of herring. The anchor point for 2000 was assumed to be half the rate for 2005 as seal populations were thought to have doubled between 2000 and 2005 (Ifremer, 2007). A linear interpolation was done to estimate seal-discard rates between anchor points established in 1980 and 2000, and the 2005 rate was carried forward unaltered to 2007. This seal-discard rate for herring was used in place of boat-based discards from 1980-2007 for subdivision 28 (Table 4).

Table 4. Anchor points of seal-damaged discards (%) for herring caught in subdivision 28. Dashed line (-) indicates interpolated rate based on Ifremer (2007).

Year	Seal-damaged discard
1980	0.00
1981-1999	-
2000	1.88
2001-2004	-
2005	3.75[a]
2006	3.75[a]
2007	3.75[a]

[a]2005 rate carried forward

Recreational catches

Almost no data for recreational catches exist for Latvia except for cod. Therefore, we relied on recreational catch rates from Estonia, and applied these to the coastal population of Latvia to estimate recreational catches for species from 1991-2007.

Three ports have offered boat charters to catch cod recreationally since 2004. In one harbor, Liepaja, 15 boats were estimated to catch between 3-5 tonnes in 2007 (M. Plikshs, unpubl. data). Assuming the same catch rates for the other two harbors, we estimated the recreational catch of cod to be 12 tonnes per year since 2004.

Table 5. Anchor points for Latvia's recreational catch for the period 2004-2007, based on half the average Estonian reported recreational catch for 2004 and 2007 (Anon., 2006b; 2007). See Veitch *et al.* (this volume).

Common Name	Recreational catch 2004-2007 t·year^{-1}
Herring	1.24
Salmon	2.04
Flounder	50.67
Garfish	30.73
Sea trout	1.65
Perch	2.17
Smelt	35.48

LATFRA reported that Latvian recreational fishers also caught herring, salmon, flounder, garfish, seatrout, perch and smelt. We relied on recreational catch information from Estonia to estimate these catches from 2004-2007. To remain conservative, we used half of the average reported recreational catch rates from Estonia. These were transformed into *per capita* catch rates for the coastal population (see Methods in Veitch *et al.*, this volume). We estimated the coastal population for Latvia as the total population of coastal districts to be approximately 1,676,000 inhabitants (Anon., 2006c). Multiplying the estimated coastal population of Latvia with the *per capita* catch rates, we estimated Latvia's recreational catches for the above species from 2004-2007 (Table 5). For all species, including cod, we assumed a recreational catch of zero in 1990. Linear interpolations for all Latvian recreational catches were performed in the intervening years from 1991-2003.

RESULTS

ICES landing statistics for Latvia have only been incorporated since 1991, prior to that they were included in the landing statistics of the USSR (Table 6). In 1991, the ICES landings statistics reported landings of 55,461 t, which decreased slightly for the following two years, but then increased to reach 86,123 t in 1997. From 1998-2007, the average annual ICES landing statistics were 81,144 t, with a peak of 93,088 t in 2005. The time series ended with landings of 89,366 t in 2007. From 1991-2007, ICES landing statistics report a total catch of 1,211,724 t for Latvia (Figure 2).

Table 6. ICES landing statistics presented as totals for Latvia (t) from 1992-2007, prior to which catches are not reported independently (see text for details).

Common name	1950-1989	1990-1999	2000-2007
Cod	n/a	43,680	39,937
Herring	n/a	237,265	192,818
Sprat	n/a	263,669	410,376
Salmon	n/a	1,882	531
Flatfishes	n/a	4,004	7,065
'Others'	n/a	6,044	4,453

Illegal, Unreported and Unregulated (IUU) catches

IUU is used in this report to quantify any catches made by a country that are not included in the ICES landing statistics. Adjustments to ICES landing statistics, unreported ('unallocated') landings, discards, and recreational catches account for our IUU adjustments (see Methods for details and sources).

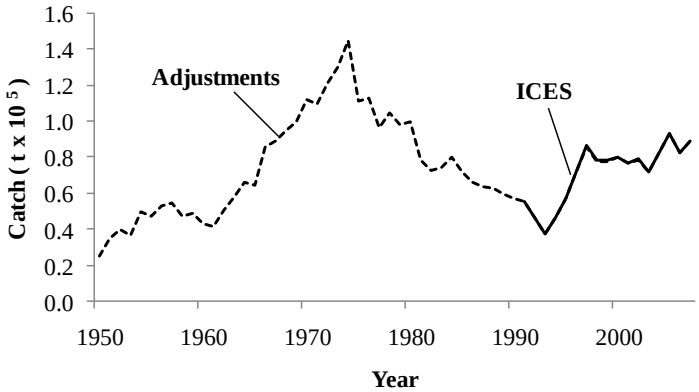

Figure 2. ICES landing statistics and adjustments to ICES landing statistics for Latvia from 1950-2007

Adjustments to ICES landing statistics

Overall, there were a total of 3,063,556 t of adjustments to ICES landing statistics from 1950-2007 (Table 7). The majority of these adjustments were due to the fact that prior to 1991, Latvian landings were reported as part of the former USSR, and there has been no retroactive adjustment to ICES landing statistics (Figure 2). For the time period from 1950-1990, a total 3,062,720 t of adjustments were made. Herring and cod adjustments had the largest proportions of adjustments, accounting for 43% (1,317,909 t) and 28% (863,759 t), respectively. Sprat and the group 'others' accounted for 16% (496,191 t) and 11%

(323,414 t) of the adjustments, respectively. Flatfish and salmon had minor adjustments made to the ICES landing statistics, with flatfish accounting for 2% (54,866 t) and salmon 0.2% (7,414 t).

From 1991-2007, there was a total of 836 t in adjustments to ICES landing statistics. The majority of this was explained by adjustments to cod data, which had a net increase of 656 t. Flatfishes were the group with the next largest adjustment to ICES landing statistics, with a total of 112 t. The group 'others' had a total adjustment of 48 t, and salmon had an increase of 20 t. Herring and sprat data had no adjustments during this time period.

Table 7. Decadal totals of adjustments to ICES landing statistics for Latvia (t).

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	181,990	171,990	227,550	276,192	6,015	22
Herring	206,340	331,000	396,766	349,485	34,318	0
Sprat	18,910	83,950	293,056	83,863	16,412	0
Salmon	660	1,410	1,433	3,287	621	6
Flatfishes	12,580	23,010	15,469	3,165	625	16
'Others'	17,460	83,500	207,109	14,304	1.027	14

Unreported landings

Unreported landings were assumed to have begun in Latvia following their separation from the USSR, and in 1991, the estimated unreported landings were 4,846 t (Figure 3). This increased to a peak of 21,890 t in 1997, and by 2007 had decreased to 13,586 t (Figure 3). The total unreported landings for 1991-2007 was estimated to be 248,608 t and accounted for approximately 6% of our reconstructed total for the same period.

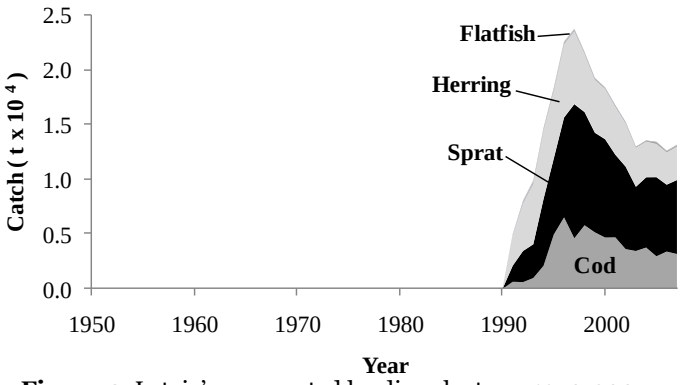

Figure 3. Latvia's unreported landings by taxa, 1950-2007.

Sprat had the highest estimated unreported landings, with an estimated total of approximately 110,000 t from 1991-2007 (Table 8), adding an additional 16% to the reported sprat landings. In 1991, the estimated unreported sprat landings were 1,260 t. This increased to 11,096 t in 1997, and decreased to 6,771 t by 2007. The species with the next largest contribution to unreported landings was herring with 74,679 t from 1991-2007, which added an additional 17% t reported herring landings. Unreported herring landings were estimated to have been 2,820 t in 1991, rose to a peak of 5,866 t in 1996, and then declined to 3,361 t by 2007. Unreported cod landings contributed almost as much as herring to total unreported landings, with an estimated 61,579 t from 1991-2007 (Table 8), but this corresponded to an additional 74% of reported cod landings. Unreported cod landings were an estimated 657 t in 1991, increased to a peak of 6,556 t in 1996, and then decreased to 3,202 t at the end of the time series. The group 'others' (totaling 1,788 t) and flatfish (totaling 1,701 t) contributed an additional 17% and 15% to reported landings for these two groups, respectively. Salmon contributed the least with 403 t from 1991-2007, adding an additional 17% to reported salmon landings.

Table 8. Decadal totals of unreported landings for Latvia (t).

Common name	1950-1989	1990-1999	2000-2007
Cod	0	31,610	29,969
Herring	0	44,218	28,923
Sprat	0	54,973	55,023
Salmon	0	293	109
Flatfishes	0	794	907
'Others'	0	1,198	590

Discards

Discards are comprised of four components (ghostfishing, underwater discards, boat-based discards and seal-damaged discards), and these were estimated to total 228,270 t throughout the time series (Figure 4). Discards were estimated to be 1,044 t at the beginning of the time series, and increased to a first peak of 6,303 t in 1974. From 1975-1994, discards averaged 3,662 t·year^{-1}. For the most recent period, discards increased again, and averaged 5,940 t annually from 1995-2007, with a peak of 7,280 t in 2005 (Figure 4).

The largest contributor to discards was herring, with 103,002 t estimated for the period 1950-2007 (Table 9), which is an average discard rate of 5% of total reconstructed herring catches. Herring discards were estimated to be 349 t in 1950, and this increased to an average of 1,579 t·year^{-1} from 1950-1984. From 1985-2007, herring discards increased to an average 2,075 t annually (with a peak of 2,316 t in 1997). Sprat was the next largest contributor, with an estimated 64,012 t discarded over the time period (Table 9). Sprat discards were estimated to have been 109 t in 1950, averaged 202 t annually from 1950-1968, and then increased to average 1,537 t·year^{-1} from 1969-1978 (Figure 4). Sprat discards were lower from 1979-1993, at an average 554 t annually, but then increased again to average 2,607 t annually from 1994-2007 (with a peak of 3,594 t in 2005, Figure 4). Cod discards were estimated to be 39,750 t from 1950-2007 (Table 9). Starting at an estimated 527 t in 1950, cod discards reached a peak of 1,902 t in 1980, and during the last year under consideration were estimated to be 957 t. 'Others' contributed the next largest amount, an estimated 12,749 t over the time period, which is an average discard rate of 3.8%. 'Others' discards were estimated to be 20 t in 1950, increased to a peak of 1,577 t in 1974, and then decreased to an average of 50 t annually from 1981-2007. Flatfish discards were estimated to be 8,093 t over the time period, beginning with an estimated 35 t in 1950, increasing to a peak of 952 t in 2005, before decreasing to end the time series at an estimated 583 t. Flatfish had the highest discard rate with an average of 11% of total reconstructed flatfish catches. Salmon discards contributed the least to overall discards, with a total of 665 t over the time period (with a peak of 48 t in 1993), and an average discard rate of 6%.

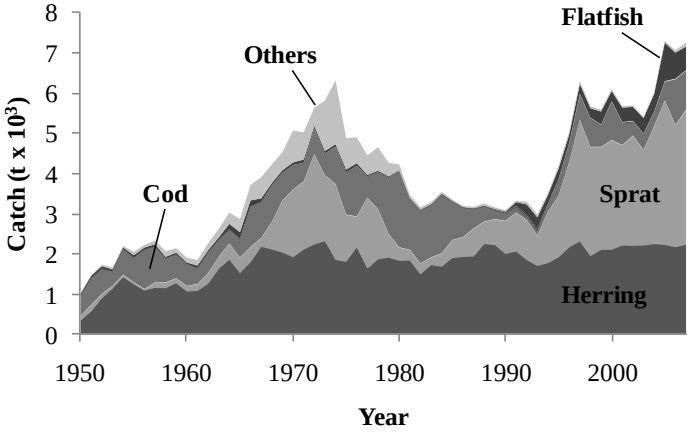

Figure 4. Latvia's discards by taxa, 1950-2007. Discards of Salmon were too small to show at present scale (See Table 9).

Table 9. Decadal totals of estimated discards for Latvia (t).

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	6,643	6,278	8,306	10,081	3,364	5,079
Herring	10,317	16,550	19,838	18,819	19,443	17,626
Sprat	946	4,198	14,653	4,193	16,753	23,270
Salmon	24	51	52	120	316	101
Flatfishes	459	840	565	116	2,153	3,961
'Others'	637	3,048	7,559	522	575	407

Recreational catches

It was assumed that there were no recreational catches in Latvia prior to 1991 (Figure 5), and in 1991 the total recreational catch was estimated as 16 t. This increased to a peak of 228 t in 2004-2007 (Figure 5). The total estimated recreational catch from 1991-2007 is 2,386 t (Table 10), and the two groups that made up the majority were 'others' and flatfishes, with overall catches of 1,275 t (53% of recreational catch) and 925 t (39% of recreational catch), respectively (Table 10). Recreational catches of 'other' fishes were estimated to be 8 t in 1991, increasing to a peak of 122 t in 2004-2007.

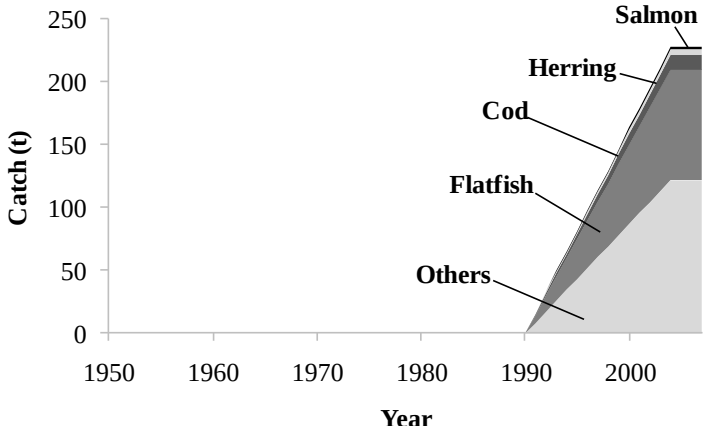

Figure 5. Latvia's recreational catches by taxa from 1950-2007.

Recreational catches of flatfishes were estimated to have been 6 t in 1991, increasing to a peak of 88 t in 2004-2007. The estimated total recreational catch for cod were 126 t, salmon 38 t and herring 23 t for the period 1991-2007 (Table 10).

Table 10. Decadal totals of estimated recreational catch for Latvia (t).

Common name	1950-1989	1990-1999	2000-2007
Cod	0	39	87
Herring	0	7	16
Salmon	0	12	26
Flatfishes	0	283	642
'Others'	0	389	886

Total Reconstructed Catch

Total reconstructed catches from 1950-2007 were estimated to be 4,754,544 t (Figure 6; Table 11). See Appendix Table A1 for complete time series data on all additions to catch by taxonomic group. In 1950, the reconstructed catch was an estimated 26,274 t, and increased to a peak of 151,329 t in 1974 (Figure 6). Reconstructed catches decreased to 49,852 t in 1993, increased to average 98,775 t·year^{-1} for the remainder of the time period, and were estimated to end the time period with 110,423 t in 2007 (Figure 6). Herring had the largest adjustments to ICES landing statistics, as well as the most discards, while sprat had the highest amount of unreported landings. 'Others' and flatfish had the highest amount of recreational catch.

ICES landing statistics report 1,211,724 t from 1991-2007, our total reconstructed catch for the same time period was 1,553,914 t, an increase of 28% (Figure 7). For the entire 1950-2007 time period, unreported landings, discards, recreational catches and ICES data source adjustments accounted for 7%, 6%, 0.1% and 87% of total reconstructed IUU (Table 11). The same components accounted for 69%, 30%, 1% and 0.03% for the 2000-2007 time period.

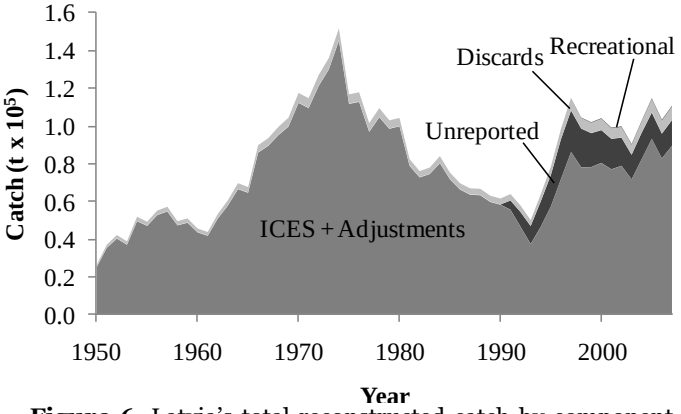

Figure 6. Latvia's total reconstructed catch by component from 1950-2007.

Herring had the highest reconstructed catch, 40% of the total reconstructed catch, with an estimated catch of 1,924,158 t from 1950-2007 (Tabe 12). Reconstructed herring catches were an estimated 7,319 t in 1950, increased to a peak of 48,720 t in 1973, then averaged 34,562 t·year^{-1} for the remainder of the time period, ending in 2007 at 28,003 t.

Sprat had the next highest reconstructed catch, 28% of the total reconstructed catch, with an estimated 1,344,243 t from 1950-2007 (Table 12). Sprat catches went through two periods of high catches, and two periods of lower catches. In 1950 sprat catches were an estimated 2,289 t and from 1950-1967 averaged approximately 3,700 t·year^{-1}. The 1980s were the other period of lower catches between two peaks, and from 1980-1988 sprat catches averaged 8,292 t·year^{-1}. From 1968-1979 sprat catches increased to average 29,094 t·year^{-1} with a peak of 47,124 t in 1972, and during the other period of high catches, 1989-2007, sprat catches averaged 44,942 t·year^{-1} with an overall peak of 75,482 t in 2005.

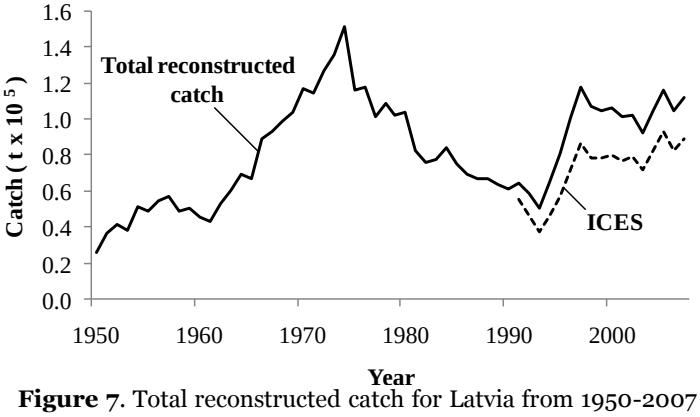

Figure 7. Total reconstructed catch for Latvia from 1950-2007 and ICES landings statistics from 1991-2007.

Cod accounted for 22% of the total reconstructed catch, with an estimated total of 1,048,830 t from 1950-2007 (Table 12). In 1950, reconstructed cod catches were an estimated 14,967 t, and averaged 19,410 t·year^{-1} until 1978. Catches increased from 1979-1986 and averaged 36,868 t·year^{-1} with an overall peak of

54,001 t in 1980. In the latter part of the time series reconstructed cod catches decreased to an average 9,095 t·year^{-1} from 1987-2007, ending the time period with 8,440 t in 2007.

Table 11. Latvia's total catch (tonnes) by decade by catch component.

Component	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
ICES landing statistics	n/a	n/a	n/a	n/a	556,544	655,180
Adjustments	437,940	694,860	1,141,383	730,296	59,019	58
Unreported landings	n/a	n/a	n/a	n/a	126,232	115,522
Discards	19,026	30,964	50,973	33,851	42,603	50,044
Recreational catches	n/a	n/a	n/a	n/a	729	1,657
Total reconstruction	456,966	725,824	1,192,356	767,147	785,127	822,860

The group 'others' contributed the next largest amount to our total reconstruction, 7%, with an estimated total of 379,723 t from 1950-2007. 'Others' catches increased from 580 t in 1950 to a peak of 44,780 t in 1974, then decreased to average 981 t·year^{-1} from 1981-2007. Flatfishes make up 1.6% of our reconstructed catch, with an estimated total of 76,654 t from 1950-2007. From an estimated 995 t in 1950, flatfish catches rose to peak at 4,695 t in 1965. From 1966-2007, reconstructed flatfish catches averaged 1,182 t·year^{-1} and had another, smaller peak of 2,958 t in 2005. Salmon contributed 0.2% to our reconstructed catch, with an estimated total of 10,935 t from 1950-2007, and an average of 189 t·year^{-1}.

Table 12. Decadal totals of the estimated total reconstructed catch for Latvia (t).

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	188,633	178,268	235,856	286,273	84,707	75,095
Herring	216,657	347,550	416,604	368,304	328,397	239,383
Sprat	19,856	88,148	307,709	88,056	351,807	488,669
Salmon	684	1,461	1,485	3,407	3,124	773
Flatfishes	13,039	23,850	16,034	3,281	7,860	12,591
'Others'	18,097	86,548	214,668	14,826	9,233	6,350

DISCUSSION

ICES landing statistics reported approximately 1.2 million t of catches from 1991-2007. For the same period, our reconstructed catch was nearly 1.6 million t, i.e., an additional 28%. From 1950-2007, our reconstructed catch was approximately 4,755,000 t, four times larger than the catches attributed to Latvia directly by ICES landing statistics for the period (however, this ignores the entity of the 'former USSR', and is thus misleading). The IUU component with the greatest contribution to our reconstruction was adjustments to ICES landing statistics, mainly from the period when ICES landing statistics were not reported independently for Latvia (1950-1990).

Unreported landings and discards represented 7% and 6% of total IUU respectively; yet unreported landings are assumed to have only begun in 1991, whereas discards are assumed to have to have been occurring throughout the time period, therefore unreported landings are occurring at a higher rate than discards. The species that contributed the most to unreported landings was sprat, with an estimated total of 109,996 t from 1991-2007 (adding 16% to reported sprat landings), but unreported cod landings accounted for the greatest increase to reported landings, an additional 74%. The largest contributor to discards was herring, with an estimated 103,002 t from 1950-2007. Flatfish discards were 8,093 t from 1950-2007. Recreational catches contributed the least to the reconstruction, with an estimated 2,386 t from 1991-2007.

We believe our reconstruction represents a conservative estimation of Latvia's total fisheries catches from the Baltic Sea, because we consistently used minimum estimates. Our rates of unreported cod catches from 1993 onwards were provided by LATFRA, and were country-specific. LATFRA estimated that unreported cod catches added an additional 75% to reported cod landings in 1993, which, compared to ICES estimate of 40.2% in 1993 for western cod stocks (ICES, 2008a), is much higher. For all other taxonomic groups, we used ICES data in absence of other information, but these should all be seen as minimum estimates, as it is known that only some countries report IUU catches to ICES, yet the total is split between all the countries. Although we have been able to correct for the estimates of unreported landings and discards for countries that are known to not submit estimates to ICES (e.g., Sweden does not submit unreported landing estimates, see Persson, this volume), it is likely that other countries do not report estimates of these catches to ICES either. If countries insisted on maintaining the confidentiality clause, there would still be a way of improving the quality of data of these catches, and that would be by providing two sets of data: one set from countries that do report IUU catches and discard estimates, along with their landings, and one set from countries that do not report such catch estimates, and their landings.

This would allow for a better idea of the proportions that these fishery sectors contribute to overall catches in the Baltic Sea.

It would also be beneficial for most countries to increase the level of monitoring and reporting of recreational fisheries, and Latvia is no exception. Very little information was found regarding recreational fisheries, resutking in approximate estimates. Long-term monitoring would help determine fishing pressure and possible conservation measures that should be taken to ensure that all fish species will be available for recreational fishing for generations.

Our catch reconstruction for Latvia, though a conservative estimate that mostly likely underestimates true catches, is still more accurate than the current assumption of zero (or close to zero) IUU catch when there are no 'hard' data. This method of reconstruction that accounts for all fishery sectors, has been used successfully elsewhere (Zeller *et al.,* 2006; Zeller *et al.,* 2007; Zeller and Pauly, 2007).

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APPENDIX A

Appendix Table A1. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for Latvia (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	25,230	0	1,044	0	26,274
1951	N/A	35,440	0	1,492	0	36,932
1952	N/A	40,300	0	1,743	0	42,043
1953	N/A	37,030	0	1,676	0	38,706
1954	N/A	49,510	0	2,207	0	51,717
1955	N/A	47,030	0	2,066	0	49,096
1956	N/A	52,760	0	2,229	0	54,989
1957	N/A	54,660	0	2,343	0	57,003
1958	N/A	47,290	0	2,074	0	49,364
1959	N/A	48,690	0	2,153	0	50,843
1960	N/A	43,580	0	1,914	0	45,494
1961	N/A	41,780	0	1,862	0	43,642
1962	N/A	50,920	0	2,269	0	53,189
1963	N/A	57,810	0	2,630	0	60,440
1964	N/A	66,440	0	3,034	0	69,474
1965	N/A	64,550	0	2,871	0	67,421
1966	N/A	85,820	0	3,720	0	89,540
1967	N/A	89,390	0	3,909	0	93,299
1968	N/A	95,020	0	4,222	0	99,242
1969	N/A	99,550	0	4,533	0	104,083
1970	N/A	112,130	0	5,064	0	117,194
1971	N/A	109,360	0	5,019	0	114,379
1972	N/A	121,120	0	5,631	0	126,751
1973	N/A	129,850	0	5,807	0	135,657
1974	N/A	145,026	0	6,303	0	151,329
1975	N/A	111,567	0	4,876	0	116,443
1976	N/A	112,619	0	4,902	0	117,521
1977	N/A	96,772	0	4,449	0	101,221
1978	N/A	104,529	0	4,656	0	109,185
1979	N/A	98,410	0	4,265	0	102,675
1980	N/A	99,759	0	4,224	0	103,983
1981	N/A	78,776	0	3,464	0	82,240
1982	N/A	72,670	0	3,164	0	75,834
1983	N/A	74,460	0	3,294	0	77,754
1984	N/A	80,210	0	3,548	0	83,758
1985	N/A	71,719	0	3,358	0	75,077
1986	N/A	66,237	0	3,198	0	69,435
1987	N/A	63,542	0	3,178	0	66,720
1988	N/A	63,244	0	3,259	0	66,503
1989	N/A	59,679	0	3,163	0	62,842
1990	N/A	58,241	0	3,095	0	61,336
1991	55,461	34	4,846	3,329	16	63,686
1992	46,404	67	7,719	3,303	32	57,525
1993	37,346	26	9,438	2,993	49	49,852
1994	46,056	452	13,430	3,511	65	63,514
1995	57,112	194	16,496	4,198	81	78,081
1996	71,786	3	21,010	5,045	97	97,941
1997	86,123	2	21,890	6,287	114	114,416
1998	78,109	0	20,358	5,665	130	104,261
1999	78,147	0	17,899	5,584	146	101,777
2000	80,329	0	17,286	6,090	162	103,867
2001	76,930	3	16,071	5,673	179	98,856
2002	78,802	14	14,846	5,687	195	99,544
2003	71,609	0	12,969	5,401	211	90,190
2004	82,296	40	13,937	6,015	227	102,515
2005	93,088	1	13,817	7,280	228	114,414
2006	82,760	0	13,011	7,054	228	103,052
2007	89,366	0	13,586	7,243	228	110,423

Appendix Table A2. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for cod (*Gadus morhua*) for Latvia (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	14,440	0	527	0	14,967
1951	N/A	18,700	0	683	0	19,383
1952	N/A	17,480	0	638	0	18,118
1953	N/A	10,400	0	380	0	10,780
1954	N/A	17,980	0	656	0	18,636
1955	N/A	17,190	0	627	0	17,817
1956	N/A	27,330	0	998	0	28,328
1957	N/A	24,900	0	909	0	25,809
1958	N/A	16,820	0	614	0	17,434
1959	N/A	16,750	0	611	0	17,361
1960	N/A	15,640	0	571	0	16,211
1961	N/A	11,280	0	412	0	11,692
1962	N/A	14,420	0	526	0	14,946
1963	N/A	11,830	0	432	0	12,262
1964	N/A	9,830	0	359	0	10,189
1965	N/A	12,890	0	470	0	13,360
1966	N/A	27,660	0	1,010	0	28,670
1967	N/A	24,610	0	898	0	25,508
1968	N/A	24,940	0	910	0	25,850
1969	N/A	18,890	0	689	0	19,579
1970	N/A	16,780	0	612	0	17,392
1971	N/A	12,560	0	458	0	13,018
1972	N/A	17,290	0	631	0	17,921
1973	N/A	14,670	0	535	0	15,205
1974	N/A	25,217	0	920	0	26,137
1975	N/A	28,632	0	1,045	0	29,677
1976	N/A	34,258	0	1,250	0	35,508
1977	N/A	14,601	0	533	0	15,134
1978	N/A	25,077	0	915	0	25,992
1979	N/A	38,465	0	1,404	0	39,869
1980	N/A	52,099	0	1,902	0	54,001
1981	N/A	34,927	0	1,275	0	36,202
1982	N/A	36,135	0	1,319	0	37,454
1983	N/A	35,956	0	1,312	0	37,268
1984	N/A	40,291	0	1,471	0	41,762
1985	N/A	26,511	0	968	0	27,479
1986	N/A	20,172	0	736	0	20,908
1987	N/A	13,308	0	486	0	13,794
1988	N/A	10,665	0	389	0	11,054
1989	N/A	6,128	0	224	0	6,352
1990	N/A	5,381	0	196	0	5,577
1991	2,627	0	657	136	1	3,420
1992	1,250	0	625	87	2	1,963
1993	1,333	0	1,000	119	3	2,454
1994	2,379	452	2,123	186	3	5,143
1995	6,471	182	4,990	397	4	12,044
1996	8,741	0	6,556	442	5	15,744
1997	6,187	0	4,640	602	6	11,435
1998	7,778	0	5,834	692	7	14,310
1999	6,914	0	5,186	508	8	12,616
2000	6,280	0	4,710	932	9	11,930
2001	6,298	0	4,724	537	9	11,568
2002	4,867	0	3,650	335	10	8,862
2003	4,634	0	3,476	392	11	8,513
2004	5,027	29	3,792	335	12	9,195
2005	3,996	-7	2,992	456	12	7,449
2006	4,566	0	3,425	1,136	12	9,139
2007	4,269	0	3,202	957	12	8,440

Appendix Table A3. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for herring (*Clupea harengus*) for Latvia (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	6,970	0	349	0	7,319
1951	N/A	11,580	0	579	0	12,159
1952	N/A	17,960	0	898	0	18,858
1953	N/A	22,840	0	1,142	0	23,982
1954	N/A	28,500	0	1,425	0	29,925
1955	N/A	24,980	0	1,249	0	26,229
1956	N/A	21,820	0	1,091	0	22,911
1957	N/A	23,210	0	1,161	0	24,371
1958	N/A	22,990	0	1,150	0	24,140
1959	N/A	25,490	0	1,275	0	26,765
1960	N/A	21,360	0	1,068	0	22,428
1961	N/A	21,640	0	1,082	0	22,722
1962	N/A	25,180	0	1,259	0	26,439
1963	N/A	32,600	0	1,630	0	34,230
1964	N/A	37,190	0	1,860	0	39,050
1965	N/A	30,550	0	1,528	0	32,078
1966	N/A	35,870	0	1,794	0	37,664
1967	N/A	43,580	0	2,179	0	45,759
1968	N/A	42,300	0	2,115	0	44,415
1969	N/A	40,730	0	2,037	0	42,767
1970	N/A	38,480	0	1,924	0	40,404
1971	N/A	42,180	0	2,109	0	44,289
1972	N/A	44,790	0	2,240	0	47,030
1973	N/A	46,400	0	2,320	0	48,720
1974	N/A	37,104	0	1,855	0	38,959
1975	N/A	36,149	0	1,807	0	37,956
1976	N/A	43,342	0	2,167	0	45,509
1977	N/A	32,754	0	1,638	0	34,392
1978	N/A	37,361	0	1,868	0	39,229
1979	N/A	38,206	0	1,910	0	40,116
1980	N/A	36,631	0	1,832	0	38,463
1981	N/A	36,148	0	1,836	0	37,984
1982	N/A	28,916	0	1,495	0	30,411
1983	N/A	32,883	0	1,726	0	34,609
1984	N/A	31,629	0	1,686	0	33,315
1985	N/A	35,087	0	1,902	0	36,989
1986	N/A	35,081	0	1,929	0	37,010
1987	N/A	34,760	0	1,940	0	36,700
1988	N/A	39,671	0	2,249	0	41,920
1989	N/A	38,679	0	2,224	0	40,903
1990	N/A	34,318	0	2,001	0	36,319
1991	33,270	0	2,820	2,064	0	38,154
1992	25,965	0	4,401	1,852	0	32,219
1993	21,949	0	5,580	1,704	1	29,234
1994	22,676	0	5,668	1,774	1	30,119
1995	24,972	0	4,991	1,918	1	31,882
1996	27,523	0	5,934	2,168	1	35,625
1997	29,330	0	5,866	2,316	1	37,513
1998	24,417	0	4,883	1,948	1	31,250
1999	27,163	0	4,075	2,105	1	33,345
2000	26,768	0	4,016	2,109	2	32,894
2001	26,652	0	3,998	2,213	2	32,864
2002	25,284	0	3,792	2,207	2	31,285
2003	24,187	0	3,628	2,214	2	30,031
2004	23,559	0	3,534	2,249	2	29,344
2005	22,202	0	3,330	2,229	2	27,763
2006	21,762	0	3,264	2,170	2	27,198
2007	22,404	0	3,361	2,236	2	28,003

Appendix Table A4. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for sprat *(Sprattus sprattus)* for Latvia (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	2,180	0	109	0	2,289
1951	N/A	3,110	0	156	0	3,266
1952	N/A	2,170	0	109	0	2,279
1953	N/A	1,170	0	59	0	1,229
1954	N/A	1,100	0	55	0	1,155
1955	N/A	920	0	46	0	966
1956	N/A	620	0	31	0	651
1957	N/A	2,540	0	127	0	2,667
1958	N/A	2,780	0	139	0	2,919
1959	N/A	2,320	0	116	0	2,436
1960	N/A	2,610	0	131	0	2,741
1961	N/A	3,310	0	166	0	3,476
1962	N/A	5,190	0	260	0	5,450
1963	N/A	5,890	0	295	0	6,185
1964	N/A	7,950	0	398	0	8,348
1965	N/A	7,620	0	381	0	8,001
1966	N/A	7,620	0	381	0	8,001
1967	N/A	4,310	0	216	0	4,526
1968	N/A	13,530	0	677	0	14,207
1969	N/A	25,920	0	1,296	0	27,216
1970	N/A	33,470	0	1,674	0	35,144
1971	N/A	33,950	0	1,698	0	35,648
1972	N/A	44,880	0	2,244	0	47,124
1973	N/A	32,690	0	1,635	0	34,325
1974	N/A	37,680	0	1,884	0	39,564
1975	N/A	23,399	0	1,170	0	24,569
1976	N/A	15,281	0	764	0	16,045
1977	N/A	35,163	0	1,758	0	36,921
1978	N/A	24,887	0	1,244	0	26,131
1979	N/A	11,656	0	583	0	12,239
1980	N/A	6,571	0	329	0	6,900
1981	N/A	5,331	0	267	0	5,598
1982	N/A	5,349	0	267	0	5,616
1983	N/A	3,695	0	185	0	3,880
1984	N/A	6,625	0	331	0	6,956
1985	N/A	8,827	0	441	0	9,268
1986	N/A	9,737	0	487	0	10,224
1987	N/A	13,900	0	695	0	14,595
1988	N/A	11,039	0	552	0	11,591
1989	N/A	12,789	0	639	0	13,428
1990	N/A	16,412	0	821	0	17,233
1991	17,996	0	1,260	963	0	20,219
1992	17,388	0	2,434	991	0	20,813
1993	12,553	0	2,548	755	0	15,856
1994	20,132	0	5,416	1,277	0	26,825
1995	24,383	0	6,193	1,529	0	32,105
1996	34,211	0	8,211	2,121	0	44,543
1997	49,314	0	11,096	3,020	0	63,430
1998	44,858	0	9,420	2,714	0	56,992
1999	42,834	0	8,395	2,561	0	53,791
2000	46,186	0	8,360	2,727	0	57,273
2001	42,769	0	7,142	2,496	0	52,407
2002	47,540	0	7,226	2,738	0	57,504
2003	41,743	0	5,719	2,373	0	49,835
2004	52,399	0	6,445	2,942	0	61,786
2005	64,647	0	7,240	3,594	0	75,482
2006	54,638	0	6,119	3,038	0	63,795
2007	60,454	0	6,771	3,361	0	70,586

Appendix table A5. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for salmon (*Salmo salar*) for Latvia (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	120	16	5	0	141
1951	N/A	40	0	1	0	41
1952	N/A	100	0	4	0	104
1953	N/A	60	0	2	0	62
1954	N/A	60	0	2	0	62
1955	N/A	70	0	3	0	73
1956	N/A	50	0	2	0	52
1957	N/A	40	0	1	0	41
1958	N/A	50	0	2	0	52
1959	N/A	70	0	3	0	73
1960	N/A	80	0	3	0	83
1961	N/A	120	0	4	0	124
1962	N/A	160	0	6	0	166
1963	N/A	170	0	6	0	176
1964	N/A	170	0	6	0	176
1965	N/A	190	0	7	0	197
1966	N/A	160	0	6	0	166
1967	N/A	110	0	4	0	114
1968	N/A	130	0	5	0	135
1969	N/A	120	0	4	0	124
1970	N/A	80	0	3	0	83
1971	N/A	80	0	3	0	83
1972	N/A	90	0	3	0	93
1973	N/A	100	0	4	0	104
1974	N/A	177	0	6	0	183
1975	N/A	219	0	8	0	227
1976	N/A	210	0	8	0	218
1977	N/A	164	0	6	0	170
1978	N/A	136	0	5	0	141
1979	N/A	177	0	6	0	183
1980	N/A	245	0	9	0	254
1981	N/A	184	0	7	0	191
1982	N/A	174	0	6	0	180
1983	N/A	286	0	10	0	296
1984	N/A	372	0	14	0	386
1985	N/A	333	0	12	0	345
1986	N/A	416	0	15	0	431
1987	N/A	395	0	14	0	409
1988	N/A	349	0	13	0	362
1989	N/A	533	0	19	0	552
1990	N/A	607	0	22	0	629
1991	481	0	31	39	0	552
1992	278	0	36	37	1	351
1993	243	13	50	48	1	355
1994	130	0	24	22	1	178
1995	139	0	27	26	1	193
1996	151	0	31	31	2	214
1997	169	1	35	34	2	241
1998	125	0	25	24	2	176
1999	166	0	34	33	2	235
2000	150	0	30	22	3	204
2001	135	2	28	27	3	195
2002	110	0	23	23	3	159
2003	49	0	10	10	3	72
2004	31	1	7	7	4	49
2005	20	3	5	5	4	36
2006	16	0	4	4	4	27
2007	20	0	4	4	4	32

Appendix table A6. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for the category 'flatfish' for Latvia (t). N/A: part of ICES category 'former USSR'

Year	ICES Landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	960	0	35	0	995
1951	N/A	1,460	0	53	0	1,513
1952	N/A	1,670	0	61	0	1,731
1953	N/A	1,230	0	45	0	1,275
1954	N/A	1,010	0	37	0	1,047
1955	N/A	1,510	0	55	0	1,565
1956	N/A	1,290	0	47	0	1,337
1957	N/A	1,410	0	51	0	1,461
1958	N/A	950	0	35	0	985
1959	N/A	1,090	0	40	0	1,130
1960	N/A	750	0	27	0	777
1961	N/A	1,670	0	61	0	1,731
1962	N/A	1,380	0	50	0	1,430
1963	N/A	1,520	0	55	0	1,575
1964	N/A	3,640	0	133	0	3,773
1965	N/A	4,530	0	165	0	4,695
1966	N/A	3,980	0	145	0	4,125
1967	N/A	2,430	0	89	0	2,519
1968	N/A	1,560	0	57	0	1,617
1969	N/A	1,550	0	57	0	1,607
1970	N/A	1,690	0	62	0	1,752
1971	N/A	2,150	0	78	0	2,228
1972	N/A	1,830	0	67	0	1,897
1973	N/A	1,780	0	65	0	1,845
1974	N/A	1,645	0	60	0	1,705
1975	N/A	1,903	0	69	0	1,972
1976	N/A	1,817	0	66	0	1,883
1977	N/A	907	0	33	0	940
1978	N/A	1,001	0	37	0	1,038
1979	N/A	746	0	27	0	773
1980	N/A	417	0	15	0	432
1981	N/A	311	0	11	0	322
1982	N/A	509	0	19	0	528
1983	N/A	376	0	14	0	390
1984	N/A	159	0	6	0	165
1985	N/A	169	0	6	0	175
1986	N/A	139	0	5	0	144
1987	N/A	320	0	12	0	332
1988	N/A	252	0	9	0	261
1989	N/A	513	0	19	0	532
1990	N/A	530	0	19	0	549
1991	445	1	31	91	6	574
1992	624	66	97	270	13	1,069
1993	475	13	99	292	19	898
1994	337	0	91	211	25	664
1995	411	12	107	256	32	818
1996	336	3	81	203	38	662
1997	413	1	93	246	44	798
1998	400	0	84	236	50	771
1999	563	0	110	328	57	1,058
2000	434	0	79	253	63	828
2001	619	0	103	358	69	1,150
2002	608	1	93	347	76	1,124
2003	682	0	93	384	82	1,241
2004	777	10	97	438	88	1,410
2005	1,720	5	193	952	88	2,958
2006	1,169	0	131	645	88	2,033
2007	1,056	0	118	583	88	1,846

Appendix Table A7. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for the category 'others' for Latvia (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-ational	Total
1950	N/A	560	0	20	0	580
1951	N/A	550	0	20	0	570
1952	N/A	920	0	34	0	954
1953	N/A	1,330	0	49	0	1,379
1954	N/A	860	0	31	0	891
1955	N/A	2,360	0	86	0	2,446
1956	N/A	1,650	0	60	0	1,710
1957	N/A	2,560	0	93	0	2,653
1958	N/A	3,700	0	135	0	3,835
1959	N/A	2,970	0	108	0	3,078
1960	N/A	3,140	0	115	0	3,255
1961	N/A	3,760	0	137	0	3,897
1962	N/A	4,590	0	168	0	4,758
1963	N/A	5,800	0	212	0	6,012
1964	N/A	7,660	0	280	0	7,940
1965	N/A	8,770	0	320	0	9,090
1966	N/A	10,530	0	384	0	10,914
1967	N/A	14,350	0	524	0	14,874
1968	N/A	12,560	0	458	0	13,018
1969	N/A	12,340	0	450	0	12,790
1970	N/A	21,630	0	789	0	22,419
1971	N/A	18,440	0	673	0	19,113
1972	N/A	12,240	0	447	0	12,687
1973	N/A	34,210	0	1,249	0	35,459
1974	N/A	43,203	0	1,577	0	44,780
1975	N/A	21,265	0	776	0	22,041
1976	N/A	17,711	0	646	0	18,357
1977	N/A	13,183	0	481	0	13,664
1978	N/A	16,067	0	586	0	16,653
1979	N/A	9,160	0	334	0	9,494
1980	N/A	3,796	0	139	0	3,935
1981	N/A	1,875	0	68	0	1,943
1982	N/A	1,587	0	58	0	1,645
1983	N/A	1,264	0	46	0	1,310
1984	N/A	1,134	0	41	0	1,175
1985	N/A	792	0	29	0	821
1986	N/A	692	0	25	0	717
1987	N/A	859	0	31	0	890
1988	N/A	1,268	0	46	0	1,314
1989	N/A	1,037	0	38	0	1,075
1990	N/A	993	0	36	0	1,029
1991	642	33	47	37	8	767
1992	899	1	126	66	17	1,110
1993	793	0	161	75	26	1,055
1994	402	0	108	40	35	585
1995	736	0	187	73	43	1,039
1996	824	0	198	81	52	1,154
1997	710	0	160	69	61	999
1998	531	0	112	51	69	763
1999	507	0	99	48	78	732
2000	511	0	92	48	87	738
2001	457	1	76	42	96	672
2002	393	13	62	37	104	609
2003	314	0	43	28	113	498
2004	503	0	62	45	122	731
2005	503	0	56	44	122	725
2006	609	0	68	61	122	860
2007	1,163	0	130	102	122	1,517

CATCH RECONSTRUCTION FOR LITHUANIA IN THE BALTIC SEA FROM 1950–2007[1]

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ABSTRACT

Total marine fisheries catches by Lithuania (or its equivalent entity during the USSR period) in the Baltic Sea were estimated from 1950-2007. Since 1992, ICES landing statistics have been reporting commercial landings for independent Lithuania, but have not retroactively adjusted their data to attribute landings to Lithuania during the USSR period. Our catch reconstruction used the ICES landing statistics database as a reported data baseline for commercial catches. Additional sources were used to provide data source 'adjustments' to ICES landing statistics, as well as estimates of unreported landings, discards, and recreational catches. The resultant reconstructed catch totaled approximately 1.2 million tonnes, which is 1 million tonnes higher than the catch attributed to Lithuania by ICES since 1950. For comparison, from 1992-2007 our reconstructed catch was 48% higher than ICES reported landings of 200,000 tonnes. The main species targeted were cod (*Gadus morhua*), herring (*Clupea harengus*), and sprat (*Sprattus sprattus*). We believe that our reconstruction is a conservative estimate of the total level of exploitation. Increased data collection, transparency, and accessibility to information would have a positive effect on management of the Baltic Sea marine ecosystem.

INTRODUCTION

Lithuania is the southernmost of the three Baltic republics, has an area of 65,300 km^2 and shares a border to the north with Latvia, a southeast border with Belarus, and Poland and Russia (Kaliningrad exclave) to the southwest (Figure 1). Lithuania declared its independence from the USSR in 1990, in 1991 joined the UN and the World Trade Organization (WTO), and subsequently joined the European Union (EU) in 2004 (Vycius and Radzevicius, 2009). In 2005, the population was estimated at 3,416,000 (UN, 2007), which accounts for approximately 1.2% of the total population of the Baltic. Lithuania has a 12 nautical mile territorial limit (within which only Lithuania is licensed to fish), although Lithuanian fishers have access to areas beyond this boundary. In recent years, the most important fisheries species have been herring (*Clupea harengus*), sprat (*Sprattus sprattus*), and Atlantic cod (*Gadus morhua*).

Lithuania's fisheries can be divided into four sectors: 1) Baltic open-sea fishing (trawling); 2) Baltic coastal small-scale fishing; 3) Distant Water Fleet fishing outside the Baltic Sea; and 4) inland freshwater fishing.

1. The open-sea fishing fleet in the Baltic is composed mostly of trawlers, mainly targeting herring and sprat in ICES subdivision 26 (Figure 1), and less importantly cod, flounder (*Platichthys flesus*), salmon (*Salmo salar*), bream (*Abramis brama*), sea trout (*Salmo trutta*), and other miscellaneous fishes (ICES, 2007). As of 2004, there were 45 trawlers between 24 – 40 m in length and 15 vessels between 12 – 24 m long using otter bottom or otter pelagic trawls. There were also 15 gillnet vessels, although some of the larger "trawl" vessels also use gillnets, and less occasionally, drift nets and longlines for targeting cod (ICES, 2007). Drift gillnets have been prohibited for use in the Baltic Sea by the EU since January 2008.

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2. An estimated 200 small fishing vessels operate in Lithuania's coastal areas (FAO, 2009). The Baltic coastal small-scale fishing fleet has traditionally been important for coastal people, and although it does not contribute significantly to GDP or exports, continues to have local importance. Species such as cod, herring, smelt (*Osmerus eperlanus*), pikeperch (*Sander lucioperca*), perch (*Perca fluviatilis*), and vimba (*Vimba vimba*) are targeted with boats under 12 m (ICES, 2007).

3. The Distant Water Fleet was developed during the Soviet period. Landings decreased in 1990 from 300,000 tonnes to only 33,000 tonnes in 1997 as a result of increased fuel prices, ageing vessels, and competition from foreign markets. More recently, landings have been increasing, but in 2006 were still only about 30% of the 1990 landings (Vycius and Radzevicius, 2009). This fishery will not be considered further in this report.

4. The inland freshwater fishery is mainly based around the Curonian Lagoon, the Kaunas, Antaliepte, and Elektrenai reservoirs; and the Lower Nemunas basin. Landings accounted for approximately 2% of total reported landings in 2006. This fishery is not accounted for in the following analysis.

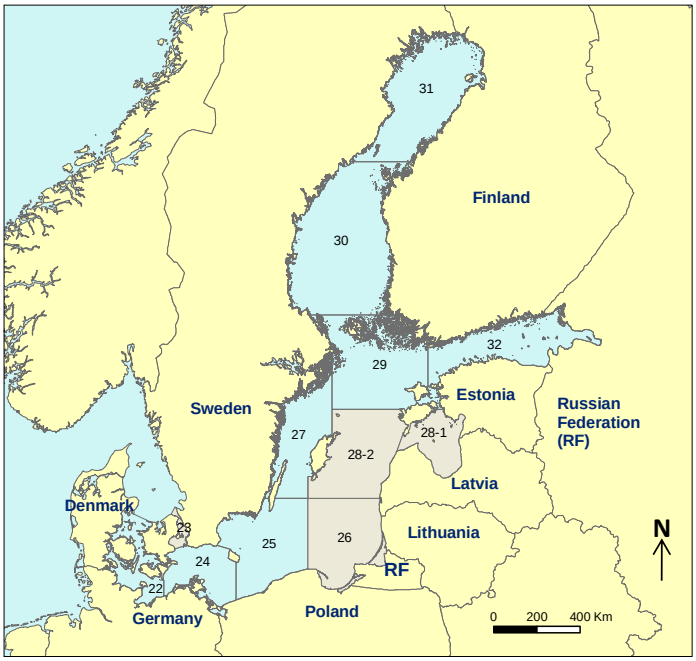

Figure 1. Map of the Baltic Sea with ICES subdivisions and surrounding countries. Lithuania's coastline borders ICES subdivision 26.

In 2006, landings from the Baltic Sea and its coastal fisheries accounted for approximately 10% of the total fish landed in Lithuania, while approximately 88% came from the Distant Water Fleet, and 2% from inland fisheries (Vycius and Radzevicius, 2009). Lithuania's reported landings presently account for approximately 1.3% of total reported landings in the Baltic Sea, and during the 1950 – 2007 time period have on average accounted for approximately 1.7%. The Lithuanian Fisheries Department distributes Lithuania's quota (allocated by the EU's Common Fisheries Policy [CFP]) to fishing companies, but for a variety of reasons Lithuania's allocated quota is not always fully utilized (Vycius and Radzevicius, 2009).

The objective of the present study is to estimate total catches (in contrast to reported landings) for Lithuania, from 1950 – 2007, which includes time-series estimates of Illegal, Unreported and Unregulated (IUU) catches, discards, and recreational catches. The focus is on utilizing available knowledge and information sources to derive estimated catch time series for all components, for Baltic Sea waters. The general methodology used relies heavily on previously described approaches for catch data reconstruction (Zeller *et al.*, 2006; Zeller *et al.*, 2007; Zeller and Pauly, 2007).

METHODS

ICES landings statistics were used as the baseline for our reconstruction of Lithuania's total fisheries catches in the Baltic Sea from 1950-2007 (ICES, 2009). ICES landings statistics present fisheries catches for Lithuania, as a separate entity, only from 1992 onward. Prior to 1990, Lithuania was part of the USSR and fisheries catches for what is now Lithuania were presented as part of USSR landings. ICES has not made retroactive adjustments to the landings statistics to account for the dismantling of the USSR. Therefore, landings data obtained from our collaborators at the Latvian Fish Resource Agency (LATFRA) were used for the 1950-1991 time period. Landings data were provided for the former USSR, disaggregated by country, with separate landings data for Lithuania, Latvia, Estonia and Russia (M. Plikshs, pers. comm., LATFRA).

All catches that are not included in the ICES landings statistics were considered part of Illegal, Unreported and Unregulated fishing (IUU). Here, IUU catches comprised of four components: a) '*adjustments*' to ICES landings statistics based on time series data from ICES stock assessment working group data or national government data (i.e., LATFRA); b) '*unreported*' landings (referred to as 'unallocated' catches by ICES); c) '*discards*' being fish that are caught but not retained; and d) '*recreational*' catches. The sum of these components plus the officially reported ICES landings statistics provided our total reconstructed catch for Lithuania from 1950-2007.

Our reconstruction represented the main species or groups targeted commercially by Lithuania including cod (eastern stock only; *Gadus morhua*); herring (*Clupea harengus*); sprat (*Sprattus sprattus*); salmon (*Salmo salar*); the flatfishes, which included European flounder (*Platichthys flesus*), European plaice (*Pleuronectes platessa*), and turbot (*Psetta maxima*); and an additional 27 taxa included in a grouping called 'others'.

Illegal, Unreported, and Unregulated (IUU) catches

These IUU components included a) '*adjustments*' to ICES landings statistics to estimate to make the best estimate of commercial landings; b) '*unreported*' landings that did not form a part of ICES landings statistics; c) '*discards*', which were comprised of four categories, each estimated separately; d) '*recreational*' catches. Below we provide the data and sources for these components, which together formed the basis for our reconstruction of Lithuania's total fisheries catches from 1950-2007.

Adjustments to ICES landings statistics

Adjustments were made to the publicly available ICES landing statistics using national data obtained from LATFRA and information contained in ICES stock assessment working group reports. The disaggregated landings data obtained from LATFRA were the only source of landings data for Lithuania from 1950-1989. As these were not presented in ICES landings statistics, they were considered adjustments to landings (Table 1). Species specific adjustments were made to landings using ICES stock assessment working group data for salmon from 1990-1996 (ICES, 2008b), for cod from 1991-2007 (ICES, 2007; 2008a) and turbot, a part of our flatfishes group, from 1991-2007 (ICES, 2008a). Landings for 1990 and 1991 were estimated for all other taxa by linear interpolation between the last year of data provided by LATFRA (1989) and the first year that ICES landings statistics presents data for Lithuania as a separate entity (1992).

Table 1. Sources of adjustments to ICES landings statistics for Lithuania from 1950-2007.

Common names	Years	Source
Cod	1950-1989	LATFRA
	1990-1991	Interpolated
	1992-2007	ICES (2007, 2008a)
Herring	1950-1989	LATFRA
	1990-1991	Interpolated
Sprat	1950-1989	LATFRA
	1990-1991	Interpolated
Salmon	1950-1989	LATFRA
	1990-1996	ICES (2008b)
Flatfishes	1950-1989	LATFRA
	1991-2007	ICES (2008a)
'Others '	1950-1989	LATFRA
	1990-1991	Interpolated

Unreported landings

Unreported landings for Lithuania were assumed to be zero from 1950-1990 as this was our assumption for all eastern bloc countries (see 'Methods' in Zeller *et al.*, this volume). For the time period 1993-2007, unreported landings were based on information provided by LATFRA and ICES stock assessment working group data. Rates for 1991 and 1992 were derived through linear interpolation from 0% in 1990 to the first anchor point in 1993. These estimates were interpolated to reflect the transition from a state-controlled economy to a market-based economy. Unreported landings for eastern cod from 1993-2007 were estimated to be 75%, which was based on the average range of 50-100%. (Anon., pers. comm., LATFRA).[2] Salmon's unreported landings for the period 1993-2007 were derived from ICES stock assessment working group data (see 'Methods' in Zeller *et al.*, this volume, Table 2). Anchor point rates for other taxa besides cod and salmon were estimated using an average rate based on the default Baltic-wide rates for salmon and cod for the years 1993, 1994, 2004, and 2005 (see 'Methods' in Zeller *et al.*, this volume). Linear interpolations between years of anchor points were done to estimate the rates in missing years, and the

[2]This source within LATFRA was interviewed but requested to remain anonymous for personal reasons.

2005 rate was carried forward until 2007 (Table 2). Rates for 1991-1992 were derived through linear interpolation from 0% in 1990 to the first anchor point in 1993.

Discards

Four separate categories of discards were estimated for Lithuania, each estimated as a rate and then applied to the landings data (ICES landings + adjustments + unreported landings) for each respective taxon or group. The sum of discards in all categories gave us an estimate of total discarded catches for Lithuania. The four categories considered were: a) '*underwater discards*' accounting for the mortality of fish lost from gear while deployed and actively fishing; b) '*ghostfishing*' due to lost or abandoned gear; c) '*boat-based discards*' usually resulting from fisher's behavior after the catch is brought to the surface/on board; and d) '*seal-damaged discards*' representing the portion of the catch discarded due to seal damage.

'*Underwater discards*': An underwater discard rate was applied to herring and sprat only as underwater discarding is mainly a problem associated with pelagic fisheries. Our estimates for underwater discards of herring and sprat were based on a Finnish trawl study by Rahikainen (2004) from which we estimated an underwater discard rate for herring of approximately 9% (see 'Methods' in Zeller *et al.*, this volume). Herring and sprat are both pelagic species that are caught in a mixed fishery using similar gear-types. This led us to apply the same underwater discard rate to both species. Since herring and sprat landings for Lithuania are not reported by gear-type, the estimated rate of 9% was reduced to a more conservative estimate of 5% and applied to all landings of these two species between 1950 and 2007.

'*Ghostfishing*': Estimates of ghostfishing discards were based on a Swedish study by Tschernij and Larsson (2003) that estimated the amount of cod caught by lost gear and related it to commercial catches in Sweden. Using these data, Brown *et al.* (2005) estimated the range of ghostfishing rates by lost gear to be between 0.01% and 3.2% and here, we used the average of 1.65% applied to all taxa, except herring and sprat, for all years from 1950-2007. Herring and sprat were not considered as ghostfishing is of minimal concern for pelagic species.

'*Boat-based discards*': A boat-based discard rate of 2% was applied to all taxa, except herring and sprat, from 1950-1990. Sources indicate that herring and sprat account for a negligible proportion of boat-based discards (ICES, 2005; 2007). For the period 1993-2007 boat-based discard data for cod (ICES, 2008a) and salmon (ICES, 2008b) were calculated for Lithuania from the Baltic-wide discards presented in the ICES stock assessment working group data as a fraction of the total landings presented in the same ICES report (see 'Methods' in Zeller *et al.*, this volume). The ICES stock assessment reports present a minimum, mode and maximum for salmon discards. Here we used the mode, as it was the assumed default for countries where recreational catches are not included in reported ICES landings (see 'Methods' in Zeller *et al.*, this volume). Boat-based discard rates for 2004, obtained from a Danish study (Anon., 2006) for European flounder, plaice, turbot, whiting, and other taxa were 48.0%, 34.0%, 38.5%, 36.1%, and 6.2%, respectively. These

Table 2. Anchor points for unreported landings (%) for cod (LATFRA), salmon (Table 2.1.1. in ICES, 2008b) and all other taxa (Tables 2.3.1 and 2.4.1 in ICES, 2007; Table 2.3.1. and 2.4.1 in ICES, 2008a; and Table 2.1.1 in ICES, 2008a). Dashed lines (-) indicate years when the rates were derived through linear interpolation.

Year	Cod	Salmon	Other taxa[a]
1950-1990	0.0	0.0	0.0
1991-1992	-	-	-
1993	75.0	19.4	20.3
1994	75.0	18.7	26.9
1995	75.0	19.5	-
1996	75.0	20.4	-
1997	75.0	20.8	-
1998	75.0	20.1	-
1999	75.0	20.4	-
2000	75.0	19.9	-
2001	75.0	20.4	-
2002	75.0	20.5	-
2003	75.0	20.1	-
2004	75.0	20.6	12.3
2005	75.0	20.7	11.2
2006	75.0	22.2	11.2[b]
2007	75.0	21.4	11.2[b]

[a] includes all taxa other than cod and salmon. [b] 2005 rate carried forward.

Table 3. Anchor points (%) used for estimating boat based discards for eastern cod and salmon based on sources (Tables 2.4.1, 2.4.5b in ICES, 2007; Table 2.4.1, 2.4.5b and 2.4.20 in ICES, 2008a; and Table 2.1.2 in ICES, 2008b). Dashed lines (-) indicate years when linear interpolations were used.

Year	Eastern cod	Salmon
1950-1990	2.0	2.0
1991-1992	-	-
1993	3.4	14.1
1994	2.1	12.9
1995	1.7	13.9
1996	1.2	15.1
1997	3.9	14.9
1998	3.4	14.2
1999	2.5	14.8
2000	6.8	10.3
2001	3.2	15.0
2002	2.2	15.8
2003	2.8	15.4
2004	1.8	15.6
2005	3.0	15.2
2006	13.2	17.4
2007	11.3	14.2

values were used as a constant rate for all years from 1993-2007. The 1991-1992 rates were estimated from the default rate of 2% in 1990 to the first anchor point in 1993 by linear interpolation.

'*Seal-damaged discards*': Seal-damaged discards have been a concern in the Baltic Sea since the 1980s when seals started to recover from historically low population levels (Österblom *et al.*, 2007). Seal-damaged discard data were used in place of boat-based discards when seal-damaged discard rates were higher than the boat-based discard rates. This was done to avoid the possibility of double accounting since we assumed that some seal-damaged discards may have been included in estimates of boat-based discards.

Seal-damaged discards in Lithuania were only considered for cod. Seal-damaged discards were estimated to be 20% of Lithuania's cod landings for 2007 (S. Toliusis, unpubl. data). The rates for 1981-2006 were then derived through linear interpolation between the assumed rate of 0% in 1980 and the anchor point for 2007 of 20%. These seal-discard rates were higher than the boat-based discard rates from 1983-2007 and therefore replaced the default boat-based discard rate for these years. The interpolated rate for 1983 (2.2%) was the first year that the seal-damaged discard rate was higher than the default boat-based discard rate (2%).

Recreational catches

Recreational catches were assumed to be zero until the 1990s as recreational fishing was forbidden during the USSR period, except for in Poland and Russia. From 1990-2007, the years of transition from a state-controlled to a market-based economy, little information regarding Lithuania's recreational catches exists. We therefore estimated catches for this period based on the number of fishers and the catch rates of the nearest neighboring countries.

The proportion of Lithuania's coastal population that engages in recreational fishing was based on the proportion of Kaliningrad's coastal population that fishes recreationally (Harper *et al.*, this volume). Using 2002 census data for Kaliningrad and the number of fishers for Kaliningrad, we derived a recreational fishing participation rate for Lithuania. We combined this with the coastal population of Lithuania and estimated that there were 49,000 recreational fishers in Lithuania in 2002. The coastal population of Lithuania was estimated as the sum of the three coastal administrative districts, Klaipedos, Telsiu and Taurages. Assuming the same catch composition as Germany and half of Germany's catch rate (kg·fisher^{-1}) for 2005/2006, as a conservative estimate for Lithuania, we applied this catch rate to the number of recreational fishers in Lithuania and derived recreational catch estimates for cod, herring and flounder. To get a complete time series from 1990-2007, we carried the 2005 values forward, unaltered to 2007 and estimated values for 1990-2005 through linear interpolation.

Overall, total reconstructed catches were obtained as the sum of ICES landings statistics, adjustments, unreported landings estimates, discard estimates, and recreational catch estimates. The estimated total reconstructed catch was then compared to the officially reported data, defined here as the ICES landings statistics.

Table 4. ICES landing statistics presented as totals for Lithuania (t) from 1992-2007, prior to which catches were not reported independently but rather as part of 'former USSR'.

Common name	1990-1999[a]	2000-2007
Cod	26,111	27,048
Herring	32,857	13,842
Sprat	37,406	56,028
Flatfishes	2,966	6,646
Salmon	67	30
Others	906	2,943

[a] no ICES landings statistics for independent Lithuania prior to 1991.

RESULTS

ICES landing statistics for Lithuania have only been recorded since 1992, prior to this time they were included in the landing statistics of the USSR. In 1992, ICES landings statistics reports that Lithuania reported landings of 11,217 t, which increased to 20,470 t in 1996 (Figure 2). Following this, landings decreased and averaged 9,500 t annually from 1999-2003, then increased to end the time period at 26,743 t. From 1992-2007, ICES landing statistics reported a total catch of 206,850 t (Table 4).

Sprat landings comprise the majority of these landings, with a total of 93,434 t from 1992-2007, or 45% of the total ICES landing statistics for Lithuania. Sprat landings were 3,279 t in 1992, and increased to 10,165 t in 1996. Landings decreased in the following years, to an average of 4,340 t annually from 1997-2005. At the end of the time period, sprat landings increased to 19,745 t in 2007. Cod landings contributed the next

largest amount to the total, with 53,159 t from 1992-2007, or 26% of ICES landings. Cod landings were reported to be 2,141 t in 1992, increased to a maximum of 5,520 t in 1996, before decreasing to an average 3,583 t from 1997-2007. Herring landings were reported to be approximately half of sprat catches, with a total of around 46,700 t from 1992-2007, or 23% of total ICES landings for the period. Herring landings were approximately 5,800 t in 1992, increased to 7,000 t in 1995, and then decreased to an average 2,000 t annually from 1996-2007. Flatfish had the next largest landing, with a total of about 9,600 t from 1992-2007, or 5% of total ICES landings. Flatfish landings were 9 t in 1992, and increased to 1,155 t in 2001. From 2001-2005, flatfish landings were on average 1,000 t annually, yet this decreased at the end of the time period to 375 t in 2007. Salmon landings totaled almost 100 t from 1992-2007. All other reported species (the 'others' category, recorded by ICES since 1993) landings totaled 3,850 t from 1993-2007, or 2% of total ICES landings. 'Others' landings were 10 t in 1993, increased to 1,500 t in 2002, and then decreased to end the time period at around 100 t. Time series data for all species and taxon groups, by catch component, is available in Appendix A1-A7.

Illegal, Unreported and Unregulated (IUU) catches

IUU is used in this report to quantify any catches made by a country but not included in their official catch statistics. Adjustments to ICES landing statistics, unreported landings, discards, and recreational catches make up our IUU adjustments.

Adjustments to ICES landings statistics

A total 895,941 t of adjustments were made to ICES landing statistics for Lithuania from 1950-2007 (Figure 2; Table 5). The majority of these adjustments are due to the fact that prior to 1992, Lithuanian landings were recorded as part of the USSR, and ICES landing statistics have not been adjusted retroactively to account for this. Landings from 1950-1991 were adjusted from zero using national data and ICES Working Group reports (see Methods for all sources), as ICES landing statistics were not reported separately for Lithuania for this period.

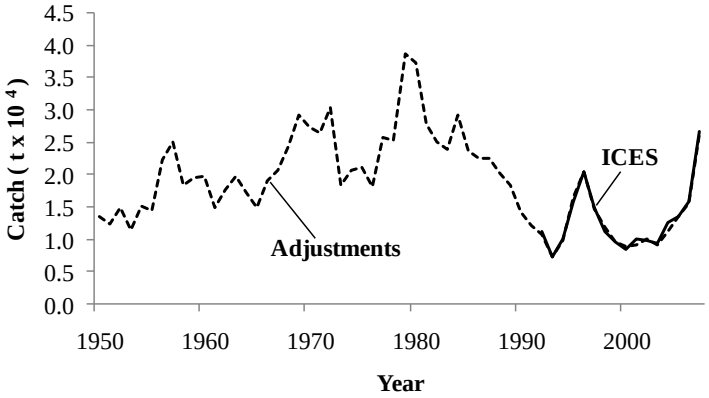

Figure 2. ICES landings statistics and Adjustments to ICES landings statistics for Lithuania from 1950-2007

Looking first at the time period before ICES landing statistics were recorded independently for Lithuania, cod's adjustments to landings accounted for 58% of the total adjustments, totaling 516,305 t from 1950-1991. Adjusted herring landings contributed 19% to total adjustments, with a total of 169,874 t during the period. Adjusted sprat landings contributed 16% to total adjustments, with a total of 145,247 t from 1950-1991. Adjustments of 'others' accounted for 6% of total adjustments, with a total of 55,818 t caught over the time period. Adjustments to salmon catches contributed a negligible amount to total adjustments, with an additional 602 t added over the time period.

Table 5. Total decadal adjustments to ICES landing statistics for Lithuania (t).

Common names	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	128,240	133,780	108,550	140,662	5,905	-2,127
Herring	13,260	24,260	60,664	58,482	13,208	0
Sprat	4,810	33,270	69,288	30,112	7,767	0
Flatfishes	1,430	3,100	2,781	1,400	790	-118
Salmon	10	0	11	453	132	0
Others	20,110	3,720	11,742	20,105	143	2

From 1992-2007, there was a net -903 t of adjustments to ICES landing statistics (2,530 t added; 3,433 t subtracted). Cod had the largest adjustments with a net adjustment of -1,295 t. Flatfish had a net adjustment of 384 t, and the 'others' group and salmon had net adjustments of 4 t each. No adjustments were made to the ICES landing statistics for herring and sprat.

Unreported landings

Unallocated catches are described for some species in ICES working group reports, and form the basis of this section of our unreported landings estimates (see Methods section for details). Unreported landings are estimated to have begun following Lithuania's independence, and in 1991, estimated unreported landings were 1,195 t (Table 6). This then increased to a peak of 7,750 t in 1996, before decreasing overall to 2,660 t in 2004 (Figure 3). For the remainder of the time period, unreported landings showed an increasing trend, and ended the time period at 4,531 t. Total unreported landings from 1991-2007 were an estimated 66,322 t, or 20% of our reconstructed total from 1991-2007.

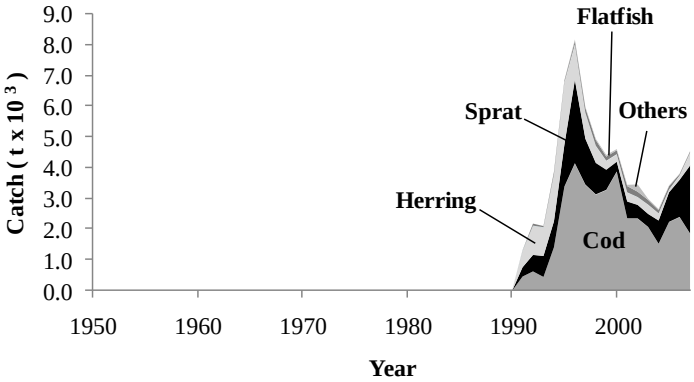

Figure 3. Lithuania's unreported landings by taxa, 1950-2007.

Cod wasthe largest contributor to unreported landings, and totaled an estimated 39,048 t from 1991-2007. It was estimated that unreported cod landings added an additional 19% of reported cod landings to our reconstruction. Starting with an estimated 466 t in 1991, unreported cod landings peaked at an estimated 4,143 t in 1996, and then decreased for the remainder of the time period, ending at 1,865 t in 2007. The next largest contribution to unreported landings was sprat, which totaled 15,411 t from 1991-2007, or an additional 7% to reported landings. Unreported sprat landings were estimated to have been 258 t in 1991, increasing to 2,440 t in 1996, decreasing at the end of the 1990s, and then showed an increasing trend for the rest of the time period, with 2,211 t in 2007. Unreported herring landings were estimated to have contributed the third greatest amount to overall unreported landings, with an estimated total of 9,547 t for the time series, or an additional 5% of reported landings. In 1991, estimated unreported herring landings were 455 t, and this increased to a peak of 1,793t in 1995. Following this, unreported herring landings decreased to a low of 84 t in 2005, and ended the time period at 402 t. Unreported flatfish landings contributed 1,663t to the total over the time period (an additional 1% on top of reported landings), with a maximum annual catch of 191 t in 2001. Unreported landings of 'others' contributed 669 t, or an additional 1% of reported landings. Unreported salmon catches were an estimated 23 t, or an additional 0.01% of reported landings.

Table 6. Decadal totals of the estimated unreported landings for Lithuania (t).

Common name	1950-1989	1990-1999	2000-2007
Cod	0	20,357	18,691
Herring	0	7,689	1,858
Sprat	0	8,591	6,819
Flatfishes	0	745	918
Salmon	0	17	6
Others	0	204	427

[a] assumption based.

Discards

Discards are comprised of four components (ghostfishing, underwater discards, boat-based discards and seal-damaged discards; for details see Methods section). Discards were estimated to be 496 t at the beginning of the time series, and until 1967 averaged 671 t annually (with a peak of 932 t in 1957; Figure 4). This then increased during the following time period, to an average of 1,084 t annually from 1967-1994 (with a peak of 1,595 t in 1979). For the remainder of the time series, the annual discards averaged 2,038 t annually (with a peak of 2,462 t in 1996). Over the entire time series, discards totaled approx. 68,000 t (Table 7).

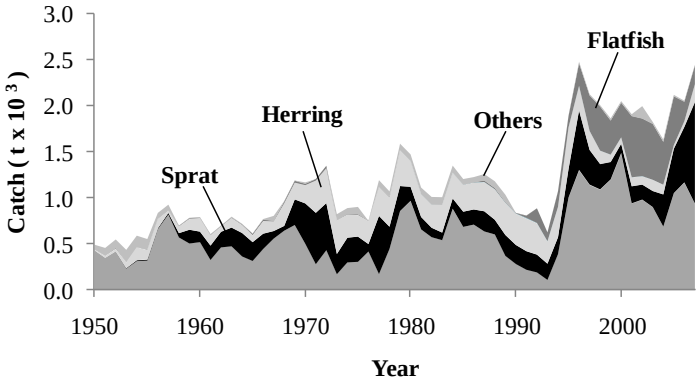

Figure 4. Lithuania's discards by taxa, 1950-2007.

The largest contributor to overall discards was cod, with an estimated total of 35,400 t from 1950-2007, which is an average discard rate of 5.8%. Cod discards were estimated to be 434 t in 1950, and fluctuated below 1,000 t until 1995 (average cod discards for the period 1950-1994, were 477 t·year^{-1}).

Cod discards were estimated to have risen to 1,488 t in 2000, and from 1995-2007, average cod discards were estimated at 1,072 t·year^{-1}. The next largest contributors to discards were sprat and herring, with totals of 12,705 t and 11,306 t respectively, over the entire time series. Herring and sprat discards rates averaged approximately 5%.

Table 7. Decadal totals of the estimated discards for Lithuania (t).

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	4,681	4,883	3,962	6,685	6,993	8,184
Herring	663	1,213	3,033	2,924	2,688	785
Sprat	241	1,664	3,464	1,506	2,688	3,146
Flatfishes	52	113	102	51	2,027	3,686
Salmon	0	0	0	17	20	6
Others	734	136	429	734	93	266

Sprat discards were estimated at 3 t in 1953, and increased to an average annual discard rate of 232 t·year^{-1} (with a peak value of 1,098 t in 2007). Herring discards were estimated at 9 t in 1950, and averaged 196 t annually throughout the time series (with a peak of 454 t in 1995).

Flatfish discards contributed the next largest amount to the total, with an estimated 6,030 t over the time series. The discard rate for flatfish is the highest out of all the species categories, with an average discard rate of 29%. Flatfish discards were estimated to have been 5 t in 1950 and averaged approximately 8 t annually from 1950-1990. For 1991-2007, average annual flatfish discards rose to an estimated 339 t (range from 26 t in 1991, to 667 t in 2001).

'Others' discards were an estimated 2,395 t over the time period, with an average discard rate of 4%. Salmon discards are estimated to have totaled 43 t over the time period, with an average discard rate of 6%.

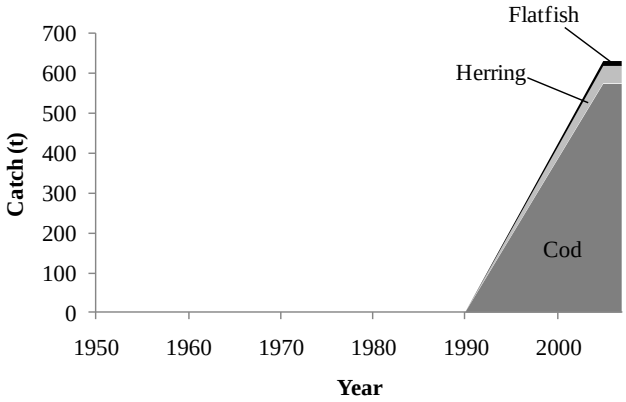

Figure 5. Lithuania's recreational catches by taxa from 1950-2007.

Recreational catches

It is assumed that there were no recreational catches in Lithuania prior to 1991. In 1991, the total recreational catch was approximately 42 t (Figure 5; Table 8), then increased to 633 t in 2005 and remained stable at this value for the rest of the time period. The total recreational catch for the time period was estimated to be 6,326 t. Cod was the most important species targeted in the recreational fishery, and contributed 5,756 t, or 91% of the recreational catch total. The species with the next largest recreational catch was herring, with a total of 447 t, followed by flatfish with a catch of 123 t for the time period.

Table 8. Decadal totals of the estimated recreational catch for Lithuania (t).

Common name	1950-1989	1990-1999	2000-2007
Cod	0	1,727	4,029
Herring	0	134	313
Flatfishes	0	37	86
Salmon	0	0	0
Others	0	0	0

Total Reconstructed Catches

The total reconstructed catch was estimated to be 14,016 t in 1950, and showed an increasing trend to a peak of 40,383 t in 1979. Following this there was a decreasing trend to 9,896 t in 1993, a large peak of 31,021 t in 1996, and another increase at the end of the time period to 33,911 t in 2007. Total reconstructed catches from 1950-2007 were estimated to be 1,243,301 t (Figure 6; Table 9; see Appendix Table A1 for complete time series data on all additions to catch by taxonomic group). ICES landing statistics report 206,850 t of catches from 1992-2007. Our total reconstructed catch for the same time period is 306,287 t, an increase of 48%. In all of the components of the adjustments for this reconstruction, cod catches contributed the most, followed by sprat and herring.

A total of 72% of our reconstructed time series is due to adjustments to ICES landing statistics, the majority of that to disaggregate Lithuania's catches from the USSR from 1950-1991. Discards accounted for 5% of our total reconstructed time series data. Unreported and recreational catches accounted for 21% and 2% of our reconstructed catch from 1991-2007 (the period that they are estimated to have been operating during).

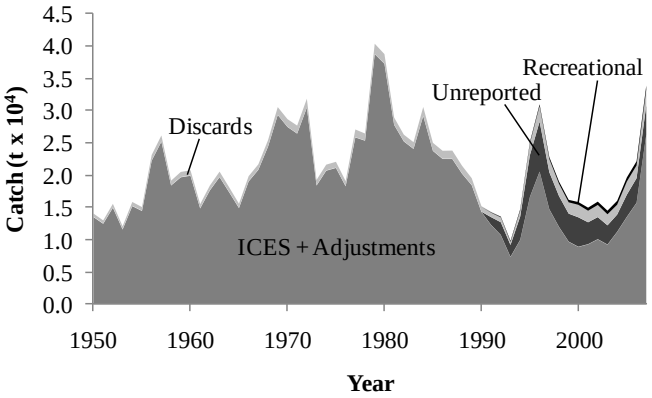

Figure 6. Total reconstructed catch by component for Lithuania from 1950-2007.

Cod contributed the most to the reconstructed catch, approximately 52%, with an estimated total of 648,359 t from 1950-2007. Cod catches were estimated to be 12,324 t in 1950, and had peaks of over 20,000 t in 1957, 1969, 1979, 1980, and 1984. Between these peaks, reconstructed cod catches averaged 11,233 t·year^{-1} from 1950-1956, increased to 13,580 t·year^{-1} from 1958-1968, decreased to 9,784 t·year^{-1} from 1970-1978, remained high from 1981-1983 at 16,663 t·year^{-1}, and finally showed a decreasing trend from 1985-2007 with an average 7,083 t·year^{-1}.

Table 9. Total catch (tonnes) by decade by each component of catch reconstruction.

Component	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
ICES landing statistics	n/a	n/a	n/a	n/a	100,313	106,537
Adjustments to ICES	167,860	198,130	253,036	251,214	27,944	-2,243
Unreported	0	0	0	0	37,603	28,719
Discards	6,371	8,008	10,990	11,915	14,508	16,069
Recreational	n/a	n/a	n/a	n/a	1,898	4,428
Total reconstructed	174,231	206,138	264,026	263,026	182,266	153,511

Sprat contributed the next largest amount to the reconstructed catch, approximately 22%, with an estimated total of 266,796 t from 1950-2007. Sprat is estimated to not have been caught by Lithuania until 1953, when 63 t were reported. Sprat catches throughout the time period had periods of higher and lower catches. Periods with lower catches (< 5,000 t) include 1953-1968 with average catches of 2,136 t·year^{-1}, 1980-1994 with average catches of 3,436 t·year^{-1}, and 1999-2003 with average catches of 3,398 t·year^{-1}. Periods with higher catches (with peaks over 5,000 t) include 1969-1979 with average catches of 7,142 t·year^{-1}, 1995-1998 with average catches of 8,414 t·year^{-1}, and 2004-2007 with average catches of 13,263 t·year^{-1}.

Total herring catches were almost as high as sprat catches – approximately 19% of the total reconstructed catch, with an estimated 237,872 from 1950-2007. Herring catches are estimated to have been 179 t in 1950, and continued with an average 2,072 t·year^{-1} from 1950-1970. For 1971-1996, average catches increased to 6,517 t·year^{-1}, with peaks of 7,928 t in 1972, 8,250 t in 1979, and 9,308 t in 1995. From 1997-2007, the average annual catches decreased to approx. 2,350 t.

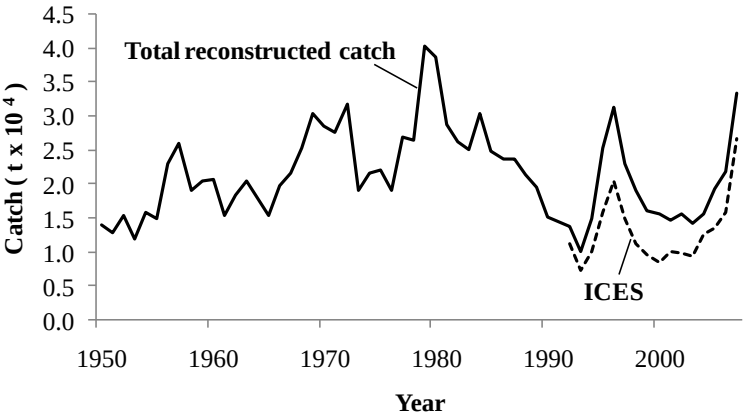

Figure 7. Total reconstructed catch for Lithuania from 1950-2007 and ICES landings statistics from 1991-2007.

Catches of species in the 'Others' category contributed the fourth highest amount to the total reconstructed catch, approximately 5%, with an estimated 62,693 t from 1950-2007. From 1950-1957 average catches were 2,561 t·year^{-1}, and then decreased from 1958-1972 to an average catch of 315 t·year^{-1}, with a peak of 1,586 t in 1967. 'Others' catches increased again from 1973-1989, when average catches were

1,911 t·year^{-1}, with a low of 3 t in 1976. For the remainder of the time period, catches decreased to 279 t·year^{-1}, although with a peak of 1,865 t in 2002.

Flatfish catches contributed approximately 2% to the reconstructed catch, with a total of 26,811 t from 1950-2007. From 1950-1995, average flatfish catches were estimated to be 243 t·year^{-1}, with a peak of 757 t in 1972. Catches increased in the latter part of the time series, and were on average 1,312 t·year^{-1} from 1996-2007, with a peak of 2,007 t in 2001.

Table 10. Decadal totals of the estimated total reconstructed catch for Lithuania (t).

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	132,921	138,663	112,512	147,346	61,092	55,825
Herring	13,923	25,473	63,697	61,406	56,575	16,798
Sprat	5,051	34,934	72,752	31,618	56,453	65,990
Flatfishes	1,482	3,213	2,883	1,451	6,564	11,218
Salmon	10	0	11	470	236	42
Others	20,844	3,856	12,171	20,839	1,346	3,638

Salmon catches made the smallest contribution to overall reconstructed catch, approximately 0.1%, or 769 t from 1950-2007. Catches were sporadic until 1979, with up to 10 t in 1955 but zero for the majority of years. From 1979-2007 average salmon catches were an estimated 26 t·year^{-1}.

DISCUSSION

Lithuania's total catches from the Baltic Sea from 1950-2007, as estimated in our reconstruction, were approximately 1.2 million t. For the period 1992-2007, ICES on behalf of Lithuania reported a total of approximately 200,000 t, since prior to 1990 Lithuania's landings were reported as part of the USSR's landings. Over the time period 1992-2007, our reconstructed catch was approximately 300,000 t, an increase of 48%. The IUU component that had that greatest contribution to the reconstruction was adjustments to ICES landing statistics (approximately 70%), mainly during the period that ICES landing statistics were not recorded independently for Lithuania (1950-1991).

Unreported landings contributed approximately 21% to our reconstructed catch from the time they are estimated to have begun in 1991 to 2007. The largest contribution to unreported landings was cod, with an estimated 40,000 t during that time period (and added 19% to estimated commercial landings). Discards are assumed to have been occurring throughout the entire time period at an average rate of 5%. Due to cod having the highest landings, they also have the highest discards, approximately 35,000 t; however, flatfish have the highest discard rate at 29%. Recreational catches contributed approximately 6,300 t for the 1991-2007 time period.

Our reconstruction of Lithuania's fisheries catches from the Baltic Sea most likely represents a conservative estimate, because, other than unreported landings of cod, we were using Baltic-wide estimates. Our rates of unreported cod landings were estimated by the Latvian Fish Resource Agency (LATFRA), and extended to apply to Lithuania. This led to a better region-specific estimate, and is approximately 35% higher than the ICES reported estimate (of unreported catches of eastern cod stock) based on Baltic-wide data. For all other species (except salmon, which we derived from ICES stock assessment working group data), we used ICES data, but these should be seen as minimum estimates (leading to a conservative reconstruction), as it is known that not all countries report IUU estimates to ICES, yet the total is given as a Baltic-wide average. Although we have corrected for the estimates of unreported landings for countries that are known to not submit estimates to ICES (e.g. Sweden, Persson, this volume), it is probable that other countries do not report estimates of these catches to ICES either. This uncertainty is due to confidentiality agreements that prevent disclosure of information related to which countries are reporting IUU and discard data, and what those values are. However, there is still a way of improving the quality of data on IUU catches while maintaining the confidentiality clause; this could be achieved by reporting the amount of IUU and discards, and the proportion of Baltic-wide landings that they relate to. The total landings by the countries that do not report estimates of these values could be reported separately, but still anonymously. This would allow for a better representation of the resources being exploited, and allow for more accurate extrapolation to cover the entire Baltic fishery.

This lack of transparency about which countries collect and report IUU and discard data makes it difficult to estimate in a statistically robust manner the amount of IUU catches. However, our conservative

estimates are better than using the alternative assumption of zero catches for IUU components. Three basic ways have been identified to change the current system to a more transparent one (Veem *et al.*, 2009). The first regards the fact that due to the confidentiality clause, information on which countries report IUU and discard data is not available to the public or to other researchers. One of the few legitimate reasons a country could have for not reporting this data is a lack of resources. Limited resources may be one of the reasons for countries not collecting this data, therefore the establishment of an EU Baltic-wide protocol to help countries that currently lack an information collection system. The second area that requires greater transparency is the decision-making process and the allocation of TACs. Significant energy and resources are spent on ICES stock assessments, with the goal of presenting science-based recommendations to the EU council (prior to 2005 these were given to the International Baltic Sea Fishery Commission) on biologically 'safe' levels of exploitation of Baltic Sea stocks, yet this advice is frequently over-ridden and in the past has contributed to the decline of many stock's abundance (Aps *et al.*, 2007; Cardinale and Svedäng, 2008). The third way that transparency could be increased is to make the reasons and results of decision making available to the public (and scientific community). As fisheries are a public resource, catch information should be easily accessible to the general public (in addition to the agreements that govern their exploitation).

Many of the stocks throughout the world are classified as over-fished or depleted; in a recent study it was found that over half of the 232 populations in the study had exhibited declines of 80% or more (Hutchings and Reynolds, 2004). However, it is a risky endeavor to wait until stocks have become depleted to introduce measures that attempt to allow stocks to recover. In fact, there is still much to be discovered about what factors determine how long marine fish populations will take to recover, and some studies have shown that the only thing that is within human's ability to control, fishing pressure, may not be enough to facilitate recovery of collapsed or severely depleted stocks (Hutchings and Reynolds, 2004). The most prudent course of action, following the precautionary principle, is not to allow stocks to become severely depleted by setting sustainable TACs, and ensuring that fishing vessels are complying with the regulations. The only way to ensure that fishing operations are in compliance is with 100% on-board observer (or video) coverage (Branch, 2006) and with constant satellite Vessel Monitoring Systems (VMS; Veem *et al.*, 2009).

Many countries, including Lithuania, could improve the knowledge of stocks in their area by monitoring and reported data from their recreational fisheries. Very little information was found regarding recreational fisheries in Lithuania, and this lack of knowledge prevents a true assessment of this sector's impacts. Consistent monitoring of recreational fisheries would help determine levels of fishing mortality, and could provide information on possible conservation measures that should be taken to ensure that future generations can enjoy recreational fishing.

Our catch reconstruction for Lithuania, though likely a conservative estimate of true catches, is still more accurate than the current assumption of zero catch when no "hard" data are available. This method of reconstruction, accounting comprehensively for IUU, been used successfully elsewhere (Zeller *et al.*, 2006; Zeller *et al.*, 2007; Zeller and Pauly, 2007). A more complete analysis of the true level of exploitation occurring in the Baltic Sea will better our understanding of resource use and together with more transparent decision making processes, regulatory legislation, and shareholder compliance, ensure that the fish stocks in the Baltic Sea will continue to support local fishing activities for Lithuanians.

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APPENDIX A

Appendix Table A1. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for Lithuania (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	13,520	0	496	0	14,016
1951	N/A	12,490	0	461	0	12,951
1952	N/A	14,970	0	553	0	15,523
1953	N/A	11,600	0	440	0	12,040
1954	N/A	15,220	0	595	0	15,815
1955	N/A	14,470	0	558	0	15,028
1956	N/A	22,270	0	842	0	23,112
1957	N/A	25,210	0	932	0	26,142
1958	N/A	18,420	0	703	0	19,123
1959	N/A	19,690	0	790	0	20,480
1960	N/A	19,930	0	797	0	20,727
1961	N/A	14,860	0	613	0	15,473
1962	N/A	17,660	0	704	0	18,364
1963	N/A	19,720	0	801	0	20,521
1964	N/A	17,340	0	723	0	18,063
1965	N/A	14,920	0	618	0	15,538
1966	N/A	19,050	0	776	0	19,826
1967	N/A	20,850	0	810	0	21,660
1968	N/A	24,450	0	972	0	25,422
1969	N/A	29,350	0	1,195	0	30,545
1970	N/A	27,500	0	1,174	0	28,674
1971	N/A	26,460	0	1,209	0	27,669
1972	N/A	30,490	0	1,352	0	31,842
1973	N/A	18,410	0	828	0	19,238
1974	N/A	20,717	0	895	0	21,612
1975	N/A	21,141	0	907	0	22,048
1976	N/A	18,293	0	756	0	19,049
1977	N/A	25,872	0	1,198	0	27,070
1978	N/A	25,365	0	1,075	0	26,440
1979	N/A	38,788	0	1,595	0	40,383
1980	N/A	37,294	0	1,479	0	38,773
1981	N/A	27,811	0	1,118	0	28,929
1982	N/A	25,248	0	1,016	0	26,264
1983	N/A	24,086	0	1,013	0	25,099
1984	N/A	29,202	0	1,356	0	30,558
1985	N/A	23,785	0	1,210	0	24,995
1986	N/A	22,533	0	1,231	0	23,764
1987	N/A	22,530	0	1,265	0	23,795
1988	N/A	20,259	0	1,187	0	21,446
1989	N/A	18,466	0	1,040	0	19,506
1990	N/A	14,323	0	842	0	15,165
1991	N/A	12,281	1,195	806	42	14,324
1992	11,217	-485	1,958	875	84	13,649
1993	7,273	66	1,821	610	127	9,896
1994	9,975	1	3,591	1,061	169	14,796
1995	15,751	884	6,464	1,879	211	25,189
1996	20,470	86	7,750	2,462	253	31,021
1997	14,824	-93	5,730	2,115	295	22,871
1998	11,105	881	4,772	1,999	337	19,094
1999	9,698	0	4,322	1,860	380	16,260
2000	8,456	444	4,550	2,052	422	15,923
2001	10,024	-725	3,382	1,908	464	15,053
2002	9,906	168	3,408	1,998	506	15,986
2003	9,415	-169	2,963	1,829	548	14,586
2004	12,625	-1,407	2,660	1,641	590	16,109
2005	13,547	-5	3,423	2,127	633	19,725
2006	15,821	-100	3,802	2,063	633	22,219
2007	26,743	-449	4,531	2,453	633	33,911

Appendix Table A2. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for cod (*Gadus morhua*) for Lithuania (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	11,890	0	434	0	12,324
1951	N/A	9,690	0	354	0	10,044
1952	N/A	11,630	0	424	0	12,054
1953	N/A	6,610	0	241	0	6,851
1954	N/A	8,820	0	322	0	9,142
1955	N/A	8,960	0	327	0	9,287
1956	N/A	18,260	0	666	0	18,926
1957	N/A	22,570	0	824	0	23,394
1958	N/A	15,800	0	577	0	16,377
1959	N/A	14,010	0	511	0	14,521
1960	N/A	14,410	0	526	0	14,936
1961	N/A	9,150	0	334	0	9,484
1962	N/A	12,870	0	470	0	13,340
1963	N/A	13,180	0	481	0	13,661
1964	N/A	10,190	0	372	0	10,562
1965	N/A	8,860	0	323	0	9,183
1966	N/A	12,390	0	452	0	12,842
1967	N/A	15,460	0	564	0	16,024
1968	N/A	17,800	0	650	0	18,450
1969	N/A	19,470	0	711	0	20,181
1970	N/A	13,940	0	509	0	14,449
1971	N/A	7,910	0	289	0	8,199
1972	N/A	12,040	0	439	0	12,479
1973	N/A	4,950	0	181	0	5,131
1974	N/A	8,443	0	308	0	8,751
1975	N/A	8,598	0	314	0	8,912
1976	N/A	11,650	0	425	0	12,075
1977	N/A	4,999	0	182	0	5,181
1978	N/A	12,428	0	454	0	12,882
1979	N/A	23,592	0	861	0	24,453
1980	N/A	26,621	0	972	0	27,593
1981	N/A	18,184	0	664	0	18,848
1982	N/A	15,874	0	579	0	16,453
1983	N/A	14,139	0	547	0	14,686
1984	N/A	19,227	0	886	0	20,113
1985	N/A	12,900	0	690	0	13,590
1986	N/A	11,736	0	715	0	12,451
1987	N/A	9,386	0	642	0	10,028
1988	N/A	8,044	0	610	0	8,654
1989	N/A	4,551	0	379	0	4,930
1990	N/A	3,208	0	291	0	3,499
1991	N/A	1,865	466	228	38	2,598
1992	2,141	-875	633	200	77	2,176
1993	574	31	454	119	115	1,293
1994	1,886	1	1,415	397	154	3,853
1995	3,629	884	3,385	1,008	192	9,097
1996	5,520	4	4,143	1,305	230	11,202
1997	4,694	-93	3,451	1,147	269	9,467
1998	3,296	880	3,132	1,095	307	8,710
1999	4,371	0	3,278	1,202	345	9,197
2000	4,721	444	3,874	1,488	384	10,910
2001	3,852	-715	2,353	945	422	6,857
2002	2,964	173	2,353	985	461	6,936
2003	2,900	-133	2,075	905	499	6,246
2004	3,382	-1,341	1,531	694	537	4,803
2005	2,993	-5	2,241	1,055	576	6,859
2006	3,301	-101	2,400	1,171	576	7,347
2007	2,935	-449	1,865	942	576	5,868

Appendix Table A3. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for herring (*Clupea harengus*) for Lithuania (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	170	0	9	0	179
1951	N/A	400	0	20	0	420
1952	N/A	520	0	26	0	546
1953	N/A	1,190	0	60	0	1,250
1954	N/A	2,750	0	138	0	2,888
1955	N/A	2,020	0	101	0	2,121
1956	N/A	2,010	0	101	0	2,111
1957	N/A	530	0	27	0	557
1958	N/A	1,380	0	69	0	1,449
1959	N/A	2,290	0	115	0	2,405
1960	N/A	2,860	0	143	0	3,003
1961	N/A	2,130	0	107	0	2,237
1962	N/A	1,080	0	54	0	1,134
1963	N/A	2,010	0	101	0	2,111
1964	N/A	1,650	0	83	0	1,733
1965	N/A	1,430	0	72	0	1,502
1966	N/A	2,650	0	133	0	2,783
1967	N/A	2,000	0	100	0	2,100
1968	N/A	4,840	0	242	0	5,082
1969	N/A	3,610	0	181	0	3,791
1970	N/A	3,920	0	196	0	4,116
1971	N/A	6,950	0	348	0	7,298
1972	N/A	7,550	0	378	0	7,928
1973	N/A	7,240	0	362	0	7,602
1974	N/A	4,969	0	248	0	5,217
1975	N/A	4,630	0	232	0	4,862
1976	N/A	4,927	0	246	0	5,173
1977	N/A	6,300	0	315	0	6,615
1978	N/A	6,320	0	316	0	6,636
1979	N/A	7,858	0	393	0	8,251
1980	N/A	5,651	0	283	0	5,934
1981	N/A	4,933	0	247	0	5,180
1982	N/A	4,962	0	248	0	5,210
1983	N/A	5,967	0	298	0	6,265
1984	N/A	5,613	0	281	0	5,894
1985	N/A	5,810	0	291	0	6,101
1986	N/A	5,804	0	290	0	6,094
1987	N/A	6,280	0	314	0	6,594
1988	N/A	6,547	0	327	0	6,874
1989	N/A	6,915	0	346	0	7,261
1990	N/A	6,708	0	335	0	7,043
1991	N/A	6,500	455	348	3	7,306
1992	5,768	0	808	329	6	6,910
1993	3,775	0	766	227	9	4,777
1994	4,988	0	1,342	316	12	6,658
1995	7,058	0	1,793	443	15	9,308
1996	4,257	0	1,022	264	18	5,561
1997	3,330	0	749	204	21	4,304
1998	2,368	0	497	143	24	3,032
1999	1,313	0	257	79	27	1,676
2000	1,198	0	217	71	30	1,515
2001	1,639	0	274	96	33	2,041
2002	1,539	0	234	89	36	1,897
2003	2,109	0	289	120	39	2,557
2004	1,845	0	227	104	42	2,217
2005	748	0	84	42	45	918
2006	1,172	0	131	65	45	1,413
2007	3,592	0	402	200	45	4,239

Appendix Table A4. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for sprat (*Sprattus sprattus*) for Lithuania (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	0	0	0	0	0
1951	N/A	0	0	0	0	0
1952	N/A	0	0	0	0	0
1953	N/A	60	0	3	0	63
1954	N/A	150	0	8	0	158
1955	N/A	190	0	10	0	200
1956	N/A	180	0	9	0	189
1957	N/A	350	0	18	0	368
1958	N/A	920	0	46	0	966
1959	N/A	2,960	0	148	0	3,108
1960	N/A	2,260	0	113	0	2,373
1961	N/A	3,080	0	154	0	3,234
1962	N/A	3,350	0	168	0	3,518
1963	N/A	4,030	0	202	0	4,232
1964	N/A	5,050	0	253	0	5,303
1965	N/A	4,040	0	202	0	4,242
1966	N/A	3,290	0	165	0	3,455
1967	N/A	1,620	0	81	0	1,701
1968	N/A	1,020	0	51	0	1,071
1969	N/A	5,530	0	277	0	5,807
1970	N/A	8,710	0	436	0	9,146
1971	N/A	11,070	0	554	0	11,624
1972	N/A	10,160	0	508	0	10,668
1973	N/A	4,330	0	217	0	4,547
1974	N/A	5,302	0	265	0	5,567
1975	N/A	5,428	0	271	0	5,699
1976	N/A	1,591	0	80	0	1,671
1977	N/A	12,520	0	626	0	13,146
1978	N/A	4,766	0	238	0	5,004
1979	N/A	5,411	0	271	0	5,682
1980	N/A	3,039	0	152	0	3,191
1981	N/A	2,671	0	134	0	2,805
1982	N/A	2,028	0	101	0	2,129
1983	N/A	1,624	0	81	0	1,705
1984	N/A	2,210	0	111	0	2,321
1985	N/A	3,279	0	164	0	3,443
1986	N/A	3,266	0	163	0	3,429
1987	N/A	4,348	0	217	0	4,565
1988	N/A	3,159	0	158	0	3,317
1989	N/A	4,488	0	224	0	4,712
1990	N/A	4,085	0	204	0	4,289
1991	N/A	3,682	258	197	0	4,137
1992	3,279	0	459	187	0	3,925
1993	2,779	0	564	167	0	3,510
1994	2,789	0	750	177	0	3,716
1995	4,799	0	1,219	301	0	6,319
1996	10,165	0	2,440	630	0	13,235
1997	6,018	0	1,354	369	0	7,741
1998	4,460	0	937	270	0	5,666
1999	3,117	0	611	186	0	3,914
2000	1,682	0	304	99	0	2,086
2001	3,135	0	524	183	0	3,841
2002	2,800	0	426	161	0	3,387
2003	3,032	0	415	172	0	3,620
2004	6,185	0	761	347	0	7,293
2005	8,635	0	967	480	0	10,082
2006	10,814	0	1,211	601	0	12,626
2007	19,745	0	2,211	1,098	0	23,054

Appendix Table A5. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for salmon (*Salmo salar*) for Lithuania (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	0	0	0	0	0
1951	N/A	0	0	0	0	0
1952	N/A	0	0	0	0	0
1953	N/A	0	0	0	0	0
1954	N/A	0	0	0	0	0
1955	N/A	10	0	0	0	10
1956	N/A	0	0	0	0	0
1957	N/A	0	0	0	0	0
1958	N/A	0	0	0	0	0
1959	N/A	0	0	0	0	0
1960	N/A	0	0	0	0	0
1961	N/A	0	0	0	0	0
1962	N/A	0	0	0	0	0
1963	N/A	0	0	0	0	0
1964	N/A	0	0	0	0	0
1965	N/A	0	0	0	0	0
1966	N/A	0	0	0	0	0
1967	N/A	0	0	0	0	0
1968	N/A	0	0	0	0	0
1969	N/A	0	0	0	0	0
1970	N/A	0	0	0	0	0
1971	N/A	0	0	0	0	0
1972	N/A	0	0	0	0	0
1973	N/A	0	0	0	0	0
1974	N/A	6	0	0	0	6
1975	N/A	1	0	0	0	1
1976	N/A	0	0	0	0	0
1977	N/A	0	0	0	0	0
1978	N/A	0	0	0	0	0
1979	N/A	4	0	0	0	4
1980	N/A	33	0	1	0	34
1981	N/A	36	0	1	0	37
1982	N/A	30	0	1	0	31
1983	N/A	33	0	1	0	34
1984	N/A	43	0	2	0	45
1985	N/A	41	0	1	0	42
1986	N/A	57	0	2	0	59
1987	N/A	62	0	2	0	64
1988	N/A	48	0	2	0	50
1989	N/A	70	0	3	0	73
1990	N/A	66	0	2	0	68
1991	N/A	62	4	5	0	71
1992	20	0	3	3	0	25
1993	15	0	3	3	0	21
1994	5	0	1	1	0	7
1995	2	0	0	0	0	3
1996	10	4	3	3	0	20
1997	4	0	1	1	0	6
1998	5	0	1	1	0	7
1999	6	0	1	1	0	8
2000	6	0	1	1	0	8
2001	4	0	1	1	0	6
2002	11	0	2	2	0	16
2003	3	0	1	1	0	4
2004	2	0	0	0	0	3
2005	2	0	0	0	0	3
2006	1	0	0	0	0	1
2007	1	0	0	0	0	1

Appendix Table A6. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for the category 'flatfish' for Lithuania (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	130	0	5	0	135
1951	N/A	80	0	3	0	83
1952	N/A	230	0	8	0	238
1953	N/A	110	0	4	0	114
1954	N/A	60	0	2	0	62
1955	N/A	150	0	5	0	155
1956	N/A	130	0	5	0	135
1957	N/A	130	0	5	0	135
1958	N/A	170	0	6	0	176
1959	N/A	240	0	9	0	249
1960	N/A	140	0	5	0	145
1961	N/A	110	0	4	0	114
1962	N/A	180	0	7	0	187
1963	N/A	170	0	6	0	176
1964	N/A	200	0	7	0	207
1965	N/A	420	0	15	0	435
1966	N/A	480	0	18	0	498
1967	N/A	240	0	9	0	249
1968	N/A	560	0	20	0	580
1969	N/A	600	0	22	0	622
1970	N/A	460	0	17	0	477
1971	N/A	510	0	19	0	529
1972	N/A	730	0	27	0	757
1973	N/A	80	0	3	0	83
1974	N/A	201	0	7	0	208
1975	N/A	252	0	9	0	261
1976	N/A	122	0	4	0	126
1977	N/A	99	0	4	0	103
1978	N/A	221	0	8	0	229
1979	N/A	106	0	4	0	110
1980	N/A	72	0	3	0	75
1981	N/A	49	0	2	0	51
1982	N/A	41	0	1	0	42
1983	N/A	25	0	1	0	26
1984	N/A	14	0	1	0	15
1985	N/A	32	0	1	0	33
1986	N/A	87	0	3	0	90
1987	N/A	471	0	17	0	488
1988	N/A	409	0	15	0	424
1989	N/A	200	0	7	0	207
1990	N/A	163	0	6	0	168
1991	N/A	125	9	25	1	160
1992	9	390	56	156	2	613
1993	120	35	31	93	3	282
1994	262	0	70	165	3	501
1995	194	0	49	121	4	368
1996	330	76	97	241	5	749
1997	624	0	140	380	6	1,150
1998	798	1	168	473	7	1,446
1999	629	0	123	367	7	1,127
2000	641	0	116	373	8	1,139
2001	1,155	-10	191	662	9	2,007
2002	1,100	-5	166	625	10	1,896
2003	1,115	-36	148	608	11	1,845
2004	909	-67	104	469	12	1,426
2005	967	0	108	532	12	1,620
2006	386	0	43	212	12	654
2007	373	0	42	205	12	632

Appendix Table A7. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for the category 'others' for Lithuania (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	1,330	0	49	0	1,379
1951	N/A	2,320	0	85	0	2,405
1952	N/A	2,590	0	95	0	2,685
1953	N/A	3,630	0	132	0	3,762
1954	N/A	3,440	0	126	0	3,566
1955	N/A	3,140	0	115	0	3,255
1956	N/A	1,690	0	62	0	1,752
1957	N/A	1,630	0	59	0	1,689
1958	N/A	150	0	5	0	155
1959	N/A	190	0	7	0	197
1960	N/A	260	0	9	0	269
1961	N/A	390	0	14	0	404
1962	N/A	180	0	7	0	187
1963	N/A	330	0	12	0	342
1964	N/A	250	0	9	0	259
1965	N/A	170	0	6	0	176
1966	N/A	240	0	9	0	249
1967	N/A	1,530	0	56	0	1,586
1968	N/A	230	0	8	0	238
1969	N/A	140	0	5	0	145
1970	N/A	470	0	17	0	487
1971	N/A	20	0	1	0	21
1972	N/A	10	0	0	0	10
1973	N/A	1,810	0	66	0	1,876
1974	N/A	1,796	0	66	0	1,862
1975	N/A	2,232	0	81	0	2,313
1976	N/A	3	0	0	0	3
1977	N/A	1,954	0	71	0	2,025
1978	N/A	1,630	0	59	0	1,689
1979	N/A	1,817	0	66	0	1,883
1980	N/A	1,878	0	69	0	1,947
1981	N/A	1,938	0	71	0	2,009
1982	N/A	2,313	0	84	0	2,397
1983	N/A	2,298	0	84	0	2,382
1984	N/A	2,095	0	76	0	2,171
1985	N/A	1,723	0	63	0	1,786
1986	N/A	1,583	0	58	0	1,641
1987	N/A	1,983	0	72	0	2,055
1988	N/A	2,052	0	75	0	2,127
1989	N/A	2,242	0	82	0	2,324
1990	N/A	94	0	3	0	97
1991	N/A	47	3	3	0	53
1992	0	0	0	0	0	0
1993	10	0	2	1	0	13
1994	45	0	12	5	0	62
1995	69	0	18	7	0	93
1996	188	2	46	19	0	254
1997	154	0	35	15	0	204
1998	178	0	37	17	0	232
1999	262	0	51	25	0	338
2000	208	0	38	19	0	265
2001	239	0	40	22	0	301
2002	1,492	0	227	136	0	1,854
2003	256	0	35	23	0	314
2004	302	1	37	27	0	367
2005	202	0	23	18	0	242
2006	147	1	17	13	0	178
2007	97	0	11	9	0	116

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

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ABSTRACT

Total marine fisheries catches in the Baltic Sea by Poland were estimated from 1950-2007 using a method called 'catch reconstruction'. Using ICES landing statistics (which have included Polish catches since 1955) as our reported data baseline, we created a more comprehensive catch-data time-series that accounts for 'adjustments to ICES landing statistics' (from sources such as ICES working group stock assessment reports and the Polish Maritime Industry), unreported ('unallocated') landings, discards, and recreational catches. ICES attributes approximately 7 million tonnes of fish to Poland from 1950-2007, our reconstruction for the same time period estimated 9.5 million tonnes, an increase of 35%. Unreported landings of cod (*Gadus morhua*) seem to be a major problem in Poland, and our reconstruction estimates almost 1 million tonnes landed illegally between 1990 and 2007. Despite this, we still believe this reconstruction remains a conservative estimate of the true rate of marine resource exploitation by Poland in the Baltic Sea. Baltic Sea fish stocks have shown significant changes since 1950, and strategies such as increased data collection to include all fishery sectors, increased accountability and transparency at the decision-making level in an ecosystem-based management context, and increased compliance with fishing restrictions, would all increase the chances of the stocks' recovery.

INTRODUCTION

Poland is located on the south coast of the Baltic Sea (Figure 1) with a total land area of 312,679 km and a population of approximately 38 million (Anon., 2009a). The capital city, Warsaw, is situated near the centre of the country, about 450km from the coast. Poland is bordered by Germany to the west, the Czech Republic and Slovakia to the south, and Ukraine, Belarus, Russia and Lithuania to the east (Figure 1). After WWII, Poland was aligned with the Eastern Bloc. In 1989, the country transformed to a free market economy, completing its economic transition by joining the European Union (EU) in 2004. Poland is considered the most successful post-communist country in eastern Europe, with an annual economic growth rate of over 6.0% (Ram, 2007). Fisheries have never contributed significantly to the economy, but the industry is deemed important to the social fabric, especially in coastal areas (FAO, 2007). There are three main sectors: 1) deep-sea trawlers; 2) cutter fisheries; and 3) coastal boat

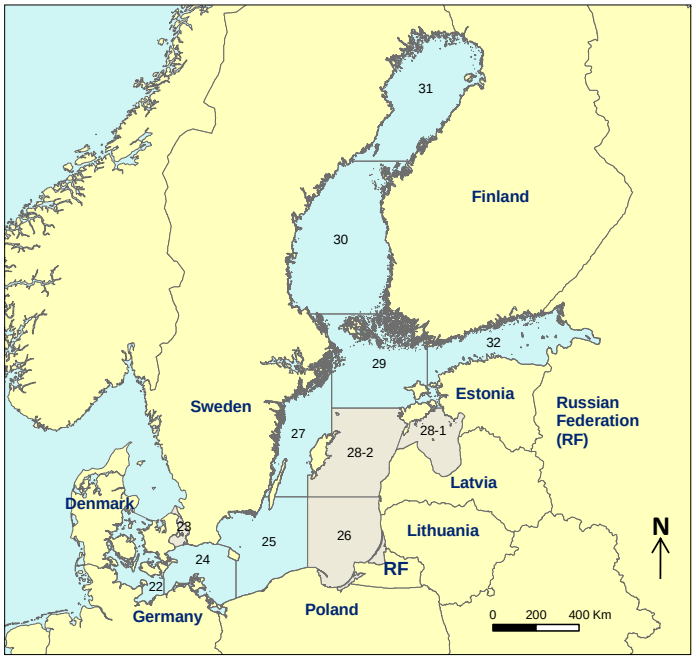

Figure 1. Map of the Baltic Sea with ICES subdivisions and surrounding countries. Poland's coastline borders ICES subdivisions 24, 25 and 26.

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fisheries. Deep-sea trawlers operate exclusively in the north Atlantic, east Atlantic, and Antarctic. Cutter vessels contribute approximately 88% of Polish reported landings in the Baltic, with coastal vessels (considered artisanal) contributing the remaining 12%. This report will address only those catches of coastal, cutter, and recreational fisheries in the Baltic, which operate mainly in ICES sub-divisions 24-26 (Figure 1).

Overall, Poland obtains more than 80% of its reported landings from the Baltic (Anon., 2008). According to the International Council for the Exploration of the Sea (ICES, 2009a), Poland's landings are mainly comprised of three species: sprat (*Sprattus sprattus*); herring (*Clupea harengus*); and cod (*Gadus morhua*). Overall, Poland's landings increased steadily from the 1950s-1970s, experienced a brief decline through privatization of the industry in the 1990s, and increased slightly in the early 2000s.

Table 1. ICES divisions and corresponding subdivisions representing the Danish Sound, Belt and Baltic Sea. Source: (ICES, 1987).

ICES Division	ICES Subdivision
IIIb- Sound	23
IIIc- Belt Sea	22
IIId- Baltic Sea	24-32

Since Poland joined the EU in 2004, landings have declined overall for a number of reasons. These include the EU fleet capacity reduction programme, rising fuel costs, falling fish prices and decreasing shares of EU Total Allowable Catches (TACs) for cod; Poland's most economically important species. Since 2004, the entire Baltic fleet has been reduced from 1,374 vessels, to 866 vessels (Anon., 2006b; 2008). In 2005, reported landings of the cutter fleet consisted predominantly of sprat (68%), herring (17%), and cod (11%; FAO, 2009) which were caught with gillnets, hooks and trawls. Boats of the coastal fleet are generally less than 15 m, and primarily use gillnets within 12 nautical miles of the shore. The reported landings of these vessels in 2005 were cod (28%), flatfishes (27%), and herring (22%; FAO, 2009). Poland has a flounder-directed (*Platichthys flesus*) gillnet fishery which operates predominantly within ICES sub-division 25 (Figure 1; ICES, 2005b).

Historically, all Polish landings were reported from ICES division IIId (prior to 1980). In 1978, reporting by ICES subdivision was initiated in the Baltic (ICES, 1995). ICES division IIId became equivalent to ICES subdivisions 24-32, which represents the Baltic Sea (Figure 1; Table 1). ICES divisions IIIb and IIIc are equivalent to ICES sub divisions 23 and 22, respectively (Figure 1; Table 1), and are collectively known as the 'transition zone' between the Skagerrak and Baltic Sea (ICES, 1995). Since reporting by subdivision began, Poland has reported roughly equal landings from subdivisions 25 and 26 (about 45% of the Polish total in each) and a small portion (about 10%) in subdivision 24 (Table 2). In the 2000s, a very small amount of sprat was reported from subdivisions 27, 28 and 29 (Table 2).

Table 2. Percent distribution of Poland's reported landings by ICES subdivision, by decade (1980-2007). Prior to 1980 all landings were reported from ICES division IIId. Data source: (ICES, 2009).

Fishing area	Reported landings (%)		
	1980-1989	1990-1999	2000-2007
ICES Division[a]			
IIId	37.0	n/a[b]	n/a[b]
ICES Subdivision			
24	6.6	9.9	8.4
25	30.7	46.1	46.7
26	25.9	44.1	44.8
27	0.0	0.0	0.03
28	0.0	0.0	0.05
29	0.0	0.0	0.03

[a] historically, landings were reported by ICES division as opposed to subdivision. In 1978, reporting began by subdivision (ICES, 1987). Consequently, some reporting in the 1980s is by division and some by subdivision. [b] not-applicable.

Sport and recreational fishing began in the late 1980s. It became more popular after 1993, when some fishers converted their commercial cutters into recreational tour boats fishing for cod (Radtke and Dabrowski, 2007). A severe lack of quantitative record exists, however a restrictive quota was created in 2004 to control angling of cod to some extent. An initiative to distribute public surveys seeks to obtain further information regarding recreational fishing activities (ICES, 2005a).

Before 1989, Poland administered the regulations of the Baltic Sea Commission (CPMR), and all fish sold on local markets were distributed through the government-owned company, Centrala Rybna. All exports and imports were managed by Rybex, which was also government-owned. Privatization of the fishing industry reduced the number of nationally owned vessels from 226 in the early 1990s, to 8 in 2006. Though privatization in the 1990s had seemingly little effect on reported landings, IUU (Illegal, Unreported and Unregulated fishing) were reportedly non-existent in Poland prior to the early 1990s

(Anon., pers. comm.).[2] Historically, fishers had strict quotas and were required to land their catches along with detailed reports at national collection points. Fishers were thus unable to sell directly to the market, which made IUU fishing unprofitable (Anon., pers. comm.). Poland joined the EU in 2004 and became subject to the rules of the Common Fisheries Policy (CFP). This included a reduction in fleet capacity and a new TAC system which consequently, made over-fishing and underreporting very economical for private fishers, and especially those targeting cod. The EU commission banned Poland from cod fishing after discovering one particular fisher had registered only 1/3 of cod landings in the first semester of 2007 (Anon., pers. comm.). The country is now being forced to make up for underreported landings with additional reductions to Poland's current share of the TAC for cod. ICES estimates underreporting in the Polish cod fishery ranges between 35-45% (Anon., pers. comm.), the World Wildlife Fund 50% (Anon., 2009b), and an estimate of more than 300% was obtained from a highly reliable anonymous source interviewed in 2008.

In the first half of the 1970s, Poland's cod fishery was one of the most important of its kind in the Baltic. Polish landings accounted for 30% of the total cod landings from the Baltic, and about 38% of these were taken from the eastern stock (Subdivisions 25-32; ICES, 1995). These stocks are now considered to be in the worst condition of any cod in the Baltic, and thus the majority of Poland's management schemes are concerned with the conservation of this species. Minimum mesh size, landing size, closed areas and seasons are being used as current management controls on cod fishing. The introduction of the Bacoma trawl in 2004 has also helped to reduce bycatch of juvenile cod (FAO, 2007). Polish fishers have displayed very strong opposition to fishing bans as well as the repercussions associated with unregulated and underreported fishing. They argue that even with increased individual fishing quotas, the reduction in fleet capacity in combination with low overall TACs for commercial species, and high fuel prices have made fishing unprofitable. Although Poland's share of EU quotas for cod have been exceeded consistently since 2004, their TACs for herring and sprat are often left unfulfilled (up to 50%). This is due to the low prices for herring and sprat in comparison to cod, as well as the increased imports from countries such as Norway. Despite these drawbacks to marine fisheries, the processing sector in Poland has grown consistently since 2004 (FAO, 2009).

The purpose of this study is to provide an estimate of Poland's total fisheries catches (in contrast to reported landings) in the Baltic Sea from 1950-2007. The 'ICES catch statistics database' provides landings data for Poland from 1955-2007 (ICES, 2009a). These data are reported landings only, with no apparent effort to fully represent the total catch (which would account for IUU as well as reported landings). Therefore, for the purposes of this report the ICES catch statistics will be referred to as ICES 'landings statistics' to better reflect the nature of the data. Estimates of IUU in this study include data source adjustments to reported landings, unreported (referred to as 'unallocated' by ICES) landings, discards, and recreational catches. Our approach utilizes previously reported data by ICES, a review of the academic and grey literature, as well as correspondence with local experts. Our correspondence with local authorities entailed high degrees of desired anonymity by those interviewed. We would like to acknowledge those who provided information despite the risks involved pertaining to job security in the politically charged atmosphere which surrounds the topic of IUU and other controversial fisheries issues.

METHODS

The 'ICES Catch Statistics database' (ICES, 2009a), is the only publicly available resource available that presents annual landings data for all taxa and all fishing areas within the Baltic Sea. For the purposes of our catch reconstruction, we referred to the ICES catch statistics as the 'ICES landings statistics', which reflects the true nature of the data presented (i.e., the database presents '*reported landings*', not total catches). Thus, ICES landings statistics provided the official baseline for our reconstruction to which 4 categories of Illegal, Unreported and Unregulated (IUU) catches were added to estimate total catch: i) '*adjustments*', being positive or negative additions to reported data, based on reputable ICES stock assessment working group data (ICES, 2009b), as well as national datasets; ii) '*unreported' landings* (referred to by ICES as 'unallocated' catches) being catches taken but not reported to officials; iii) '*discards*', being fish caught and disposed of at sea; and iv) '*recreational catches'*. Adjustments to reported landings provided the best estimate of commercial landings in Poland from 1950-2007, to which estimates of unreported landings, discards and recreational catches were added. When sufficient data to derive

[2] Many sources interviewed for or interacted with in this report expressed a strong desire to remain anonymous for personal reasons.

anchor points in specific years were unavailable, we applied the default approaches outlined in chapter 1 for former eastern bloc countries.

We created six taxonomic groups to facilitate our catch reconstruction for the main commercially targeted species including cod (eastern and western stocks), herring, sprat, and Atlantic salmon (*Salmo salar*). We also reconstructed catches specific to a group of flatfishes: plaice (*Pleuronectes platessus*); flounder; and turbot (*Psetta maxima*), as well as a miscellaneous group for all 'other' taxa.

Illegal, Unreported and Unregulated (IUU) catches

The following outlines the specific methods derived for estimating IUU in Poland to supplement officially reported landings from ICES. Adjustments were made for all species during the early 1950s using Polish national datasets that provided information to supplement many missing landings data from ICES. In later years, adjustments to cod, salmon and flatfish landings used ICES stock assessment working group data (Table 3). Unreported landings and discards were accounted for as rates (percentages), which were applied to reconstructed catches. Rates of unreported landings were applied to the sum of ICES landings statistics and adjustments, while discard rates were applied to the sum of ICES landings statistics, adjustments, and unreported landings. Recreational catches were estimated using a combination of German and Danish data. The addition of IUU to ICES landings statistics represents Poland's total marine fisheries catches from the Baltic Sea from 1950-2007.

Adjustments to ICES landings statistics

Fisheries data were extracted from the 'ICES landings statistics database' for Poland for the years 1950-2007. Data was missing for all species from 1950-1055, and salmon data were missing from 1950-1959. Preliminary adjustments consisted of adding the national data to supplement these missing records (Table 3). There were some discrepancies in groupings of taxa between the national dataset and ICES landings statistics, and therefore, 'flatfishes nei' from the Polish dataset were treated as 'flounder' (part of our flatfish group); and 'other taxa' as 'finfishes nei' which were included in our 'others' grouping (Table 3).

Table 3. Sources and time periods for which adjustments to ICES landings statistics were made in Denmark, 1950-2007.

Common name	Data source	
	National[a]	ICES stock assessment working group[b]
Sprat	1950-1954	-
Herring	1950-1954	-
Eastern cod	1950-1954	1965-2007
Western cod	-	1997-2007
Salmon	1950-1959	1998-2007
European eel	1950-1954	-
Flounder (Flatfishes nei)	1950-1954	-
Plaice	-	1970-2005
Turbot	-	1973-2005
Flounder	-	1973-1974 & 1978-2003
Others (Finfishes nei)	1950-1954	-

[a] The Polish Maritime Fish Industry Statistical database (Anon., 1989); [b] ICES stock assessment working group reports (ICES, 2007; 2008a; 2008b).

In later years, adjustments were made to cod, salmon and flatfish landings using information from ICES stock assessment working group reports (ICES, 2007; 2008a; 2008b; Table 3). To maintain a consistent and conservative approach in our reconstruction, we made adjustments in all years that data were available for cod from the ICES stock assessment working group data for Poland (Table 3). Adjustments to the ICES landings statistics of cod were based on the separately reported landings of eastern cod (Tables 2.3.1 in ICES, 2007) and western cod (Tables 2.4.1 in ICES, 2007). The reported landings of ICES were adjusted using the combined total for both cod stocks (Table 3).

Landings of salmon and flatfishes were adjusted only when a greater value was presented in the ICES stock assessment working group report (Table 3). ICES stock assessment working group data (ICES, 2008a) also allowed us to introduce a higher degree of taxonomic detail to landings of flatfishes from ICES landings statistics from 1970 to 2005. ICES stock assessment working group data present landings for turbot, plaice and flounder which when summed, were equivalent to data presented for 'flatfishes nei' in the ICES landings statistics (Table 3).

Unreported landings

Due to regulations and state control in former eastern bloc countries prior to the 1990s, a value of 0% was assigned for unreported landings between 1950 and 1990. During this time period, all landed catch had to be delivered directly to national authorities and all fish sold for a similar price. These regulations gave fishers little incentive to not report and the consequences of non-compliance were severe (Anon. pers. comm.). Therefore, we proceeded with the assumption that unreported landings were minimal prior to 1990. It is unlikely that underreporting never occurred, but information beyond this general assumption was unavailable. A possibility of state-controlled mis-reporting (potentially for strategic cold-war reasons) also remains unresolved.

Table 4. Rates (%) used as anchor points to estimate unreported landings (t) for herring based on data from the Sea Fisheries Institute in Gdynia (2005) and (2007). Interpolated values indicated by dashed line (-).

Year	Unreported landings (%)
1950-1990	0[a]
1991-1992	-
1993-2003	86[b]
2003	86
2004	113
2005	109
2006	143
2007	134

[a] assumed default value; [b] rate from 2003.

To phase in the behavior of underreporting during the transition to a market economy (with the collapse of the former eastern bloc), we performed a linear interpolation between 1990 (0%) and our first anchor point in 1993 for cod, salmon, herring, and 'others'. The category 'others' in this instance, was designated for all taxa for which species-specific information on unreported landings were unavailable (including all flatfishes). All unreported landings were estimated by applying an annual percentage to the sum of ICES landings statistics and adjustments.

Cod: According to an open letter authored in 2007/2008 by Dr. Zbigniew Karnicki, former Vice-Director of the Polish Sea Fisheries Institute (MIR, see Appendix A), beginning in the 1990s, the Polish government actively sought to subvert EU rules by encouraging industry noncompliance. Additional information, obtained from anonymous sources during interviews conducted in 2008 by the UBC Fisheries Centre, indicated that from the 1990s to the present, underreporting of cod catches has been at least 300% of reported landings. The source interviewed, who has extensive experience in fisheries issues in Poland, further stated that this value may even underestimate unreported landings in the early 1990s (Anon. pers. comm.) Therefore, a rate of 300% was assigned for the period 1993-2007. Linear interpolation was used to phase in the behavior of underreporting from 0% to 300% between 1990 and 1993.

Table 5. Anchor points (%) used for estimating unreported landings for others from 1950-2007 based on sources (Tables 2.3.1 and 2.4.1 in ICES, 2007; Table 2.1.2. in ICES, 2008a). Dashed lines (-) indicate years when linear interpolations were used.

Year	Unreported landings (%)
1950-1990	0.0
1991-1992	-
1993	20.3
1994	26.9
1995-2006	-
2007	11.2

Salmon: Records from the early 1990s indicate that at least 50% of salmon landings were unreported (ICES 2008b). Therefore, a fixed rate of 50% was applied to nominal landings in all years between 1993 and 2007 (Table 4). To account for the transition to a market economy, a linear interpolation was performed between 1990 (0%) and our first anchor point in 1993 (50%).

Herring: To determine a rate of unreported landings for herring in 1993, we used trade data (from 2003-2007) and compared imports and exports, as well as consumption and nominal landing (Anon., 2006b) and (Anon., 2008). Trade data were used as reported, without the use of product to live weight conversions due to the uncertainty of product form and to stay conservative in our estimates (W. Swartz, pers. comm., UBC Fisheries Centre). Rates of unreported landings were derived annually for the period 2003-2007. The value derived for 2003 (86%) was carried back as a fixed rate to 1993 (Table 4). We interpolated between 0% in 1990 and our first anchor point (86%) in 1993 to phase in the behavior of underreporting (Table 4).

'Others': No data pertaining to unreported landings were available for species other than cod, salmon and herring. Therefore, we estimated rates of unreported landings for all 'others' (including flatfish) using the default approach outlined in chapter 1 of this report (Table 5). To derive anchor points for 'others' we used the minimum estimates of unreported catches for salmon, cod and herring from 1993, 1994 and 2007 to create an average for this group in each of these years. To remain conservative, we used half of these

values to represent the rates of unreported landings for 'others' (Table 5). These rates were applied to total landings (ICES landings statistics + adjustments) in 1993, 1994, and 2007. Linear interpolations were performed between 1990 (0%) and our first anchor point in 1993 (15.4%), and in all other intervening years (Table 5).

Discards

Discards were estimated for four separate categories: i) underwater discards (mortality caused by deployed fishing gear); ii) ghostfishing (a result of entrapment in lost fishing gear); iii) boat-based discards (usually a result of fishers' selective behaviors onboard); and iv) seal-damaged discards. In Poland however, only categories the first three categories were applicable. Discards were estimated by applying annual rates (%) to estimates of our total annual landings (the sum of ICES landings statistics, and adjustments, and unreported landings) of each of the applicable taxa.

Underwater discards: Underwater discards were estimated only for herring and sprat since these taxa are the main pelagics targeted by trawl (Zeller *et al.*, this volume). In the Baltic Sea, herring and sprat are targeted by the same trawl fleet. Thus, the pelagic trawl fishery is inherently mixed, and uncertainty exists in species composition of landings data (ICES, 2009b). It is also known that landings statistics often reflect only the targeted species (HELCOM, 2009). Thus, information attained regarding underwater discards was applied to landings of both herring and sprat. Rahikainen *et al.* (2004) related underwater discard amounts to observed catches of herring in the trawl fishery. We transformed these data into an approximate underwater discard rate of 9% of reported landings caught by trawl (Zeller *et al.*, this volume). In Poland, landings of herring and sprat were not recorded by gear type, so we reduced the underwater discard rate to 5% to account for any other gear types used, and to remain conservative in our estimate. Thus, a rate of 5% was applied to herring and sprat landings (i.e. ICES landings statistics, adjustments and unreported landings) for all years between 1950 and 2007.

Ghostfishing: In a recent FAO report, lost and discarded fish gear were reported to contribute to approximately 10% of marine litter globally; resulting in increasingly significant threats to fish stocks (Macfadyen *et al.*, 2009). Brown *et al.* (2005) reported that during a 28 month study period, between 3 and 906 t of cod were caught by lost nets (based on data from Tschernij and Larsson, 2003). When compared to the total reported or landed catch in the same area, during the same time period, catches by lost gear were equivalent to approximately 0.01-3.2 % of the total catch of cod (Brown *et al.*, 2005). We assumed lost gear has similar effects on all species, excluding pelagics (herring and sprat), and applied the average (1.65%) from Brown *et al.* (2005) to landings from 1950 to 2007.

Table 6. Anchor points (%) used for estimating boat based discards for cod and salmon from 1950-2007 based on sources (Tables 2.4.1, 2.4.5b and 2.4.20 in ICES, 2008a; Table 2.4.5b in ICES, 2007). Dashed lines (-) indicate years when linear interpolations were used.

Year	Eastern cod	Western cod	Salmon
1950-1989	2.0	2.0	2.0
1990-1992	-	-	-
1993	3.4	14.5	14.1
1994	2.1	10.6	12.9
1995	1.7	11.3	13.9
1996	1.2	15.7	15.1
1997	3.9	10.0	14.9
1998	3.4	17.3	14.2
1999	2.5	11.6	14.8
2000	6.8	12.5	10.3
2001	3.2	11.2	15.0
2002	2.2	10.4	15.8
2003	2.8	15.8	15.4
2004	1.8	10.1	15.6
2005	3.0	18.6	15.2
2006	13.2	8.6	17.4
2007	11.3	8.3	14.2

Boat-based discards: As part of the former eastern bloc, we assumed that Polish fishers did not engage in discarding associated with economic and quota incentives prior to the early 1990s. More indirect forms of discarding would have occurred however, due to the inherent effects of fishing gear on catch and we consider that fish unfit for landing, and inedible or unpalatable fauna would likely have been discarded at sea. Due to the absence of any specific data to account for these types of discards, we assigned a conservative rate of 2% to all species from 1950-1990 excluding herring and sprat (Zeller *et al.*, this volume). From 1993-2007, we derived annual boat-based discard rates for cod and salmon based on default methods described in Zeller *et al.* (this volume). Default discard rates were also used for flatfishes and 'others' (Zeller *et al.*, this volume; Anon., 2006a), except whiting for which species-specific discard data were available (Anon., 2006a).

We derived annual discard rates beginning in 1993 for eastern cod, western cod, and salmon. As country specific discard data were unavailable, we used our default and assumption-based approach (Zeller *et al*., this volume). These methods produced annual Baltic-wide discard rates (%) for eastern cod, western cod, and salmon (Table 6), which were applied to the sum of ICES landings statistics, plus adjustments, plus unreported landings to estimate the total boat-based discards (t) for these species.

To estimate discards for the remaining taxa in Poland we relied on information from a study conducted by the Danish National Institute of Aquatic Resources (Anon., 2006a). We transformed the tonnages of discards reported for the Danish fleet over one year period to a percentage of Denmark's reported landings for the respective taxa. Discard rates were assigned annually as fixed rates (1993-2007) to the sum of ICES landings statistics, adjustments, and unreported landings. A linear interpolation was done between 1990 (0%) and our first anchor point in 1993, to phase in the behavior of boat-based discarding. We applied the following rates to the respective taxa in Poland: dab (33%), plaice (34%), flounder (48%), turbot (38%), brill (38%), whiting (38%) and 'others' (6.24%; Zeller *et al*., this volume).

Table 7. The number of Polish recreational fishers from 1986-2007 in Poland. Interpolated values indicated by dashed (-) line. Data source: (Anon., 1989).

Year	Polish fishers
1986	0
1987-1998	-
1999	6,300
2000	13,700
2001	16,100
2002	21,500
2003	26,500
2004	31,500
2005	38,000
2006	79,043
2007	79,043[a]

[a]2006 value carried forward.

Recreational catches

Sport and recreational fishing in Poland began in the late 1980s (Radtke and Dabrowski, 2007). Recreational catches were estimated for Poland by using a combination of Polish data regarding the number of recreational fishers between 1999 and 2007 (Anon., 1989), with taxon-specific, *per capita* catch data for Germany in 2005-2006 (Anon., 2007a) Recreational catch rates were presented by (1999) for cod, herring and flounder. To remain conservative, we applied half of the German recreational catch rates (Table 8) to the estimated number of recreational fishers in Poland (Table 7), to estimate recreational catches of cod, herring and flounder from 1986-2007.

Table 8. Recreational catch rates ($t \cdot fisher^{-1}$) by species used to estimate Poland's recreational catches (Anon., 2007).

Common name	Catch rate ($t \cdot fisher^{-1}$)
Cod	0.011746
Herring	0.000251
Flounder	0.000912

RESULTS

Our results estimate the total marine fisheries catches in Poland from 1950 to 2007. The reconstruction of Poland's catches uses ICES landings statistics as baseline data to represent all reported landings during the study period (1950-2007). To reconstruct Poland's total catches we estimated four components of Illegal, Unreported and Unallocated (IUU) catches to supplement our baseline data from ICES. The first step, which we termed *'adjustments'*, sought to correct any misreported or missing landings from the ICES data. Reported landings were adjusted both negatively and positively using ICES stock assessment working group data (ICES, 2008a; ICES, 2007; ICES, 2008b) as well as national data from the Polish Maritime Fish Industry (Anon., 1989). Secondly, we estimated '*unreported landings'* as a proportion of ICES landings statistics plus adjustments. *'Discard'* rates were then estimated and applied to our total reconstructed landings (ICES landings statistics + adjustments + unreported landings). Finally, '*recreational catches'* were estimated beginning in the 1990s when Poland became indepenedent with the disintegration of the former Eastern Bloc. The sum total of ICES landings statistics, adjustments, unreported landings, and recreational catches represents an estimate of the total fisheries catches from the Baltic Sea by Poland for the period 1950-2007 (see Appendix Tables B1-B7 for complete time series data on all additions to taxonomic catch data, by catch component).

ICES landings statistics

The ICES landings statistics database presented a total of approximately 7 million tonnes for all species landed from all fishing areas by Poland within the Baltic Sea for the period 1950-2007 (Figure 2). The

three species accounting for the largest portion of landings according to ICES were cod, herring and sprat (Table 9). These taxa comprise over 92% of the total landings between 1950 and 2007. Flatfishes and 'others' makeup approximately 7% of landings, and salmon less than 1% of the total landings reported between 1950 and 2007 by ICES.

Table 9. Reported landings (t) from the ICES landings statistics database for Poland (1950-2007; ICES, 2009a).

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	216,638	492,997	609,074	711,242	235,002	129,933
Herring	73,082	259,301	577,166	712,145	406,681	220,437
Sprat	36,675	137,810	414,159	190,838	505,630	621,642
Flatfishes	6,504	27,010	46,908	36,296	55,759	69,397
Salmon	0	1,936	875	2,144	2,356	1,035
'Others'	14,239	37,674	89,357	62,812	37,417	33,392

ICES landings data for salmon were missing from 1950-1959 while all other taxa were missing landings data from 1950-1955. Thus, ICES landings data reported during this decade underestimate Poland's actual landings (Table 9). According to ICES, cod and herring landings peaked in the 1980s (Figure 2; Table 9), salmon peaked in the 1990s (Table 9), 'others' peaked in the 1970s, while flatfish and sprat landings have their highest reported landings in the most recent decade (2000-2007).

Illegal, Unreported and Unregulated (IUU) catches

IUU catches including adjustments, unreported landings, discarded and recreational catches totaled an estimated 2.5 million tonnes over the period of study (1950-2007). Presented below are the individual components and their respective contributions to our estimate of the total IUU catches in Poland.

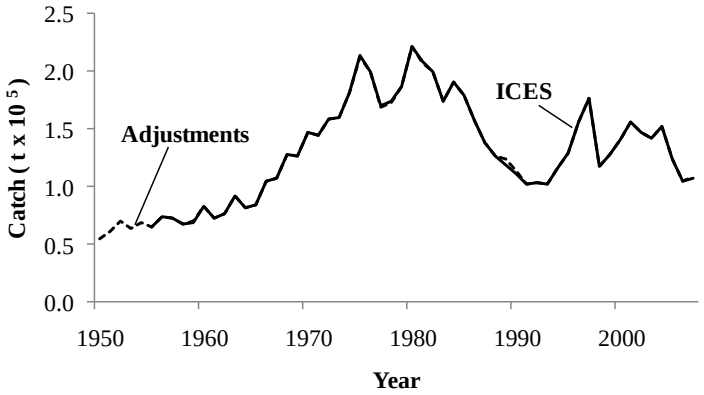

Figure 2. ICES landings statistics and adjustments to ICES landings for Poland from 1950-2007.

Adjustments to ICES landings statistics

Overall, our adjusted landings did not show substantial differences from those officially reported by ICES over the period of study, 1950-2007 (Figure 2). However, adjustments were made between 1950 and 1959 for salmon, and between 1950 and 1954 for all other taxa since these data were missing from ICES landings statistics (Figure 2; Table 10). Between 1950 and 1959, national data from the Polish Maritime Industry contributed a total of 320,181 t of adjustments for all species (Figure 2). Adjustments sourced from ICES stock assessment working group data were used for cod during the 1980s and 1990s with a total of approximately 7,000 t added to cod landings. The majority of adjustments to cod from ICES stock assessment working group data were for the eastern stock (approximately 98%) between 1955 and 2007.

Table 10. Adjustments (t) to reported landings from ICES landings statistics (1950-2007).

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	255,803	0	403	4,058	3,204	312
Herring	42,821	0	0	0	0	0
Sprat	8,408	0	0	0	0	0
Flatfishes	4,101	0	-3,492	1,159	741	1,404
Salmon	1,634	0	0	0	21	94
'Others'	7,414	0	0	0	0	0

Landings for flatfishes were accounted for by species specific landings for flounder, plaice and turbot. The totals for these thress species formed the basis for adjustments to the ICES 'flatfishes nei' group (Table 10).

Overall, both postive and negative adjustments from both national and ICES working group data summed to 328,085 t, adding approximately 4.6% to landings officially reported by ICES. This increased officially reported landings from 7.1 million tonnes to approximately 7.4 million tonnes for the period 1950 to 2007.

Unreported landings

Unreported landings were estimated only between 1990 and 2007 (Figure 3) due to Poland's alignment with the former Eastern Bloc prior to this time and the assumption that during this time eastern bloc countries reported all landings (see methods). Unreported landings were estimated by applying unreported landings rates (%). Unreported landings peaked in the mid-1990s, and to have declined steadily through the most recent decade in accordance to our adjusted landings totals (Figure 3).

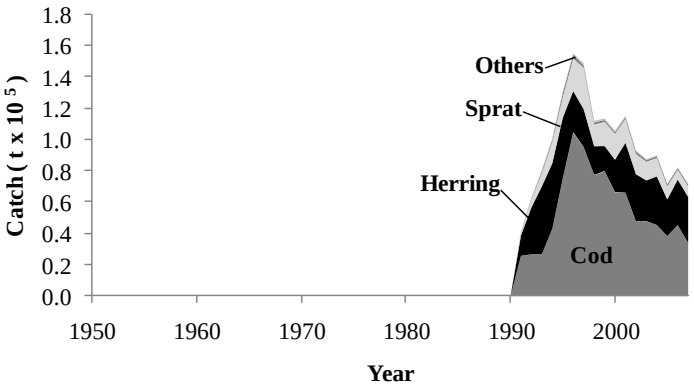

Figure 3. Poland's unreported landings by taxa, 1950-2007.

Cod had the greatest amount of unreported landings between 1990 and 2007 (Figure 3), due to sources which indicated underreporting was occurring at a rate of 300% of reported landings. Unreported landings of eastern cod totaled approximately 915,000 t between 1990 and 2007, and unreported landings of western cod totaled 29,000 t for the same time period. Unreported landings of cod totaled an estimated 945,000 t (or 57% of unreported landings of all species) during the period 1990-2007 (Table 11).

Unreported landings of herring were fairly similar in the 1990s and 2000s, totaling between approximately 255,000 and 220,000 t in each decade (Table 11). Unreported landings of sprat were approximately half the magnitude of the unreported landings of herring, and totaled approximately 100,000 t and 87,000 t in the 1990s and 2000s respectively. Flatfishes, salmon and 'others' comprised much less significant components of the total unreported landings (Figure 3; Table 11) and when combined, they represented only about 2% of the unreported landings of all species between 1990 and 2007.

Table 11. Unreported landings (t) derived for all species fished by Poland (1950-2007).

Common name	1950-1989	1990-1999	2000-2007
Cod	0	553,724	390,736
Herring	0	255,080	223,912
Sprat	0	105,147	86,565
Flatfishes	0	11,496	9,351
Salmon	0	711	565
'Others'	0	6,832	4,636

Discards

We accounted for 3 discard categories in Poland: i) underwater discards; ii) ghostfishing; and iii) boat-based discards. Discard rates were applied to landings (ICES landings statistics + adjustments + unreported landings) to estimate discards. Prior to Poland's independence from the former Eastern Bloc, only underwater discards (5% of landings) for herring and sprat, and ghostfishing (1.65% of landings for all species excluding herring and sprat) were assumed to have occurred. Thus, underwater discards of herring and sprat contributed the largest amounts to discards, but ghostfishing of cod was also important due to high catch volumes (Figure 4; Table 12).

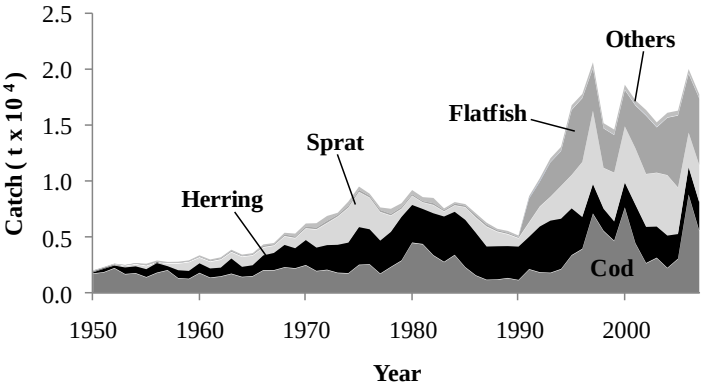

Figure 4. Total discards (t) of cod, herring, sprat, flatfishes and 'others' (1950-2007).

Boat-based discarding was assumed to have become a concern when Poland became independent after the breakup of the former eastern bloc in the early 1990s. Thus, we assume that the transition from a state-

controlled economy to a market based economy, and the associated economic incentives induced discarding practices (Figure 4). Though discards of individual taxa have fluctuated since this time, the total discards of the top four discarded species (cod, herring, sprat and flatfishes) remained relatively constant through the 1990s and 2000s, averaging at approximately 33,000 t in both decades (Figure 4; Table 12). Salmon and 'others' had noticeably lower discard totals due to low catch volumes, and low rates of discarding, respectively (Table 12).

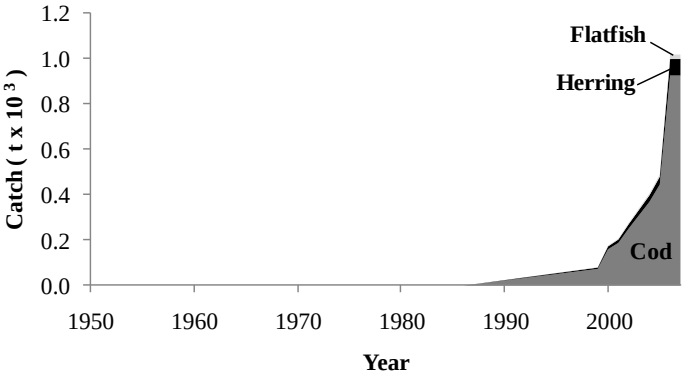

Figure 5. Total recreational catches (t) for cod, herring and flatfishes (1950-2007).

Discards of all species peaked in the most recent decade (2000-2007) with a total of approximately 138,000 t. Between 1990 and 2007, discards of cod, sprat and flatfishes increased, while those of herring, salmon and 'others' decreased. In general, discards of flatfishes may be of most concern, having increased approximately 100-fold from 390 t in the 1950s to more than 39,000 t in the most recent decade (Table 12). According to our analysis, flatfishes experience the highest rate of discarding, highlighting that despite relatively low catch volumes of flatfish, their discards appear to have exceeded those of any other species in the most recent decade (28% of all discards; Table 15).

Table 12. Discards (t) for cod, herring, sprat, flatfishes, salmon and 'others', by decade (1950-2007).

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	17,244	17,994	22,246	26,108	33,804	37,593
Herring	5,795	12,965	28,858	35,607	33,088	22,217
Sprat	2,254	6,891	20,708	9,542	30,539	35,410
Flatfishes	387	986	1,585	1,367	32,187	39,135
Salmon	60	71	32	78	416	280
'Others'	790	1,375	3,262	2,293	3,184	3,136

Over the entire period of study, discards of cod accounted for 32%, herring 28%, sprat 22%, flatfishes 15%, and salmon and 'others' combined approximately 3% of all discards from 1950-2007 (Figure 4; Table 12).

Recreational catches

Since the mid-1980s when recreational fishing began, the predominant species caught was cod (Figure 5). Since this time, annual catches of cod have increased to approximately 928 t (2006-2007), totaling 4,105 t over the entire period of study (1950-2007). Recreational catches of cod accounted for approximately 0.3% of our total catch reconstruction for cod between 1986 and 2007 (the period in which recreational fishing occurred), and 0.11% of our total reconstructed catch for cod over the period of study (1950-2007).

Table 13. Recreational catches (t) for cod, herring, sprat, flatfishes, salmon and 'others' in Poland, 1950-2007.

Common name	1950-1979	1980-1989	1990-1999	2000-2007
Cod	0	34	484	3,587
Herring	0	3	38	279
Flatfishes	0	1	10	77

Recreational catches of herring and flatfishes totaled only about 407 t between 1986 and 2007, comprising about 9% of all recreational catches combined. Due to increasing numbers of recreational fishers, recreational catches of all species appear to have increased dramatically since the onset of recreational fishing in the 1990s.

Total reconstructed catch

Our catch reconstruction for Poland, which included all taxa and all fishing areas of the Baltic Sea, totaled 9.5 million tonnes (Figure 6). Our catch reconstruction included reported landings from ICES landings statistics plus our additional estimates of IUU (adjustments to reported landings, unreported landings, discards, and recreational catches [Figure 7]) for the period from 1950 to 2007. Our estimates of IUU

added approximately 35% to landings reported by ICES between 1950 and 2007 (Figure 6). The majority of our additions of IUU occurred after 1990 (Figure 6), when Poland was no longer part of the former eastern bloc, and became subject to the policies of the EU and a market economy. During this time (1990-2007), our additions of IUU added almost 2 million tonnes to reported landings (Figure 6). Prior to 1990, our reconstruction accounted for an additional 541,000 t over the period from 1950 to 1989. During this period (1950-1989), our IUU estimates were mainly comprised of discards as well as adjustments to missing reported landings between 1950 and 1954 for all species.

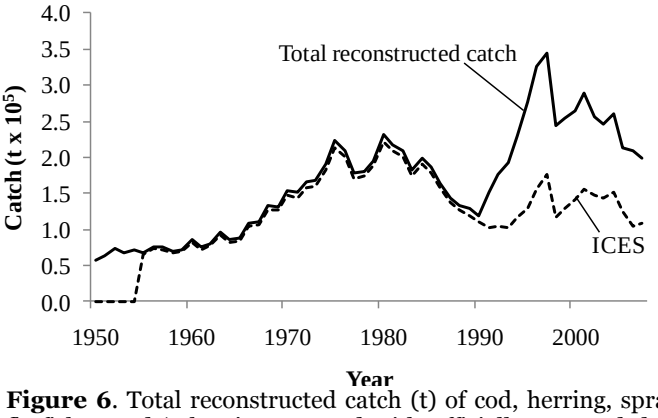

Figure 6. Total reconstructed catch (t) of cod, herring, sprat, flatfishes and 'others' contrasted with officially reported data from ICES landings statistics (1950-2007).

Considering previously reported landings and our additional estimates of IUU, each component comprised the following proportion of our total catch reconstruction (1950-2007): reported data from ICES landings statistics, 74%; adjustments, 3.5%; unreported landings, 17.3%; discards, 5.1%, and recreational catches, 0.05% (Figure 7; Table 14). Thus, unreported landings and discards were the most significant additions of IUU to reported landings. As mentioned above, cod was found to have the highest unreported landings and discards (1950-2007). Flatfishes were found to have the most significant rate of discarding since the 1990s, and greatest volume of discards in the most recent decade (2000-2007). In general, reported landings peaked in the 1970s with about 1.7 million tonnes (Table 14), while our total catch reconstruction peaked in the 1990s with approximately 2.3 million tonnes (Table 14). The majority of this difference was made up by unreported landings (Figure 7), which totaled approximately 1.65 million tonnes between 1990 and 2007 (Figure 7; Table 14).

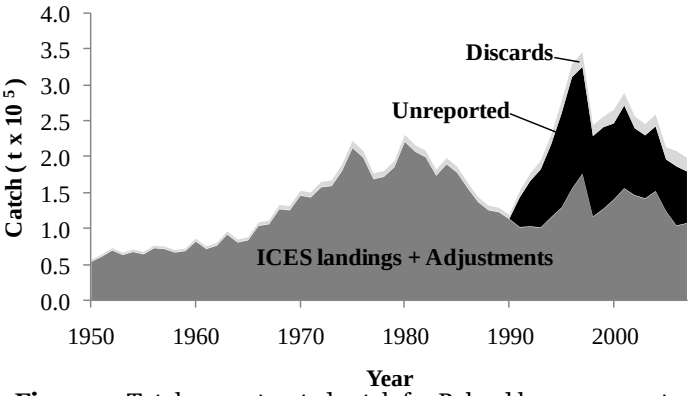

Figure 7. Total reconstructed catch for Poland by component from 1950-2007.

Table 14. Total reconstructed catches (t) for cod, herring, sprat, flatfishes, salmon, and 'others' in Poland, by IUU component (1950-2007).

Component	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
ICES landings	347,138	956,728	1,737,539	1,715,477	1,242,845	1,075,836
Adjustments	320,181	0	-3,089	5,217	3,966	1,810
Unreported landings	0	0	0	0	932,989	715,764
Discards	26,530	40,282	76,690	74,995	133,219	137,771
Recreational	0	0	0	37	532	3,942

Overall, cod was the dominant catch throughout the study period, totaling approximately 3,800,000 t between 1950 and 2007 (Table 15). Herring and sprat were close seconds with totals of approximately 2.9 and 2.2 million tonnes respectively (Table 15). Flatfishes and 'others'

Table 15. Total reconstructed catches (t) for cod, herring, sprat, flatfishes, salmon, and 'others' in Poland (1950-2007).

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod	489,685	510,991	631,723	741,443	826,218	562,161
Herring	121,698	272,266	606,024	747,755	694,887	466,845
Sprat	47,337	144,701	434,867	200,380	641,316	743,617
Flatfishes	10,992	27,996	45,001	38,823	100,193	119,364
Salmon	1,694	2,007	907	2,222	3,504	1,973
'Others'	22,443	39,049	92,619	65,105	47,433	41,164

comprised much lesser components of the catch total each with about 300,000 t over the period of study (1950-2007). Salmon had the lowest catches estimated with a total of approximately 12,000 t caught between 1950 and 2007 (Table 15).

DISCUSSION

Poland has reported annual landings data to ICES since 1955, which are available online from the publicly accessible electronic database, 'ICES catch statistics' (ICES, 2009a). The total landings reported by Poland to ICES for the period of study (1950-2007), were approximately 7 million tonnes. Our reconstruction of Poland's total fisheries catches in the Baltic Sea for the same time period were estimated to be approximately 9.5 million tonnes. Thus, our estimates of IUU contributed 35% more catches to what was reported to ICES by Poland between 1950 and 2007. Estimates of IUU were consistently conservative, using minimum estimates with linear interpolations between data anchor points. Therefore, our catch reconstruction is believed not to overestimate the total catch for Poland between 1950 and 2007. Thus, our estimates of Poland's total catches are more accurate than the current assumption of zero IUU in catch statistics reported to ICES, and although they are not statistically precise *per se*, they provide vital information for the management of Baltic fish stocks. This catch reconstruction is thus a best estimate of Poland's total catch, accounting for all fisheries sectors, using methods applied successfully to elsewhere (Zeller *et al.*, 2006; Zeller *et al.*, 2007; Zeller and Pauly, 2007).

Our catch reconstruction showed unreported landings of cod in Poland to be the most dominant form of IUU, totaling almost 1 million tonnes between 1990 and 2007. In 2007, the European Commission was finally able to launch a lawsuit against Poland for underreported landings of Baltic cod (EC, 2009). Discrepancies in the balance between landings, domestic consumption, imports and exports of cod suggest unreported landings are three times the magnitude of reported landings in recent years (Anon., 2007b). Widespread documentation of this fact by the scientific community and the media has labeled Poland as one of the main culprits of IUU fishing of cod in the Baltic Sea. While cod has evidently been overexploited (EC, 2009), decreased cod TACs have had little effect on stock recovery thus far. A recovery plan was proposed in 2006 by the European Commission to decrease cod TACs by 10% annually, but the plan lacked strategy for fishers to adapt to decreased fishing opportunities (WWF Denmark, 2006). This may have increased the potential for unreported landings of cod.

We presented relatively low levels of underreporting and discarding of herring and sprat catches. FAO (2009) reports that about 50% of Poland's herring and sprat quotas remain uncaught due to the low profitability of these species, which are mainly caught for industrial purposes (FAO, 2009). These factors result in little incentive to not report all landed catches. Economic incentives also drive fishers to catch high quantities, as opposed to high quality catches, providing little incentive to discard or high-grade catches at sea. Overall, discards of all species in our catch reconstruction contributed 20% to the total IUU estimates for Poland. A very rough estimate of recreational catches contributed less than 1% of all IUU catches.

Reconstructed catches in Poland peaked in the 1990s, when catches of cod and salmon reached their highest levels. In the most recent decade, catches of these two species have declined, while those of sprat have increased. This shift in catch composition has resulted in a decrease in economic yield per unit biomass (Thulin and Andrushaitis, 2003). This shift also represents a decrease in the mean trophic level of fisheries catches, which can be indicative of fishing down the marine food web (Pauly *et al.*, 1998). These impacts are significant in their effects on the interactions between all species. For example, the increase in sprat and decrease in cod has altered trophic interactions which are contributing to the eutrophication of the Baltic Sea (Casini *et al.*, 2008).

Our methods used as much of the information that was accessible to us as possible to derive estimates of IUU. When country-specific information was not available for Poland from national sources or correspondence with experts, we derived estimates from Baltic-wide statistics presented in ICES stock assessment working group data, since no reports of Polish IUU catches were available from ICES landings statistics. Confidentiality agreements between the Baltic countries and ICES prevent a clear presentation of country-specific data, preventing a more accurate estimate of the total extraction of fisheries resources from the Baltic Sea. Thus, overall, our methodology was compromised by a lack of transparency between the EU Member States of the Baltic Sea and the responsible scientific agency, ICES. Country-specific information pertaining to unreported landings of cod and herring were acquired from correspondence

with local experts and trade statistics, and thus, there is likely more validity to these estimates than would have otherwise been made using our default methods (as explained above).

This lack of transparency to the public, who are the ultimate beneficiaries and decision makers, severely affects fisheries policy and management. Although ICES makes scientifically-based recommendations for TACs, the responsible management commissions have had a history for overriding recommendations (which are based on long-term goals for the ecosystem), with the short term, socio-economic interests of the fishing industry. Ecosystem-based fisheries management will only be possible with increased transparency, where all landings, discards and recreational catches are reported openly, so all aspects of the marine ecosystem can be considered in management decisions (not just the target species). This will also hold both fishers and decision makers accountable for the types of actions which have driven a common resource into significant decline. To attain this level of transparency, increased enforcement is necessary. Vessel monitoring systems and 100% observer coverage are two ways of preventing IUU fishing, and the unnecessary waste caused by discarding unwanted catches at sea. If these types of enforcement could be implemented successfully, all fish caught would be returned to port, and reported landings would equate to total catch, providing a transparent source of data for the public and scientific community to evaluate.

ACKNOWLEDGMENTS

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APPENDIX A: Open letter by Zbigniew Karnicki

There are moments in life where one must make difficult decisions. There are principles in life that one should not breach. One of these principles is to abide the rectitude and independence of scientific opinions. Polish Baltic fishery is going through one of the toughest moments in history. That is why those responsible for fishery should obtain a full spectrum of knowledge concerning the cause of this crisis, in order to be able to use this knowledge as a base to consider different ways to resolve this situation and make responsible decisions. The Sea Fisheries Institute (MIR) in Gdynia is the sole scientific institution [*att. trans.* in Poland] which collects data for the use of the Common Fisheries Policy of the European Union and carries out research necessary to manage Baltic fishery. MIR research concerns fishery resources and the economics of fishery. The statutory obligation of MIR is to report information to the fishery administration in coherence with the best scientific knowledge, based on facts and fully documented data. As vice-director of MIR responsible for scientific research my duty was to follow this principle.
On September 11th, I received from the minister of the Maritime Economy Ministry (MGM) Marek Grobarczyk a fax requesting answers to the following questions:

1. What repercussions will the Polish fish branch face after stopping cod fishery in accordance with European Commission regulation 804/2007?
2. What negative consequences for Poland may arise due to violating the ban on cod fishery?

This fax was not addressed to the director of MIR but directly to me. On September 12th, I sent via fax a response based on my best knowledge to minister M. Grobarczyk, ending with the following conclusions:

- In light of the above I believe that breaching the CE Regulation 804/2007 will have decisively negative consequences for Polish Baltic fishery and also a wider negative effect for Poland as a member of the European Union.
- Instead of igniting a dispute with the European Commission I believe that it is necessary to begin a dialogue with the fishery branch on how to lessen the negative impact of the current situation both today and – especially - in the following years.
- It is also necessary to negotiate with the European Commission in order to establish the volume of over-fishing the cod quota by our fishermen and minimize the sanctions for the current situation in the following years. The minimization of further, negative steps taken by the European Commission may only be possible on the basis of well-documented activities led be the State and aimed at limiting unreported fishing, both in the current year and in the following years.

Two days later minister M. Gorbarczyk sent to the director of MIR a fax containing the following content:

Dear Sir,

I would like to inform you that MIR is obtaining signals, coming from different communities, regarding the inadequate consideration of comments and postulates of these communities in the process of preparing position papers and opinions by MIR's employees. This phenomenon seems to be especially urgent in the context of research on the Baltic cod resources, which – for obvious reasons – is the object of particular interest of the government and public opinion in Poland.

In connection with the above I would like to express my deep disquiet with this state of the matter especially since these remarks mostly apply to the attitude of director Zbigniew Karnicki. Taking into consideration the great sensitivity of the issue at stake I cannot remain oblivious to this type of signals, I therefore ask you to consider the possibility of recalling director Karnicki from his duties and calling in his place a person which guarantees adequate objectivity in the future activities of MIR.

Signed: Marek Grobarczyk

From the content above it is obvious that the minister believes that MIR, and its science director in particular should, when formulating his opinions, take into consideration the position of the fishery community. In summary, MIR scientists, often prominent experts with international reputation, should present the opinion that "there is plenty of cod in the sea" and not publicize the results of independent cod

resource research carried out in cooperation with all Baltic countries, which show just the opposite. Apart from this, we should assure that breaching the basic principles of the common fisheries policy of the European Union will not have negative consequences for Polish fishery, which definitely has little to do with the truth.
I believe that this is an unacceptable threat to independence of scientific opinion in general and MIR in particular. It also shows that the Ministry is not interested in finding out the details of the scientific basis for the cod resource assessment and the causes of the current crisis, but only expects MIR to give opinions serving the demands of a part of the fishery community or political interest. Minister M. Grobarczyk to this day has not found the time to meet with MIR representatives in order to have presented to him the opinion about the economic situation of Polish fishery based on data obtained by MIR directly from ship owners.

In light of the facts listed above I came to the conclusion that the only solution in this situation is to facilitate MIR's director decision and resign from the post myself, at the same time passing my decision to the public opinion as a protest against the fisheries policy led by the Maritime Economy Ministry.
I would like to underline that, in coherence with my best knowledge as a man concerned with fishery for the past 50 years, including 15 years of engagement in Polish, European and world fishery problems on the post of fishery policy director at FAO/United Nations in Rome, that the highest price for the current politics of the Minister will be paid by Polish fishermen. I fully sustain my opinion, based on my knowledge of European Union law, that the European Commission will sustain in force the regulation 804/2007 - enforcing a ban on cod fishery for Poland up to the end of this year, will demand that Poland, and *de facto* Polish fishermen, return the cod quota excess in the following year, and that Polish cod fishery, due to the current activities of the Ministry, will be under the special surveillance of EU inspectors. This will lead to the continuation of the liquidation process of Polish fishery caused by irresponsible political decisions.

That is why I hereby call upon Minister M. Grobarczyk to immediately begin talks with fishery organizations on the possibilities and methods of limiting the effects of the current crisis in the fishery sector.

Telling fishermen "we are not encouraging you to fish, but if you decide to do so you will not be punished" is unacceptable. It leads to a further fragmentation of the community and reinforcement of the position of the European Commission by showing that the Polish fishery administration does not have a clear policy towards fishery and is not controlling the situation.

Sincerely,

Zbigniew Karnicki, PhD

APPENDIX B

Appendix Table B1. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for Poland (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	0	54,724	0	2,058	0	56,782
1951	0	61,746	0	2,361	0	64,107
1952	0	70,425	0	2,666	0	73,091
1953	0	64,151	0	2,547	0	66,698
1954	0	68,278	0	2,716	0	70,994
1955	64,970	41	0	2,651	0	67,662
1956	73,344	191	0	2,941	0	76,476
1957	72,184	185	0	2,812	0	75,181
1958	67,331	201	0	2,829	0	70,361
1959	69,309	239	0	2,950	0	72,498
1960	82,806	0	0	3,404	0	86,210
1961	72,358	0	0	3,032	0	75,390
1962	77,043	0	0	3,224	0	80,267
1963	92,583	0	0	3,907	0	96,490
1964	81,513	0	0	3,469	0	84,982
1965	84,602	0	0	3,595	0	88,197
1966	104,652	0	0	4,378	0	109,030
1967	106,912	0	0	4,504	0	111,416
1968	127,860	0	0	5,422	0	133,282
1969	126,399	0	0	5,348	0	131,747
1970	146,647	149	0	6,252	0	153,048
1971	144,222	107	0	6,279	0	150,608
1972	158,239	425	0	6,928	0	165,592
1973	160,521	-278	0	7,213	0	167,456
1974	181,736	-230	0	8,217	0	189,723
1975	213,665	-309	0	9,556	0	222,912
1976	200,298	-246	0	8,921	0	208,973
1977	170,046	-321	0	7,690	0	177,415
1978	174,520	-1,351	0	7,568	0	180,737
1979	187,645	-1,035	0	8,067	0	194,677
1980	221,785	145	0	9,243	0	231,173
1981	208,893	-794	0	8,611	0	216,710
1982	200,369	59	0	8,538	0	208,966
1983	174,538	142	0	7,602	0	182,282
1984	190,702	38	0	8,167	0	198,907
1985	178,757	107	0	7,987	0	186,851
1986	157,424	116	0	7,155	0	164,695
1987	137,791	244	0	6,328	6	144,369
1988	126,496	66	0	5,780	13	132,355
1989	118,722	5,094	0	5,585	19	129,420
1990	110,620	3,366	0	5,176	25	119,187
1991	102,493	5	41,080	8,667	31	152,277
1992	103,626	-16	62,178	10,210	38	176,035
1993	102,001	6	78,951	11,899	44	192,901
1994	116,500	-81	99,408	12,941	50	228,818
1995	129,569	259	129,223	16,608	56	275,716
1996	155,817	398	153,017	17,610	63	326,905
1997	176,979	130	146,037	20,462	69	343,676
1998	117,144	22	110,722	15,103	75	243,066
1999	128,096	-123	112,373	14,544	81	254,972
2000	141,154	56	104,546	18,566	177	264,499
2001	156,551	71	114,488	17,195	208	288,513
2002	146,897	57	92,708	16,345	278	256,285
2003	142,684	-21	87,380	15,273	342	245,658
2004	152,076	610	90,216	16,162	407	259,470
2005	124,106	649	72,073	16,353	491	213,671
2006	104,628	21	82,418	20,069	1,020	208,157
2007	107,740	367	71,936	17,808	1,021	198,872

Appendix Table B2. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for cod (*Gadus morhua*) for Poland (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	-	48,048	0	1,754	0	49,802
1951	-	51,159	0	1,867	0	53,026
1952	-	61,248	0	2,236	0	63,484
1953	-	46,606	0	1,701	0	48,307
1954	-	48,742	0	1,779	0	50,521
1955	39,030	0	0	1,425	0	40,455
1956	49,953	0	0	1,823	0	51,776
1957	56,151	0	0	2,050	0	58,201
1958	36,509	0	0	1,333	0	37,842
1959	34,995	0	0	1,277	0	36,272
1960	49,412	0	0	1,804	0	51,216
1961	37,892	0	0	1,383	0	39,275
1962	40,942	0	0	1,494	0	42,436
1963	47,514	0	0	1,734	0	49,248
1964	39,735	0	0	1,450	0	41,185
1965	41,498	0	0	1,515	0	43,013
1966	56,007	0	0	2,044	0	58,051
1967	56,003	0	0	2,044	0	58,047
1968	63,245	0	0	2,308	0	65,553
1969	60,749	0	0	2,217	0	62,966
1970	68,440	0	0	2,498	0	70,938
1971	54,151	0	0	1,977	0	56,128
1972	56,746	347	0	2,084	0	59,177
1973	49,790	0	0	1,817	0	51,607
1974	48,650	0	0	1,776	0	50,426
1975	69,318	0	0	2,530	0	71,848
1976	70,466	0	0	2,572	0	73,038
1977	47,703	-1	0	1,741	0	49,443
1978	64,113	0	0	2,340	0	66,453
1979	79,697	57	0	2,911	0	82,665
1980	123,486	0	0	4,507	0	127,993
1981	120,942	-941	0	4,380	0	124,381
1982	92,541	0	0	3,378	0	95,919
1983	76,474	0	0	2,791	0	79,265
1984	93,429	0	0	3,410	0	96,839
1985	63,260	0	0	2,309	0	65,569
1986	43,237	-1	0	1,578	0	44,814
1987	32,667	0	0	1,192	6	33,865
1988	33,351	0	0	1,217	11	34,580
1989	31,855	5,000	0	1,345	17	38,217
1990	28,730	3,298	0	1,169	23	33,220
1991	25,748	0	25,748	2,137	28	53,662
1992	13,314	0	26,628	1,857	34	41,833
1993	8,909	0	26,727	1,817	40	37,493
1994	14,426	-91	43,005	2,147	46	59,533
1995	25,001	-1	75,000	3,388	51	103,439
1996	34,856	-1	104,565	3,951	57	143,428
1997	31,659	0	94,977	7,102	63	133,800
1998	25,778	0	77,334	5,564	68	108,745
1999	26,581	-1	79,740	4,672	74	111,066
2000	22,120	0	66,360	7,646	161	96,287
2001	21,992	0	65,976	4,444	189	92,601
2002	15,892	-4	47,665	2,678	253	66,484
2003	16,029	-87	47,827	3,155	311	67,235
2004	15,090	30	45,360	2,249	370	63,099
2005	12,767	-5	38,286	3,067	446	54,562
2006	15,080	11	45,273	8,792	928	70,084
2007	10,963	367	33,990	5,562	928	51,811

Appendix Table B3. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for herring (*Clupea harengus*) for Poland (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	-	3,303	0	165	0	3,468
1951	-	7,196	0	360	0	7,556
1952	-	5,794	0	290	0	6,084
1953	-	13,046	0	652	0	13,698
1954	-	13,482	0	674	0	14,156
1955	15,507	0	0	775	0	16,282
1956	18,418	0	0	921	0	19,339
1957	8,385	0	0	419	0	8,804
1958	15,448	0	0	772	0	16,220
1959	15,324	0	0	766	0	16,090
1960	18,407	0	0	920	0	19,327
1961	17,635	0	0	882	0	18,517
1962	16,848	0	0	842	0	17,690
1963	28,370	0	0	1,419	0	29,789
1964	19,160	0	0	958	0	20,118
1965	20,724	0	0	1,036	0	21,760
1966	27,743	0	0	1,387	0	29,130
1967	32,143	0	0	1,607	0	33,750
1968	41,186	0	0	2,059	0	43,245
1969	37,085	0	0	1,854	0	38,939
1970	46,018	0	0	2,301	0	48,319
1971	43,022	0	0	2,151	0	45,173
1972	45,343	0	0	2,267	0	47,610
1973	51,213	0	0	2,561	0	53,774
1974	55,957	0	0	2,798	0	58,755
1975	68,533	0	0	3,427	0	71,960
1976	63,850	0	0	3,193	0	67,043
1977	60,212	0	0	3,011	0	63,223
1978	63,850	0	0	3,193	0	67,043
1979	79,168	0	0	3,958	0	83,126
1980	68,614	0	0	3,431	0	72,045
1981	64,005	0	0	3,200	0	67,205
1982	76,329	0	0	3,816	0	80,145
1983	82,329	0	0	4,116	0	86,445
1984	78,326	0	0	3,916	0	82,242
1985	85,865	0	0	4,293	0	90,158
1986	77,109	0	0	3,855	0	80,964
1987	60,616	0	0	3,031	0	63,647
1988	60,624	0	0	3,031	1	63,656
1989	58,328	0	0	2,916	1	61,246
1990	60,919	0	0	3,046	2	63,967
1991	45,991	0	13,145	2,957	2	62,095
1992	52,864	0	30,220	4,154	3	87,240
1993	50,833	0	43,588	4,721	3	99,145
1994	49,111	0	42,111	4,561	4	95,787
1995	45,676	0	39,166	4,242	4	89,088
1996	31,246	0	26,793	2,902	4	60,945
1997	28,939	0	24,814	2,688	5	56,446
1998	21,873	0	18,755	2,031	5	42,665
1999	19,229	0	16,488	1,786	6	37,509
2000	24,516	0	21,022	2,277	13	47,827
2001	37,611	0	32,250	3,493	15	73,369
2002	35,512	0	30,450	3,298	20	69,280
2003	30,703	0	26,327	2,851	24	59,906
2004	27,764	0	31,317	2,954	29	62,064
2005	21,766	0	23,637	2,270	35	47,708
2006	20,544	0	29,370	2,496	72	52,482
2007	22,021	0	29,538	2,578	72	54,209

Appendix Table B4. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for sprat (*Sprattus sprattus*) for Poland (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	-	1,147	0	57	0	1,204
1951	-	733	0	37	0	770
1952	-	1,252	0	63	0	1,315
1953	-	2,182	0	109	0	2,291
1954	0	3,094	0	155	0	3,249
1955	5,108	0	0	255	0	5,363
1956	580	0	0	29	0	609
1957	4,264	0	0	213	0	4,477
1958	11,544	0	0	577	0	12,121
1959	15,179	0	0	759	0	15,938
1960	9,829	0	0	491	0	10,320
1961	11,305	0	0	565	0	11,870
1962	13,651	0	0	683	0	14,334
1963	10,693	0	0	535	0	11,228
1964	17,431	0	0	872	0	18,303
1965	16,863	0	0	843	0	17,706
1966	13,579	0	0	679	0	14,258
1967	12,410	0	0	621	0	13,031
1968	14,741	0	0	737	0	15,478
1969	17,308	0	0	865	0	18,173
1970	20,171	0	0	1,009	0	21,180
1971	31,855	0	0	1,593	0	33,448
1972	38,861	0	0	1,943	0	40,804
1973	49,835	0	0	2,492	0	52,327
1974	61,969	0	0	3,098	0	65,067
1975	62,445	0	0	3,122	0	65,567
1976	56,079	0	0	2,804	0	58,883
1977	50,502	0	0	2,525	0	53,027
1978	28,574	0	0	1,429	0	30,003
1979	13,868	0	0	693	0	14,561
1980	16,033	0	0	802	0	16,835
1981	11,205	0	0	560	0	11,765
1982	14,188	0	0	709	0	14,897
1983	8,492	0	0	425	0	8,917
1984	10,954	0	0	548	0	11,502
1985	22,156	0	0	1,108	0	23,264
1986	26,967	0	0	1,348	0	28,315
1987	34,887	0	0	1,744	0	36,631
1988	25,359	0	0	1,268	0	26,627
1989	20,597	0	0	1,030	0	21,627
1990	14,299	0	0	715	0	15,014
1991	23,200	0	1,624	1,241	0	26,065
1992	30,126	0	4,218	1,717	0	36,061
1993	33,701	0	6,841	2,027	0	42,569
1994	44,556	0	11,986	2,827	0	59,369
1995	46,182	0	11,730	2,896	0	60,808
1996	77,472	0	18,593	4,803	0	100,869
1997	105,298	0	23,692	6,450	0	135,440
1998	59,091	0	12,409	3,575	0	75,075
1999	71,705	0	14,054	4,288	0	90,047
2000	84,325	0	15,263	4,979	0	104,567
2001	85,757	0	14,321	5,004	0	105,082
2002	81,244	0	12,349	4,680	0	98,273
2003	84,097	0	11,521	4,781	0	100,399
2004	95,798	0	11,783	5,379	0	112,960
2005	74,329	0	8,325	4,133	0	86,787
2006	55,890	0	6,260	3,107	0	65,257
2007	60,202	0	6,743	3,347	0	70,292

Appendix Table B5. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for salmon (*Salmo salar*) for Poland (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	-	366	0	13	0	379
1951	-	128	0	5	0	133
1952	-	67	0	2	0	69
1953	-	71	0	3	0	74
1954	-	145	0	5	0	150
1955	-	41	0	1	0	42
1956	-	191	0	7	0	198
1957	-	185	0	7	0	192
1958	-	201	0	7	0	208
1959	-	239	0	9	0	248
1960	320	0	0	12	0	332
1961	52	0	0	2	0	54
1962	293	0	0	11	0	304
1963	335	0	0	12	0	347
1964	357	0	0	13	0	370
1965	177	0	0	6	0	183
1966	116	0	0	4	0	120
1967	61	0	0	2	0	63
1968	140	0	0	5	0	145
1969	85	0	0	3	0	88
1970	70	0	0	3	0	73
1971	58	0	0	2	0	60
1972	87	0	0	3	0	90
1973	98	0	0	4	0	102
1974	119	0	0	4	0	123
1975	88	0	0	3	0	91
1976	103	0	0	4	0	107
1977	80	0	0	3	0	83
1978	87	0	0	3	0	90
1979	85	0	0	3	0	88
1980	70	0	0	3	0	73
1981	100	0	0	4	0	104
1982	179	0	0	7	0	186
1983	196	0	0	7	0	203
1984	233	0	0	9	0	242
1985	280	0	0	10	0	290
1986	222	0	0	8	0	230
1987	401	0	0	15	0	416
1988	300	0	0	11	0	311
1989	163	0	0	6	0	169
1990	568	0	0	21	0	589
1991	350	0	58	62	0	471
1992	463	0	154	97	0	714
1993	191	0	96	45	0	332
1994	184	0	92	40	0	316
1995	133	0	67	31	0	230
1996	125	0	63	31	0	219
1997	110	0	55	27	0	192
1998	114	4	59	28	0	205
1999	118	17	68	33	0	236
2000	125	19	72	26	0	242
2001	156	24	90	45	0	315
2002	189	8	99	51	0	347
2003	176	22	99	51	0	348
2004	82	6	44	23	0	155
2005	109	5	57	29	0	200
2006	107	10	59	33	0	209
2007	91	0	46	22	0	158

Appendix Table B6. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for the category 'flatfish' for Poland (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	0	750	0	27	0	777
1951	0	653	0	24	0	677
1952	0	658	0	24	0	682
1953	0	717	0	26	0	743
1954	0	1,323	0	48	0	1,371
1955	1,780	0	0	65	0	1,845
1956	1,200	0	0	44	0	1,244
1957	1,174	0	0	43	0	1,217
1958	948	0	0	35	0	983
1959	1,402	0	0	51	0	1,453
1960	1,631	0	0	60	0	1,691
1961	2,157	0	0	79	0	2,236
1962	2,388	0	0	87	0	2,475
1963	2,749	0	0	100	0	2,849
1964	1,582	0	0	58	0	1,640
1965	2,418	0	0	88	0	2,506
1966	3,817	0	0	139	0	3,956
1967	2,675	0	0	98	0	2,773
1968	4,048	0	0	148	0	4,196
1969	3,545	0	0	129	0	3,674
1970	3,962	149	0	150	0	4,261
1971	4,093	107	0	153	0	4,353
1972	4,940	78	0	183	0	5,201
1973	4,278	-278	0	146	0	4,146
1974	4,668	-230	0	162	0	4,600
1975	5,139	-309	0	176	0	5,006
1976	4,394	-246	0	151	0	4,299
1977	4,879	-320	0	166	0	4,725
1978	5,418	-1,351	0	148	0	4,215
1979	5,137	-1,092	0	148	0	4,193
1980	3,429	145	0	130	0	3,704
1981	2,958	147	0	113	0	3,218
1982	4,214	59	0	156	0	4,429
1983	2,809	142	0	108	0	3,059
1984	3,865	38	0	142	0	4,045
1985	3,533	107	0	133	0	3,773
1986	5,044	117	0	188	0	5,349
1987	4,468	244	0	172	0	4,884
1988	3,030	66	0	113	0	3,209
1989	2,946	94	0	111	0	3,151
1990	2,253	68	0	85	0	2,406
1991	4,009	5	281	2,096	1	6,392
1992	3,906	-16	545	2,166	1	6,602
1993	5,101	6	1,037	2,979	1	9,123
1994	4,900	10	1,321	3,033	1	9,264
1995	8,964	260	2,343	5,694	1	17,262
1996	8,836	399	2,216	5,601	1	17,054
1997	6,168	130	1,417	3,731	1	11,448
1998	5,835	18	1,229	3,479	1	10,562
1999	5,787	-139	1,107	3,324	2	10,080
2000	5,602	37	1,021	3,222	3	9,885
2001	6,725	47	1,131	3,812	4	11,719
2002	9,232	53	1,411	5,199	5	15,901
2003	7,343	44	1,012	4,046	7	12,452
2004	8,828	574	1,156	5,155	8	15,721
2005	11,239	649	1,331	6,457	10	19,686
2006	9,583	0	1,073	5,273	20	15,950
2007	10,845	0	1,215	5,971	20	18,050

Appendix Table B7. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for the category 'others' for Poland (t).

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	0	1,110	0	41	0	1,151
1951	0	1,877	0	69	0	1,946
1952	0	1,406	0	51	0	1,457
1953	0	1,529	0	56	0	1,585
1954	0	1,492	0	54	0	1,546
1955	3,545	0	0	129	0	3,674
1956	3,193	0	0	117	0	3,310
1957	2,210	0	0	81	0	2,291
1958	2,882	0	0	105	0	2,987
1959	2,409	0	0	88	0	2,497
1960	3,207	0	0	117	0	3,324
1961	3,317	0	0	121	0	3,438
1962	2,921	0	0	107	0	3,028
1963	2,922	0	0	107	0	3,029
1964	3,248	0	0	119	0	3,367
1965	2,922	0	0	107	0	3,029
1966	3,390	0	0	124	0	3,514
1967	3,620	0	0	132	0	3,752
1968	4,500	0	0	164	0	4,664
1969	7,627	0	0	278	0	7,905
1970	7,986	0	0	291	0	8,277
1971	11,043	0	0	403	0	11,446
1972	12,262	0	0	448	0	12,710
1973	5,307	0	0	194	0	5,501
1974	10,373	0	0	379	0	10,752
1975	8,142	0	0	297	0	8,439
1976	5,406	0	0	197	0	5,603
1977	6,670	0	0	243	0	6,913
1978	12,478	0	0	455	0	12,933
1979	9,690	0	0	354	0	10,044
1980	10,153	0	0	371	0	10,524
1981	9,683	0	0	353	0	10,036
1982	12,918	0	0	472	0	13,390
1983	4,238	0	0	155	0	4,393
1984	3,895	0	0	142	0	4,037
1985	3,663	0	0	134	0	3,797
1986	4,845	0	0	177	0	5,022
1987	4,752	0	0	173	0	4,925
1988	3,832	0	0	140	0	3,972
1989	4,833	0	0	176	0	5,009
1990	3,851	0	0	141	0	3,992
1991	3,195	0	224	173	0	3,592
1992	2,953	0	413	218	0	3,584
1993	3,266	0	663	310	0	4,239
1994	3,323	0	894	333	0	4,550
1995	3,613	0	918	357	0	4,888
1996	3,282	0	788	321	0	4,391
1997	4,805	0	1,081	464	0	6,351
1998	4,453	0	935	425	0	5,813
1999	4,676	0	916	441	0	6,034
2000	4,466	0	808	416	0	5,691
2001	4,310	0	720	397	0	5,427
2002	4,828	0	734	439	0	6,001
2003	4,336	0	594	389	0	5,319
2004	4,514	0	555	402	0	5,472
2005	3,896	0	436	397	0	4,729
2006	3,424	0	383	367	0	4,175
2007	3,618	0	405	328	0	4,352

RUSSIAN FISHERIES CATCHES IN THE BALTIC SEA FROM 1950 – 2007[1]

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ABSTRACT

The total marine and brackish-water fisheries catches in the Baltic Sea taken by the Russian Federation (or the equivalent entity pre-1991) were estimated for the time period 1950-2007 using an approach called 'catch reconstruction'. Although there are reported data available elsewhere (e.g., ICES), they generally describe commercial landings rather than total catches. The reconstructed catch from 1950-2007 was approximately 3.7 million tonnes, attributing an additional 3 million tonnes to Russia's catches above what is reported by ICES for this time period; the largest contributors to the total reconstructed catch were herring (*Clupea harengus*) and sprat (*Sprattus sprattus*). From 1992-2007 when ICES landing statistics were reported for Russia independently, our reconstructed catch was 950,000 tonnes, or 28% higher than reported landings. We used ICES landings statistics as the reported data baseline to which estimates of IUU catches were added, including: data source adjustments to reported landings; estimates of unreported landings; estimates of discards; and estimates of recreational catches. We believe that our reconstruction represents a conservative estimate.

INTRODUCTION

The Russian Federation (Russia) was formed in 1991 after the collapse of the Soviet Union (USSR), and is the only Baltic country that is not a member of the European Union. Russia stretches from the Pacific Ocean to the Baltic Sea, and two administrative regions of Russia, Leningrad and the Russian exclave Kaliningrad oblasts, have direct access to the Baltic Sea (Figure 1).

Leningrad oblast borders Finland to the north and Estonia to the west. Within the Baltic Sea, 15,470 km² of the Gulf of Finland is controlled by Leningrad oblast (Anon., 2007c). Kaliningrad oblast borders Lithuania on the east and Poland on the west. It is a Russian exclave, and thus shares no land border with Russia, but it has direct access to the Baltic Sea. Kaliningrad oblast controls approximately 1,203 km² of Curonian lagoon, 495 km² of Vistula lagoon, and 10,000 km² of the Baltic Sea (Anon., 2006b). Approximately 90% of Russian catches taken from the Baltic Sea are from ICES statistical subdivision 26, which borders the Kaliningrad oblast (Figure 1).

Russian fisheries statistics for the exclave of Kaliningrad are collected separately for Curonian lagoon, Vistula lagoon and the Baltic Sea (ICES subdivision 26, Figure 1). In Curonian lagoon, 7-10 species are commercially important out of 31 species available. They are mostly brackish water species, with common bream (*Abramis brama*) constituting 52.2% of reported landings, pikeperch (*Stizostedion lucioperca*) 10.6%, roach (*Rutilus rutilus*) 14.9%, and European smelt (*Osmerus eperlanus*) 2.1% (Anon., 2007c). In 2006, the landings for bream, pikeperch and roach were 99.2%, 80.1%, and 72.2% of the allocated quota, respectively. In Vistula lagoon, Baltic herring (*Clupea harrengus membras*) constitutes 85% of total landings out of 28 species available. Bream and pikeperch constitute 8% and 5% of total landings, respectively. Due to proximity of coastal waters and comparatively inexpensive fishing gear, such as

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gillnets and traps, catch quotas in Vistula lagoon were almost completely filled in recent years (Anon., 2006b).

Major commercial species caught in the waters near Leningrad oblast (ICES subdivision 32, Figure 1) are herring (*Clupea harengus*) and sprat, which constituted approximately 76% of total landings in 2007 (Anon., 2006b). European smelt and brackish water fish, such as pikeperch, bream and northern pike (*Esox lucius*) are also commercially important. In 2007, the majority of herring (97%) was caught by trawl, while gillnets accounted for approximately 3%. Sprat is mostly caught as bycatch during herring trawls. In 2007, 48% of the quota for herring was caught, and pikeperch and bream had landings that were 29% and 38% of their quotas, respectively (Anon., 2007c).

Figure 1. Map of the Baltic Sea with ICES subdivisions and surrounding countries. Russia's coastline borders ICES subdivisions 26 (Kaliningrad) and 32 (Leningrad).

In ICES subdivision 26, major commercial fish species include sprat, herring, and cod (*Gadus morhua*). In recent years, fisheries landings in subdivision 26 were significantly below the allocated quota, with 53.8%, 55%, and 60% of the quota being caught in 2004, 2005, and 2006, respectively (Shibaev, 2004). The only species for which the quota was routinely met was cod, which had 97% of its quota caught in 2006. Pelagic and bottom trawling are the most common fishing techniques in the Baltic Sea proper (ICES subdivision 26), and gillnets are used less frequently. Catches in Vistula lagoon are taken by gillnets and traps, and 80% of catches in Curonian lagoon are taken with gillnets (Shibaev, 2004).

Starting in the 1990s, Russia's fisheries landings began to decline. After the dissolution of the USSR, Russia lost fisheries access to ICES sub-divisions 28 and 29, which are partly within the waters of the now independent Baltic states of Estonia, Latvia, and Lithuania. However, the main reason for declining landings was stated to be inefficient distribution of quotas and new requirements to obtain separate paperwork for fishing either within 12 nautical miles or Russian exclusive economic zone (Shibaev, 2004). Furthermore, often quotas were distributed very late in the fishing season and fishers had less time to catch their assigned quota. Another reason for the decline in catches was the deterioration of fishing vessels and equipment since the dissolution of the USSR. Fishers could rarely afford new vessels, and combined with increases in fuel prices, and the requirement to sell all catches in the territory of Russia, led to increased operating costs and low landings (Anon., 2006b).

The Russian fisheries can be divided into three categories: 1) state-owned fisheries; 2) fisheries-collective farms; and 3) small, private fishing enterprises. Recently, 35-40 private fishing businesses were registered to fish in the waters surrounding Kaliningrad with a total of approximately 300 small boats. Of these small, private fishing businesses, 78% were local, 17% were registered in other regions of Russia, and 5% were foreign-owned (Shibaev, 2004). In 2000, approximately half of the catch quotas in Kaliningrad were received by small, private firms, and half were assigned to collective farms (Shibaev, 2004). State-owned fisheries operate the larger vessels remaining from the Soviet era, whereas the small, private firms use a variety of vessel types. The collective farms are still assigned a large portion of the catch quota in comparison to the small, private enterprises (Shibaev, 2004).

Currently, fisheries statistics in these two administrative divisions of Russia are obtained from reports collected every 15 days from registered fisheries, and information from log books, collected at the time of

landing. Logbook data provides information on fishing location, landings by taxa, gear types used, and effort. This procedure is similar to that of European Union countries.

Prior to 2005, fisheries statistics were collected and reported by separate organizations for the Kalingrad and the Leningrad oblast. From 2005-2007 the Federal Agriculture Civil Service became responsible for collecting data for both areas. This is now the responsibility of the Federal Fishery Agency. Recreational and subsistence (household use) fishing has traditionally represented a challenge for governmental organizations due to its massive character and poor organization of license distribution. However, there are some recreational catch data, including the number of recreational fishers and catch rates that enabled estimates of recreational catches to be made (Shibaev, 2004).

The purpose of this study is to provide an estimate of total marine and brackish water fisheries catches in the Baltic Sea by the Russian Federation or its equivalent entity (1950-2007) utilizing an approach called 'catch reconstruction' described by Zeller *et al.* (2007) and Zeller and Pauly (2007). The resultant reconstructed total catch estimates are then compared to the official fisheries landings data that represent the publicly reported data.

METHODS

ICES landings statistics (ICES, 2009) were used as the reported landings data baseline for our reconstruction of Russia's fisheries catches in the Baltic Sea for the period 1950-2007. Thus, the ICES landings statistics are taken as the *reported* data, as they are the only data source that is readily publicly available (via the ICES website), and covers all taxa landed, countries, years (since at least 1950), and areas of the Baltic Sea for the time period considered here. However, ICES landing statistics were only available for the Russian Federation (Russia) from 1993-2007. Prior to 1990, Russia's landings were reported as part of the overall 'USSR' landings, which combined the landings of Russia, Estonia, Latvia, and Lithuania. The Latvian Fish Resource Agency (LATFRA) during the USSR period was the central office for data collection for the Baltic States and Russia. Landings data provided by Maris Plikshs, the director of LATFRA, allowed for the separation of Russia's catches from USSR landings from 1950-1989. The sum of these disaggregated USSR landings data (LATFRA source) was virtually identical to the ICES reported landings for the 'former' USSR during the same time period.

National landings data for Russia's fisheries in the Baltic Sea were collected from the Leningrad oblast and the Kaliningrad oblast, the exclave located between Poland and Lithuania, from reports published by the Federal Agency on Fisheries in the Northwestern Baltic (Sevzaprybvod) and the Federal Agency on Fisheries in the Western Baltic (Zapbaltrybvod; Anon., 2006b; 2007c). Here, landings data from these two districts were combined to form the total landings for Russia (for separate data see Appendix C and D).

For the period 1950-1989, the disaggregated USSR landings data supplied by LATFRA were used as the sole estimate of reported landings and are presented here as an adjustment to the reported data (i.e., ICES landings statistics) as they were not supplied by ICES directly. Thus, USSR data provided by ICES were not used. For the 1990-2007 period, adjustments to the ICES landings statistics were made using ICES stock assessment working group data (ICES, 2007; 2008b) and national data provided by Russia (Anon., 2006b; 2007c). In addition to these adjustments, estimates of unreported landings (ICES terminology: 'unallocated' catches) were added to the adjusted ICES landings, discards were then applied to this total as a means of estimating discarded catch, and recreational catches were also estimated. The resulting sum of ICES landings statistics, adjustments, unreported landings, total discards and recreational catches represented the total reconstructed catch for Russia from 1950-2007.

The reconstruction illustrated in this report is presented specifically for the main commercially targeted species including cod; herring; sprat; salmon (*Salmo salar*); the flatfish group, which includes European flounder (*Platichthys flesus*) and turbot (*Psetta maxima*); and another 25 taxa grouped here as 'others'.

Illegal, Unreported and Unregulated (IUU) catches

Illegal, Unreported and Unregulated (IUU) fishing are a major source of underreporting in fisheries catch data, globally (Zeller and Pauly, 2007) and are also of concern in the Baltic Sea (Menn, 2006; Anon., 2007b; ICES, 2008a). Here, we considered all catches not included in the ICES landings statistics as IUU catches, comprising of: a) '*adjustments*' to ICES landings statistics based on reliable sources for reported landings data such as ICES stock assessment working group data and national data sources; b)

'*unreported*' landings (defined by ICES as 'unallocated' catches) being all other landings that are not specifically reported by country and year; c) '*discards*', which consisted of four categories; and d) '*recreational*' catches.

Adjustments to ICES landings statistics

Adjustments were made to the ICES landings statistics using a range of available sources (Table 1). Russia's landings data for the 1950-1989 time period were provided by LATFRA. ICES stock assessment working group data were used to make adjustments to ICES landings statistics for cod, herring and flatfishes for the 1991-2007 period (Table 1). Additional landings data for the group 'others' were obtained from national reports (Anon., 2000b; 2007c).

Table 1. Sources of adjustments to ICES landings statistics for Russia from 1950-2007.

Common name	Years	Source
Cod	1950-1989	LATFRA
	1991-2007	ICES (2007, 2008a)
Herring	1950-1989	LATFRA
	1991	ICES 2008a
Sprat	1953-1989	LATFRA
Salmon	1950-1989	LATFRA
Flatfishes	1950-1989	LATFRA
	1991-1993; 1995; 1998; 2001-2004	ICES (2008a)
'Others '	1950-1989	LATFRA
	1997-2000	Anon. (2006b, 2007c)

The adjustment data sources (Table 1) showed that no landings data were reported for sprat between 1950 and 1953. To estimate these likely missing sprat landings, we used the average landings from the first three years of reported data (1953-1955) as the estimated value in each year from 1950-1952. Missing values from 1990 onward were derived through linear interpolation between anchor points of known values or through default methods.

Unreported landings

In the Baltic Sea, unreported landings are considered the most significant component of IUU catches (Anon., 2007a). However, here we assumed that from 1950-1990, unreported landings for Russia were 0%, in line with the conservative assumption we applied to all former eastern bloc countries (Zeller *et al.*, this volume). The rationale for this was that there was little incentive not to land all that was caught, as the centralized, non-market economic system paid the same prices for all species. For the period 1993-2007, unreported landings estimates were based on what ICES refers to as 'unallocated catches'. Rates of unreported landings for all species were derived from ICES stock assessment working group data (Zeller *et al.*, this volume) which reports the tonnage of unallocated catches as a single annual value for all the Baltic Sea (i.e., non-transparent with regards to country, even though only a small subset of countries are known to provide unallocated catch data). The resulting rates for unreported landings (Table 2) were applied to landings (ICES landings statistics + adjustments) to derive tonnage of unreported landings. To estimate unreported landings for 1991 and 1992, the years which reflect the transition from a state-controlled economy to a market-based economy, values were interpolated from 0% in 1990 to the first anchor points in 1993 (Table 2).

Table 2. Anchor points (%) used for estimating unreported landings for cod, salmon and other taxa from 1950-2007 based on sources (Tables 2.3.1 and 2.4.1 in ICES, 2007; Tables 2.1.2 in ICES, 2008a). Dashed lines (-) indicate years when linear interpolations were used.

Year	Cod[a]	Salmon	Others[b]
1993	87.7	19.4	24.6
1994	123.6	18.7	30.3
1995	29.7	19.5	-
1996	13.1	20.4	-
1997	-	20.8	-
1998	-	20.1	-
1999	-	20.4	-
2000	46.0	19.9	-
2001	47.6	20.4	-
2002	47.5	20.5	-
2003	59.8	20.1	-
2004	52.9	20.6	12.3
2005	46.4	20.7	11.2
2006	46.9	22.2	11.2[c]
2007	87.7	21.4	11.2[c]

[a] eastern stock only; [b] includes all taxa other than cod and salmon; [c] 2005 rate carried forward.

Discards

Here, we separated discards into four categories, which combined gave us total discard amounts for each taxon: a) '*ghostfishing*' as a result of lost fishing gear; b) '*underwater discards*' accounting for the mortality of fish lost from actively fishing gear prior to being brought on board; c) '*boat-based discards*' usually based on fishers' catch retention behavior; and d) '*seal-damaged discards*' representing the fraction of catch discarded because of seal damage. To remain conservative, and to avoid double accounting, seal-damaged discard rates were used in place of boat-based discards for some taxa in years

when the seal-damaged discard rate was higher than the boat-based discard rate (Zeller *et al.*, this volume).

'*Ghostfishing*' is a worldwide problem highlighted in recent work by Macfadyen *et al.* (2009). The ghostfishing rate for Russia, as for the rest of the Baltic countries, was based on a Swedish study by Tschernij and Larsson (2003) that estimated the amount of cod caught in Sweden by lost gear and related it to commercial catches in Sweden. Using these data, Brown *et al.* (2005) estimated the range of ghostfishing rates by lost gear to be between 0.01% and 3.2%. Here, we used the average of 1.65% applied to all other taxa, except herring and sprat, for all years.

'*Underwater*' discards were only estimated for herring and sprat. These pelagic species are caught by the same fleet as their distribution and areas where they are fished overlap. Inaccurate data on catch composition due to the mixed nature of this fishery, and the fact that these two species are targeted by the same fleet, led us to apply the same underwater discard rate to both species (ICES, 2008a)

Our estimate of underwater discards for herring and sprat were derived from a trawl study by Rahikainen *et al.* (2004) who related underwater discard amounts to the observed herring catches brought on board. We translated this into a rate of approximately 9% for underwater discards of herring caught by trawl (Zeller *et al.*, this volume). Since herring and sprat landings for Russia are not reported by gear type, the trawl-based rate of 9 % was reduced to a more conservative estimate of 5% applied to all herring and sprat landings.

'*Boat-based*' discards were assumed to be minimal prior to 1990, as discarding was considered illegal during the USSR period, and all fisheries catches were to be landed (S.V. Shibaev, unpubl. data). However, it is likely that there were some discards of unmarketable, unpalatable or inedible species. Therefore, the assumed default rate of 2% was applied to all species, except herring and sprat for the period from 1950-1990. This rate compares conservatively to a Norwegian study that suggested a boat-based discard rate of 6% occurred in Norway's fisheries where discarding is illegal (Jensen, 2004). From 1990-1993, estimates of boat-based discards were derived through linear interpolation between the 1990 rate of 2% and the first anchor point in 1993 (Table 3). From 1993-2007, boat-based discards for salmon and cod were estimated using ICES stock assessment working group data (Zeller *et al.*, this volume). For all other species, discards were derived from a Danish study (Anon., 2006a).

'*Seal-damaged*' discards, associated with fixed-gear fisheries, have been a concern in the Baltic Sea since the 1980s when seal populations increased dramatically from a previously depleted state (Österblom *et al.*, 2007). Data on seal-discards for Russia were not available, but Russia borders Finland in subdivision 32. Since both Russia and Finland employ stationary gear vulnerable to seal discard within this area, the magnitude of the seal discards and the species affected by seal-damage is likely to be very similar between these two countries. Therefore, we applied our estimated Finnish seal-damaged discard rate to Russia's catches within subdivision 32 for salmon, herring, pike perch and European perch for the period 1980-2007 (Rossing *et al.*, this volume). We substituted the seal-damaged discard rate for the boat-based discard rate for subdivision 32 only in instances when the seal-damaged discard rate was higher than the boat-based discard rate. This approach was used to avoid double accounting and to apply a conservative estimate, as boat-based discard values may already include some seal-damaged discards. For all other subdivisions we used the boat-based discard rate.

Table 3. Boat-based salmon discard rates as a % (derived from Table 2.1.2 in ICES, 2008b) for Russia were used except for ICES subdivision 32 when our seal-damaged discard rates, derived from Finnish Game and Fisheries Research Institute (FGFRI) data, were greater (1981-2007). Values in *italics* indicate an interpolated rate.

Year	Discards	
	Boat-based	Seal-damaged
1980	2.00	0.00
1981	2.00	*6.89*
1982	2.00	*13.78*
1983	2.00	*20.66*
1984	2.00	*27.55*
1985	2.00	*34.44*
1986	2.00	*41.33*
1987	2.00	*48.22*
1988	2.00	*55.10*
1989	2.00	*61.99*
1990	2.00	*68.88*
1991	*6.00*	*75.77*
1992	*10.00*	*82.66*
1993	14.00	*89.54*
1994	13.00	*96.43*
1995	14.00	*103.32*
1996	15.00	*110.21*
1997	15.00	*117.10*
1998	14.00	*123.98*
1999	15.00	*130.87*
2000	10.33	137.76
2001	14.98	203.44
2002	15.75	255.80
2003	15.43	337.31
2004	15.62	380.54
2005	15.21	113.18
2006	17.38	149.26
2007	14.22	102.66

Seal-damaged discard rates for salmon in subdivision 32 were compared to the default boat-based discard rates, and the higher rates between the two categories were used to estimate discards in subdivision 32 only (Table 3). For all other subdivisions and years prior to 1980, the default boat-based discard rates were used.

For herring, seal-damaged discard rates from subdivision 32 were compared to the default boat-based discards for the period 1980-2007 (Table 4). As boat-based discards for herring were assumed to be zero for the entire study period, the seal-damaged discard rate was used from 1981-2007 as it was the higher rate.

Seal-damaged discard data for pikeperch and European perch, derived from FGFRI, were applied to Russia's landings of these species in subdivision 32 when the seal-discard rate was higher than the default boat-based discard rate. Seal-damaged discard rates were higher than the default boat-based discard rates from 2005-2007 for both species (see Appendix Table A1 and A2).

Table 4. Seal-damaged discard rates for herring in Subdivision 32, derived from Finnish Game and Fisheries Research Institute (FGFRI) data, were used in place of boat-based discards from 1981-2007. Boat-based discards were assumed to be zero from 1950-2007. Dashed (-) line indicates an interpolated rate.

Year	Seal-damaged
1980	0.00
1981-1999	-
2000	0.00
2001	0.00
2002	0.02
2003	0.01
2004	0.00
2005	0.12
2006	0.00[a]
2007	0.38

[a] less than 0.01.

Recreational catches

Reports of recreational catches for Russia were mostly lacking throughout the time period considered. Reported recreational catch totals were available for Vistula lagoon in Leningrad oblast and Curonian lagoon in Kaliningrad oblast for 2005/2006 (Anon., 2006b; 2007c). Catches in these two recreational fishing areas were presented as the total number of recreational fishers and the total tonnage of fish caught, for all species combined. Anchor points were established for the number of fishers in 1980 and 1950 using an assumption-based approach. We assumed that in 1980 there were half the numbers of recreational fishers as in 2005, and in 1950 there were a quarter of the fishers as in 2005. To obtain a complete time series of number of fishers from 1950-2007, a linear interpolation was done between anchor points. We derived a catch rate of 5 kg·fisher^{-1}·year^{-1} from the number of fishers and the total recreational catch for 2005/2006. This catch rate was held constant back in time to 1950 and combined with the number of fishers to estimate the total recreational catch. The same methodology was applied to Vistula lagoon and Curonian lagoon to estimate total recreational catch.

To estimate the catch by taxon for each of the two recreational fishing areas, information was obtained regarding the recreational catch composition of the nearest neighboring country that reported recreational catches. For recreational catches in Vistula lagoon, the species composition of recreational catches was assumed to be similar to that of Finland, which is the nearest neighboring country that reported recreational catches (Rossing *et al.*, this volume). The catch composition included 17 taxonomic groups. For each of these taxonomic groups, the average proportion of the Finnish recreational catches from 1980-2007 were applied to the estimated recreational catches for Vistula lagoon.

For Curonian lagoon, recreational catch composition was based on Germany's recreational catch composition (Rossing *et al.*, this volume). Germany is the nearest neighboring country to Kaliningrad that provides detailed data on its recreational catches. The average proportion of cod, herring and flounder that were caught in Germany's recreational fisheries were applied to the estimated recreational catches for Curonian lagoon.

Overall, total reconstructed catches were obtained as the sum of ICES landings statistics, adjustments, and estimates of unreported landings, discards and recreational catches. The estimated total reconstructed catch was then compared to the officially reported data, defined here as the ICES landings statistics.

RESULTS

ICES landings statistics only exist for the Russian Federation (Russia) from 1992 onward. Prior to 1990, Russia was part of the Union of Soviet Socialist Republics (USSR) and landings for Russia were reported to ICES as part of the overall USSR landings, which also included landings for Estonia, Latvia and Lithuania. For the period between 1990 and 2007, ICES landings statistics reported a total of 739,288 t for Russia

(Figure 2). The time series of ICES landings showed a decrease in landings from 50,000 t in 1992 to around 37,000 t in 1994. Landings increased again around 1998, reaching a high of almost 60,000 t in 2001. Landings decreased to an average of approximately 44,000 t·year^{-1} in the period from 2004-2007 (Figure 2). Here, we treat the ICES landings statistics as the officially reported data foundation, as it is the only readily available and publicly accessible fisheries data source that covers all countries, all years, all taxa and all statistical areas.

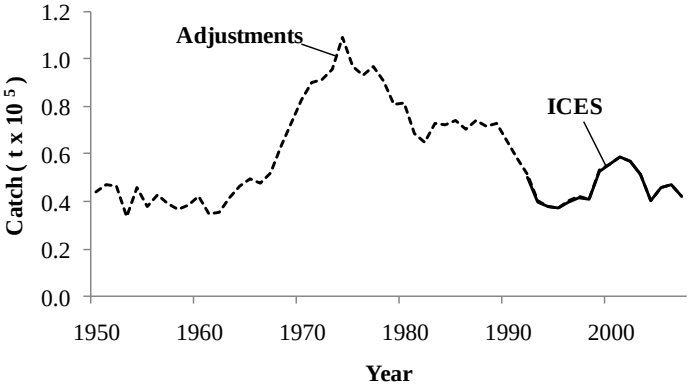

Figure 2. ICES landings statistics and adjustments to ICES landings statistics for Russia, 1950-2007.

Illegal, Unreported and Unregulated (IUU) catches

All catches (and landings) that are not reported in the ICES landings statistics were considered here as IUU catches and were added to the ICES landings statistics to form our estimate of total reconstructed catch. These IUU components included: a) '*adjustments*' to ICES landings statistics from other reliable data sources of reported landings, including ICES stock assessment working group data and national data sources; b), '*unreported*' ('unallocated') landings; c) '*discards*'; and d) '*recreational*' catches. Combining the estimated IUU components with the ICES landings statistics formed the total catch reconstruction for 1950-2007. See Appendix Tables B1-B7 for complete time series data on all additions to taxonomic catch data, by catch component

Table 5. Total adjustments (tonnes) to ICES landings of commercially targeted species in Russia from 1950-2007.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod[a]	142,250	35,730	45,114	159,770	8,274	-489
Herring	184,400	214,250	353,267	351,244	66,342	0
Sprat	16,040	158,430	411,235	96,654	27,184	0
Flatfishes	1,710	1,770	1,615	3,242	772	4
Salmon	660	40	54	827	211	27
'Others'	67,130	76,000	116,782	112,544	11,068	436

[a] eastern stock only.

Adjustments to ICES landings statistics

Additional landings data for Russia were obtained from the Latvian Fish Resources Agency (LATFRA), from ICES stock assessment working group reports and from national sources (see methods for source details). These provided the information to make adjustments to the ICES landings statistics. Landings for the period 1950-1989 were adjusted from zero using the obtained from the LATFRA, as there were no officially reported ICES landings for Russia during this period (which were part of the 'former USSR' ICES category). Thus, adjustments were quite substantial for the early period from 1950-1990, after which only minor adjustments were made to the reported landings (Figure 2, Table 5). Cod, herring and sprat were the largest contributors to these adjustments (Table 5). The total tonnage of adjustments to ICES landings was approximately 2,660,000 t over the study period (1950-2007), with the majority from 1950-1990.

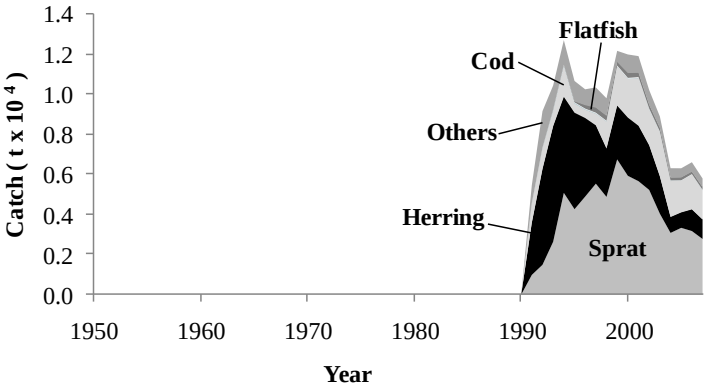

Figure 3. Russia's unreported landings by taxa, 1950-2007.

Unreported landings

Unreported landings from 1950-1990 were assumed to be zero (see methods). For the 1991-2007 period, total estimated unreported landings for all species combined were approximately 145,900 t (Figure 3, Appendix Table B1). Unreported landings increased dramatically from zero in 1990 to just over 11,000 t·year^{-1} in 1999, before declining to around 6,000 t·year^{-1} by 2007.

Table 6. Total (tonnes) unreported landings of commercially targeted species for Russia from 1950-2007.

Common name	1950-1989	1990-1999	2000-2007
Cod[a]	0	7,850	14,978
Herring	0	30,381	13,016
Sprat	0	32,517	32,108
Flatfishes	0	1,084	1,560
Salmon	0	81	35
'Others'	0	7.582	4,791

[a] eastern stock only.

Over the study period, the majority of unreported landings were of herring and sprat, with estimated totals of about 43,400 t and 64,600 t, respectively (Appendix Table B3 and B4). Unreported landings of herring and sprat were quite substantial during the 1990s, each averaging approximately 3,500 t·year^{-1} (Figure 3). Cod represented 16% of the total unreported catch and 'others' represented 8% (Figure 3, Appendix Table B2). Flatfish and salmon contributed less to the overall unreported landings with estimated totals of approximately 2,600 t and 120 t, respectively (Appendix Table B6 and B5). Unreported landings of flatfishes were most substantial during the 2000s with a total of about 1,560 t, while the highest levels of unreported landings for salmon occurred in the 1990s, totaling just over 80 t (Table 6).

Discards

From 1950-2007, estimated discards for all species totaled approximately 178,700 t (Figure 4). Unlike unreported catches, discards were of concern throughout the study period. Total discards peaked during the 1970s, with a total of over 44,000 t summed over the decade, while discards of cod over the entire study period were around 18,800 t (Figure 4). Cod discards fluctuated considerably, ranging from approximately 20 t·year^{-1} to 1,000 t·year^{-1}. Herring discards averaged 1,700 t·year^{-1} during the 1970s and 1980s, which was much higher than during other periods (Figure 4). The highest levels of discards for sprat were also during the 1970s with over 20,500 t in that decade. Total flatfish discards were estimated at over 9,500 t for the 1950-2007 period, with peaks in the 1990s and 2000s (Figure 4, Table 7) and a total of approximately 9,000 t for these two decades. Salmon discards totaled approximately 580 t over the entire study period, and peaked during the early to mid-1990s (Figure 4). Estimated discards of 'others' totaled about 21,000 t over the study period.

Table 7. Total discards (tonnes) of commercially targeted species for Russia from 1950-2007.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod[a]	5,192	1,304	1,647	5,832	1,535	3,208
Herring	9,020	10,713	17,663	17,562	11,614	5,192
Sprat	802	7,922	20,562	4,833	10,220	13,197
Flatfishes	62	65	59	118	3,005	6,173
Salmon	24	1	2	296	194	58
'Others'	2,450	2,774	4,263	4,105	3,693	3,295

[a] eastern stock only.

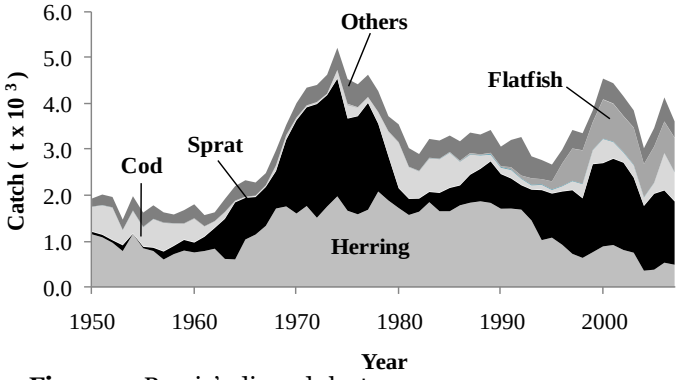

Figure 4. Russia's discards by taxa, 1950-2007.

Recreational catches

Total catches by Russia's recreational fisheries in the Baltic Sea from 1950-2007 were estimated at approximately 14,800 t (Figure 5). Recreational catches increased gradually from about 100 t·year^{-1} in 1950 to around 225 t·year^{-1} by 1980. From 1980 to 2007, recreational catches continued to increase steadily, with the highest levels estimated for 2005 through 2007 at 450 t·year^{-1}. Recreational fisheries are dominated by cod, which represents nearly 70% of the total recreational catch, while 'others' represented 20%, herring represented 8% and flatfishes represented 2% of the total recreational catch (Figure 5, Table 8). Recreational catches of cod increased steadily over the study period from 77 t·year^{-1} in 1950 to 310 t·year^{-1} in 2007 (Figure 5), and totaled 10,000 t during the study period. Recreational catches of herring were minimal, adding only about 1,200 t to the total catch over the study period, while recreational catches of sprat were even lower, totaling only about 20 t from 1950-2007 (Figure 5; Appendix Table B5). Recreational catches of flatfishes increased from 3 t·year^{-1} in 1950 to 11 t·year^{-1} in 2007, totaling almost 350 t over the 1950-2007 time period. Recreational catches of salmon were also low, totaling 52 t over the study period.

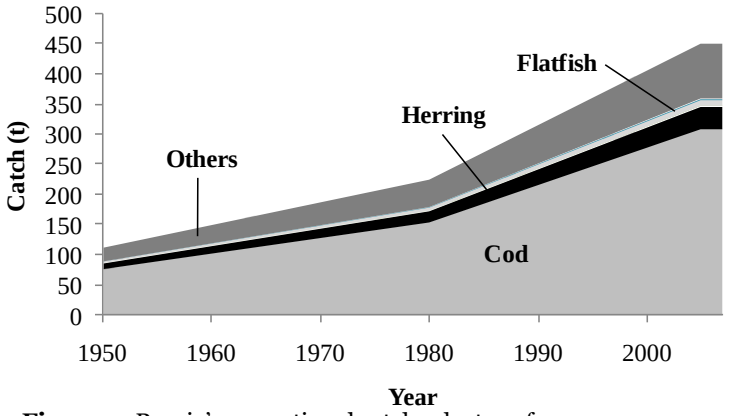

Figure 5. Russia's recreational catches by taxa from 1950-2007.

Table 8. Total recreational catches (t) for Russia from 1950-2007.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod[a]	890	1,148	1,406	1,827	2,446	2,384
Herring	106	137	168	218	292	285
Sprat	2	2	3	4	5	5
Flatfishes	31	39	48	63	84	82
Salmon	5	6	7	10	13	12
'Others'	259	339	411	535	780	785

[a] eastern stock only.

Total reconstructed catch

The total reconstructed catch for Russia, which combined ICES landings statistics with IUU estimates (reporting adjustments, unreported landings, discards and recreational catches), was estimated to be 3,739,244 t for the 1950-2007 time period (Figure 6). Overall, adjustments to landings, unreported landings, discards and recreational catches added over 3 million t to the ICES landings statistics, which were reported to be about 740,000 t over the study period (Figure 7). However, these landings were only for the period 1992-2007, as ICES did not report landings for Russia as a separate entity prior to this period. As ICES landings statistics data for Russia, specifically, were only available from 1992 onward, the total reconstructed catch was compared to the ICES landings statistics for the period from 1992-2007. During this period, the total reconstructed catch was 28% higher than the ICES landings statistics data (Figure 7, Appendix Table B1).

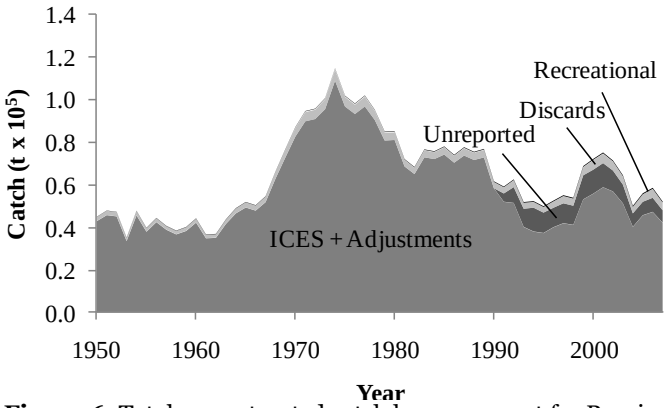

Figure 6. Total reconstructed catch by component for Russia from 1950-2007.

Adjustments to ICES landings contributed the majority of additional landings, representing 71% of the total reconstructed catch. Other contributions to the total reconstructed catch were discards and unreported landings representing 5% and 4%, respectively (Appendix Table B1). Recreational catches were relatively low and contributed only a minor amount (0.4%) to the total reconstructed catch. Discards were

most substantial in the 1970s and 1980s, and unreported landings were largest in the 1990s and 2000s (Table 9). Recreational catches increased steadily over the study period, but were low compared to other IUU components.

Over the study period, Russia's fisheries in the Baltic Sea were dominated by herring and sprat, which together represented 73% of the total reconstructed catch (Table 10). Herring and sprat catches, including reported landings (ICES landings statistics) and unreported catches (adjustments, unreported landings, discards, and recreational catches) were highest during the 1970s, but were significant throughout the study period in comparison to catches of other taxa (Table 10).

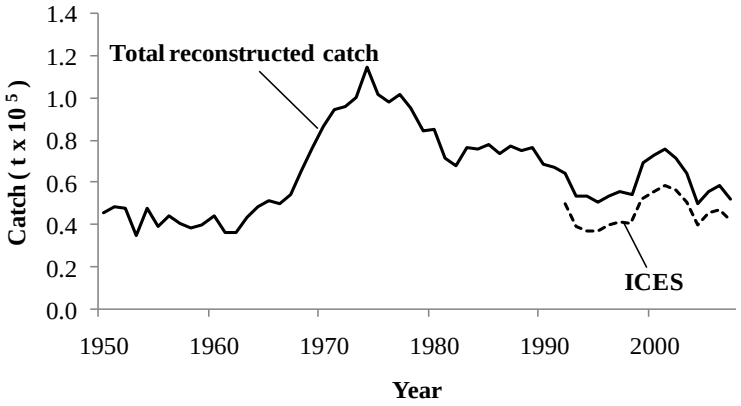

Figure 7. Russia's total reconstructed catch from 1950-2007 and ICES landings statistics from 1991-2007.

Table 9. Total Reconstructed catch (tonnes) by component for all taxa for Russia from 1950-2007.

Component	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
ICES	0	0	0	0	340,568	398,719
Adjustments	408,190	486,220	928,090	724,190	113,851	-23
Unreported	0	0	0	0	79,494	68,198
Discards	17,551	22,778	44,196	32,746	30,261	31,124
Recreational	1,292	1,671	2,043	2,656	3,619	3,552

DISCUSSION

This study presents separate catch data for Russia, which has been disaggregated from the former USSR landings. This is probably the first time that such a comprehensive time series of Baltic Sea fisheries data for Russia has been made publicly available in the English literature for Russia's fisheries.

The present study subsitutes, at least for the Baltic Sea, the USSR disaggregation efforts of Zeller and Rizzo (2007), wich were based entirely on FAO data. Our reconstruction of Russia's total fisheries catches in the Baltic Sea for the period 1950-2007 were estimated to be approximately 3.7 million tonnes. As ICES has not retroactively adjusted its landings data to reflect the dismantling of the USSR, here we compare the ICES landings data to our reconstructed catch for the period 1992-2007 (as this is the only period when data were presented for Russia separately in the publicly accessible ICES landings statistics database), and over the time period 1950-2007. ICES landings statistics reported total landings of approximately 739,000 t for Russia over the period 1992-2007. Our reconstruction of Russia's total catches in the Baltic Sea for the same period (1992-2007) was approximately 946,800 t, and was therefore 28% higher than the ICES landings statistics over the same time period. However, when making the comparison between Russia's landings statistics as presented in ICES (1992-2007), and our catch reconstruction (1950-2007), our estimated total catches were approximately 500% higher. The large discrepancy between the total ICES landings and our reconstructed catch when considering the entire study period (1950-2007) was predominantly due to the adjustments made to ICES landings statistics using the disaggregated USSR landings data provided by LATFRA.

Table 10. Total (tonnes) reconstructed catch for commercially targeted species in Russia from 1950-2007.

Common name	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007
Cod[a]	148,332	38,182	48,167	167,428	40,115	51,256
Herring	189,526	225,100	371,098	369,025	244,180	109,036
Sprat	16,844	166,354	431,800	101,490	214,621	277,145
Flatfishes	1,803	1,874	1,722	3,423	9,726	18,745
Salmon	689	47	63	1,133	901	279
'Others'	69,839	79,113	121,480	117,093	58,258	43,341

[a] eastern stock only.

Our diaggregation of Russian catches into the two oblasts, suggested that for the entire 1950-2007 time period, both regions caught approximately equal amounts of fish (St. Petersburg 50.1%, Kaliningrad 49.9%, Appendix tables C, D). However, by the 2000s, this pattern had changed drastically, with

Kaliningrad accounting for 90% of fisheries catches, and St. Petersburg for 10% (Appendix tables C, D). Fisheries out of St. Petersburg appear to have declined substantially by the 2000s.

Unreported landings are a serious concern for fisheries worldwide and are considered to be the most significant component of IUU in the Baltic Sea (Anon., 2007b). Unreported landings for Russia were only considered from the early 1990s onward and represented 15% of the total reconstructed catch for the period 1992-2007. Discards have been identified as a major contributor in underestimating the impacts of global fisheries on the marine ecosystems (Alverson, 1994). Discarded catches were considered for Russia throughout the entire study period, and represented 4% of the total reconstructed catch from 1950-2007. Both unreported landings and discards were dominated by herring and sprat, which were also the most significant fisheries in Russia throughout the study period.

Recreational fisheries were a minor contributor to the total reconstructed catch; however, our estimates were very rudimentary for this catch component. Recreational fisheries data were lacking for most of the time-period considered, with reports only for a few years during the most recent decade. While the magnitude of recreational fisheries is likely much less than commercial fisheries, improved data collection is necessary in order to build a more complete picture of total fisheries catches from the Baltic Sea, particularly as these two fisheries often target different taxa. Recreational fisheries in Russia were dominated by cod and 'others' while commercial fisheries were dominated by herring and sprat. In order to improve recreational fisheries data, Russia should conduct creel surveys on a regular basis (e.g., every few years) used to expand to Russia Baltic Sea-wide catches, and use estimation methods between survey years.

Illegal, Unreported and Unregulated (IUU) fisheries are a problem worldwide, and have also been identified as a concern in the Baltic Sea, but information on IUU fisheries in Russia was sparse. A study on fishing activities in Russia's Far East estimated IUU to be 20-60% of reported catches for the area, and anecdotal evidence suggests that it might be even higher (Burnett *et al.*, 2008). The same report stated that a substantial quantity of fish caught by Russian vessels in the Barents Sea were landed in foreign ports or transferred to foreign cargo vessels before being landed and therefore unreported (Burnett *et al.*, 2008). This type of IUU activity that is known to occur in the Barents Sea is likely to occur also in other areas of Russia. However, we were unable to find similar accounts of IUU fishing activities for Russia in the Baltic Sea. To quantify the IUU components considered in this study, we had to rely on Baltic-wide estimates, which are likely to be conservative, for IUU components of Russia's Baltic Sea fisheries.

Where IUU fisheries data for Russia were not available, estimates were made based on assumptions and/or Baltic-wide approximations of unreported (IUU) catch components. ICES, in their stock assessment working group reports, presents some Baltic-wide estimates of catch components such as unreported ('unallocated') catches and discards, but do not identify which (or how many) countries have contributed to these data, even though it is known that only some countries present these components. ICES maintains confidentiality agreements with its members which generally prevents the disclosure of data. This lack of transparency in reporting by ICES means that the Baltic-wide estimates used here are likely lower than what could have been determined if ICES (and by extension, its member states) were more forthcoming with their data.

The estimates used for unreported landings should be considered minimal estimates and are therefore conservative. This is because we used reported amounts of unreported landings as a ratio to Baltic-wide landings. Although, corrections were made to the Baltic-wide landings for countries which are known to not report amounts of unreported landings (e.g., Sweden, Persson, this volume), it is likely that other countries do not report these details either. Thus, the ratio of unreported landings used would have been greater if corrections had been made to account for all non-reporting countries landings. As long as we have not overestimated any IUU catches, the assumptions used to generate our estimates are justified given the alternative assumption that non-reported or missing data are approximated as zero catch (Zeller and Pauly, 2007).

Russia is the only Baltic country that is not a member of the European Union (EU). While Russia is not bound by the same EU fisheries rules and regulations as the other Baltic countries, Russia does have a fisheries agreement with the EU that follows similar guiding principles. Baltic fisheries were regulated through the International Baltic Sea Fisheries Commission (IBSFC) until 2005 (Anon., 2007b). With all the Baltic countries except Russia joining the EU, a bilateral agreement between the European Union and the Russian Federation on "co-operation in fisheries and the conservation of the living marine resources in

the Baltic Sea" was adopted in 2006 to replace the IBSFC (Anon., 2009). Russia continues to report landings to ICES, as is the case for all the Baltic countries. Total allowable catches (TAC's) are set based on ICES recommendations but are then sanctioned by the EU in accordance with its agreement with Russia. The EU is planning a revision of its Common Fisheries Policy (CFP) in 2012, and although Russia is not bound by the CFP, the recommendations for the revised policy would hopefully also apply to the management of Russia's fisheries in the Baltic Sea. Russia should aim to align its fisheries objectives with these upcoming revisions to the CFP in order to work toward harmonizing fisheries management in an effort to facilitate movement towards ecosystem-based management. An important recommendation for the revised CFP, which also pertains to Russia, is increased transparency in fisheries data collection, decision-making and dissemination of information to all stakeholders, including the general public.

Russia has a history of nondisclosure with nationally held data, particularly with respect to fisheries catches during the Soviet era. During the Cold War, fisheries data in Russia were considered a "state secret" (V. Spirodonov, pers. comm., P.P. Shirshov Institute of Oceanology). A major concern for Russian fisheries in the Baltic Sea is a lack of consistent data made readily available to the Baltic and global community (ICES, 2005; 2007). Also, records that could have shed some light on Russia's historical catches were lost during the collapse of the USSR (S. Shibaev, unpubl. data). The time series of commercial catches is therefore incomplete and information on unreported catches, discards and recreational catches is even poorer. Russia should reduce discarding and unreported landings. Complete (100%) observer cover, video surveillance and satellite Vessel Monitoring Systems would substantially increase the accuracy of total (including IUU) catches which would in turn properly inform regulatory and policy decisions. Improved monitoring and enforcement are important, but increased transparency is even more crucial as it can enhance the quality of fisheries data and improve fisheries management and policy decisions. For an ecosystem-based management approach to be effective in the Baltic Sea, countries such as Russia need to improve the collection of data and make these widely available for the purpose of improving fisheries management and accountability in maintaining a publicly owned resource.

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APPENDIX A

Table A1. Boat-based perch (*Perca fluviatilis*) discard rates (%) for Russia used in all subdivisions except in subdivision 32 when seal-damaged discard rates derived from FGFRI data were greater (1980-2007). Values in *italics* indicate an interpolated rate.

Years	Boat-based	Seal-damaged
1980	2.00	0.00
1981	2.00	*0.00*
1982	2.00	*0.00*
1983	2.00	*0.00*
1984	2.00	*0.00*
1985	2.00	*0.00*
1986	2.00	*0.00*
1987	2.00	*0.00*
1988	2.00	*0.00*
1989	2.00	*0.00*
1990	2.00	*0.00*
1991	*3.4*	*0.00*
1992	*4.8*	*0.00*
1993	6.24	*0.00*
1994	6.24	*0.00*
1995	6.24	*0.00*
1996	6.24	*0.00*
1997	6.24	*0.00*
1998	6.24	*0.00*
1999	6.24	*0.00*
2000	6.24	*0.00*
2001	6.24	*0.00*
2002	6.24	*0.00*
2003	6.24	0.21
2004	6.24	0.20
2005	6.24	28.45
2006	6.24	75.79
2007	6.24	7.29

Table A2. Boat-based pikeperch (*Sander lucioperca*) discard rates (%) for Russia used in all subdivisions except in subdivision 32 when seal-damaged discard rates derived from FGFRI data were greater (1980-2007). Values in *italics* indicate an interpolated rate.

Years	Boat-based	Seal-damaged
1980	2.00	0.00
1981	2.00	*0.00*
1982	2.00	*0.00*
1983	2.00	*0.00*
1984	2.00	*0.00*
1985	2.00	*0.00*
1986	2.00	*0.00*
1987	2.00	*0.00*
1988	2.00	*0.00*
1989	2.00	*0.00*
1990	2.00	*0.00*
1991	*3.4*	*0.00*
1992	*4.8*	*0.00*
1993	6.24	*0.00*
1994	6.24	*0.00*
1995	6.24	*0.00*
1996	6.24	*0.00*
1997	6.24	*0.00*
1998	6.24	*0.00*
1999	6.24	*0.00*
2000	6.24	0.09
2001	6.24	0.94
2002	6.24	0.51
2003	6.24	6.22
2004	6.24	4.71
2005	6.24	17.37
2006	6.24	44.10
2007	6.24	51.94

APPENDIX B

Appendix Table B1. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for Russia (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	43,030	0	1,884	112	45,027
1951	N/A	45,840	0	1,970	116	47,926
1952	N/A	45,250	0	1,916	120	47,286
1953	N/A	33,630	0	1,476	124	35,230
1954	N/A	45,720	0	1,985	128	47,833
1955	N/A	38,030	0	1,628	131	39,790
1956	N/A	42,540	0	1,787	135	44,462
1957	N/A	38,970	0	1,634	138	40,743
1958	N/A	36,780	0	1,587	142	38,509
1959	N/A	38,400	0	1,682	146	40,228
1960	N/A	42,310	0	1,809	150	44,270
1961	N/A	34,940	0	1,574	154	36,668
1962	N/A	35,180	0	1,635	158	36,973
1963	N/A	41,680	0	1,926	162	43,767
1964	N/A	46,650	0	2,205	165	49,020
1965	N/A	49,440	0	2,333	169	51,942
1966	N/A	47,970	0	2,284	173	50,427
1967	N/A	51,940	0	2,488	176	54,604
1968	N/A	63,040	0	2,987	180	66,207
1969	N/A	73,070	0	3,538	184	76,791
1970	N/A	82,850	0	4,009	187	87,047
1971	N/A	90,030	0	4,348	191	94,569
1972	N/A	91,110	0	4,407	195	95,712
1973	N/A	95,770	0	4,629	199	100,598
1974	N/A	109,169	0	5,215	202	114,586
1975	N/A	97,016	0	4,537	206	101,758
1976	N/A	93,484	0	4,421	210	98,116
1977	N/A	97,021	0	4,629	214	101,864
1978	N/A	90,666	0	4,274	218	95,158
1979	N/A	80,974	0	3,728	221	84,923
1980	N/A	81,240	0	3,550	225	85,015
1981	N/A	68,771	0	3,035	234	72,040
1982	N/A	65,188	0	2,909	243	68,339
1983	N/A	73,076	0	3,246	252	76,574
1984	N/A	72,246	0	3,215	261	75,722
1985	N/A	74,379	0	3,328	271	77,978
1986	N/A	70,547	0	3,206	280	74,032
1987	N/A	73,905	0	3,410	288	77,603
1988	N/A	71,810	0	3,364	297	75,471
1989	N/A	73,028	0	3,483	306	76,816
1990	N/A	58,469	0	2,845	315	61,629
1991	N/A	52,100	3,908	2,821	323	59,153
1992	50,149	1,392	7,458	3,184	341	62,527
1993	39,790	475	8,531	2,741	350	51,887
1994	37,739	352	11,187	2,686	359	52,323
1995	37,390	3	9,574	2,606	368	49,941
1996	40,115	2	9,150	2,927	377	52,571
1997	41,684	316	9,358	3,356	386	55,100
1998	40,920	301	9,000	3,296	395	53,912
1999	52,785	441	11,328	3,799	405	68,757
2000	55,884	-2	11,302	4,492	414	72,089
2001	58,903	31	11,371	4,401	423	75,129
2002	56,938	0	9,845	4,137	432	71,352
2003	51,322	0	8,819	3,847	441	64,429
2004	40,289	0	6,329	3,029	450	50,098
2005	45,779	-23	6,328	3,470	460	56,014
2006	47,359	-28	6,630	4,135	460	58,557
2007	42,243	0	5,816	3,613	460	52,132

Appendix Table B2. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for cod (*Gadus morhua*) for Russia (t). N/A: part of ICES category 'former USSR' reconstructed total for Russia (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	14,850	0	542	77	15,469
1951	N/A	17,430	0	636	80	18,146
1952	N/A	19,310	0	705	83	20,097
1953	N/A	9,000	0	329	85	9,414
1954	N/A	13,520	0	493	88	14,101
1955	N/A	11,450	0	418	90	11,958
1956	N/A	16,960	0	619	93	17,672
1957	N/A	16,900	0	617	96	17,612
1958	N/A	13,270	0	484	98	13,852
1959	N/A	9,560	0	349	101	10,010
1960	N/A	14,100	0	515	103	14,718
1961	N/A	6,010	0	219	106	6,335
1962	N/A	3,890	0	142	108	4,140
1963	N/A	3,900	0	142	111	4,153
1964	N/A	650	0	24	114	787
1965	N/A	440	0	16	116	572
1966	N/A	540	0	20	119	678
1967	N/A	780	0	28	121	930
1968	N/A	3,120	0	114	124	3,358
1969	N/A	2,300	0	84	126	2,510
1970	N/A	1,150	0	42	129	1,321
1971	N/A	670	0	24	132	826
1972	N/A	810	0	30	134	974
1973	N/A	470	0	17	137	624
1974	N/A	4,741	0	173	139	5,053
1975	N/A	7,930	0	289	142	8,361
1976	N/A	4,922	0	180	144	5,246
1977	N/A	3,140	0	115	147	3,402
1978	N/A	6,640	0	242	150	7,032
1979	N/A	14,641	0	534	152	15,328
1980	N/A	27,088	0	989	155	28,232
1981	N/A	18,822	0	687	161	19,670
1982	N/A	16,120	0	588	167	16,876
1983	N/A	19,754	0	721	173	20,648
1984	N/A	19,929	0	727	180	20,836
1985	N/A	20,830	0	760	186	21,776
1986	N/A	13,962	0	510	192	14,664
1987	N/A	11,740	0	429	198	12,367
1988	N/A	7,783	0	284	204	8,271
1989	N/A	3,742	0	137	211	4,089
1990	N/A	3,521	0	129	217	3,866
1991	N/A	3,299	684	165	223	4,370
1992	884	909	743	117	229	2,882
1993	483	409	553	74	235	1,754
1994	1,114	143	1,295	95	242	2,889
1995	1,612	0	484	71	248	2,414
1996	3,304	2	331	103	254	3,993
1997	2,803	0	539	186	260	3,788
1998	4,599	0	1,295	298	266	6,458
1999	5,211	-9	1,928	297	272	7,700
2000	4,669	-438	1,946	519	279	6,975
2001	5,032	0	2,393	358	285	8,067
2002	3,793	0	1,768	212	291	6,064
2003	3,707	0	2,278	269	297	6,551
2004	3,410	0	1,804	178	303	5,696
2005	3,434	-23	1,583	233	310	5,537
2006	3,747	-28	1,745	809	310	6,582
2007	3,383	0	1,460	630	310	5,783

Appendix Table B3. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for herring (*Clupea harengus*) for Russia (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	23,240	0	1,162	9	24,411
1951	N/A	21,970	0	1,099	10	23,078
1952	N/A	19,580	0	979	10	20,569
1953	N/A	15,950	0	798	10	16,758
1954	N/A	23,430	0	1,172	11	24,612
1955	N/A	17,180	0	859	11	18,050
1956	N/A	15,970	0	799	11	16,780
1957	N/A	12,280	0	614	11	12,905
1958	N/A	14,630	0	732	12	15,373
1959	N/A	16,170	0	809	12	16,991
1960	N/A	15,360	0	768	12	16,140
1961	N/A	15,980	0	799	13	16,792
1962	N/A	16,980	0	849	13	17,842
1963	N/A	12,520	0	626	13	13,159
1964	N/A	12,310	0	616	14	12,939
1965	N/A	21,000	0	1,050	14	22,064
1966	N/A	23,170	0	1,159	14	24,343
1967	N/A	26,960	0	1,348	15	28,323
1968	N/A	34,530	0	1,727	15	36,271
1969	N/A	35,440	0	1,772	15	37,227
1970	N/A	32,350	0	1,618	15	33,983
1971	N/A	35,620	0	1,781	16	37,417
1972	N/A	30,500	0	1,525	16	32,041
1973	N/A	35,410	0	1,771	16	37,197
1974	N/A	39,858	0	1,993	17	41,868
1975	N/A	33,555	0	1,678	17	35,250
1976	N/A	32,007	0	1,600	17	33,625
1977	N/A	33,996	0	1,700	18	35,713
1978	N/A	41,944	0	2,097	18	44,059
1979	N/A	38,027	0	1,901	18	39,946
1980	N/A	34,770	0	1,739	19	36,527
1981	N/A	31,717	0	1,586	19	33,322
1982	N/A	33,140	0	1,657	20	34,817
1983	N/A	37,295	0	1,865	21	39,181
1984	N/A	33,331	0	1,667	21	35,019
1985	N/A	33,333	0	1,667	22	35,022
1986	N/A	35,936	0	1,797	23	37,756
1987	N/A	37,063	0	1,853	24	38,940
1988	N/A	37,675	0	1,884	24	39,583
1989	N/A	36,984	0	1,849	25	38,858
1990	N/A	34,442	0	1,722	26	36,190
1991	N/A	31,900	2,155	1,703	27	35,785
1992	29,251	0	3,953	1,660	27	34,891
1993	23,545	0	4,773	1,416	28	29,762
1994	15,904	0	4,275	1,009	29	21,217
1995	16,970	0	4,314	1,064	30	22,377
1996	14,780	0	3,541	916	30	19,268
1997	11,801	0	2,655	723	31	15,210
1998	10,544	0	2,218	638	32	13,432
1999	12,756	0	2,496	763	33	16,047
2000	15,063	0	2,728	890	33	18,714
2001	15,797	0	2,630	921	34	19,383
2002	14,168	0	2,152	817	35	17,172
2003	13,363	0	1,835	760	36	15,994
2004	6,585	0	807	370	36	7,798
2005	7,016	0	786	392	37	8,230
2006	9,780	0	1,095	544	37	11,456
2007	8,771	0	982	499	37	10,289

Appendix Table B4. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for sprat *(Sprattus sprattus)* for Russia (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	0	0	0	0	0
1951	N/A	0	0	0	0	0
1952	N/A	0	0	0	0	0
1953	N/A	2,490	0	125	0	2,615
1954	N/A	30	0	2	0	32
1955	N/A	620	0	31	0	651
1956	N/A	1,380	0	69	0	1,449
1957	N/A	3,410	0	171	0	3,581
1958	N/A	3,510	0	176	0	3,686
1959	N/A	4,600	0	230	0	4,830
1960	N/A	4,260	0	213	0	4,473
1961	N/A	6,170	0	309	0	6,479
1962	N/A	8,990	0	450	0	9,440
1963	N/A	17,440	0	872	0	18,312
1964	N/A	24,860	0	1,243	0	26,103
1965	N/A	18,130	0	907	0	19,037
1966	N/A	16,330	0	817	0	17,147
1967	N/A	16,900	0	845	0	17,745
1968	N/A	16,290	0	815	0	17,105
1969	N/A	29,060	0	1,453	0	30,513
1970	N/A	40,640	0	2,032	0	42,672
1971	N/A	43,030	0	2,152	0	45,182
1972	N/A	49,580	0	2,479	0	52,059
1973	N/A	48,570	0	2,429	0	50,999
1974	N/A	51,267	0	2,563	0	53,831
1975	N/A	40,180	0	2,009	0	42,189
1976	N/A	42,751	0	2,138	0	44,889
1977	N/A	46,561	0	2,328	0	48,889
1978	N/A	29,497	0	1,475	0	30,972
1979	N/A	19,159	0	958	0	20,117
1980	N/A	8,536	0	427	0	8,963
1981	N/A	6,980	0	349	0	7,329
1982	N/A	5,660	0	283	0	5,943
1983	N/A	4,413	0	221	0	4,634
1984	N/A	7,966	0	398	0	8,365
1985	N/A	10,128	0	506	0	10,635
1986	N/A	8,619	0	431	0	9,050
1987	N/A	12,168	0	608	0	12,777
1988	N/A	14,112	0	706	0	14,818
1989	N/A	18,072	0	904	0	18,976
1990	N/A	15,085	0	754	0	15,840
1991	N/A	12,099	817	646	0	13,562
1992	9,112	0	1,231	517	0	10,861
1993	10,745	0	2,178	646	1	13,570
1994	16,719	0	4,494	1,061	1	22,274
1995	14,934	0	3,796	937	1	19,667
1996	18,287	0	4,382	1,133	1	23,802
1997	22,194	0	4,994	1,359	1	28,548
1998	21,078	0	4,435	1,276	1	26,789
1999	31,627	0	6,189	1,891	1	39,708
2000	30,369	0	5,500	1,793	1	37,663
2001	31,959	0	5,321	1,864	1	39,145
2002	32,854	0	4,991	1,892	1	39,737
2003	28,663	0	3,935	1,630	1	34,229
2004	25,109	0	3,078	1,409	1	29,597
2005	29,749	0	3,332	1,654	1	34,736
2006	28,324	0	3,172	1,575	1	33,072
2007	24,808	0	2,778	1,379	1	28,966

Appendix table B5. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for salmon (*Salmo salar*) for Russia (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	50	0	2	0	52
1951	N/A	80	0	3	0	83
1952	N/A	80	0	3	0	83
1953	N/A	80	0	3	0	83
1954	N/A	100	0	4	1	104
1955	N/A	90	0	3	1	94
1956	N/A	70	0	3	1	73
1957	N/A	50	0	2	1	52
1958	N/A	40	0	1	1	42
1959	N/A	20	0	1	1	21
1960	N/A	10	0	0	1	11
1961	N/A	10	0	0	1	11
1962	N/A	10	0	0	1	11
1963	N/A	0	0	0	1	1
1964	N/A	10	0	0	1	11
1965	N/A	0	0	0	1	1
1966	N/A	0	0	0	1	1
1967	N/A	0	0	0	1	1
1968	N/A	0	0	0	1	1
1969	N/A	0	0	0	1	1
1970	N/A	20	0	1	1	21
1971	N/A	10	0	0	1	11
1972	N/A	0	0	0	1	1
1973	N/A	0	0	0	1	1
1974	N/A	4	0	0	1	5
1975	N/A	6	0	0	1	7
1976	N/A	1	0	0	1	2
1977	N/A	0	0	0	1	1
1978	N/A	2	0	0	1	3
1979	N/A	11	0	0	1	12
1980	N/A	34	0	1	1	36
1981	N/A	62	0	5	1	68
1982	N/A	57	0	7	1	65
1983	N/A	93	0	19	1	113
1984	N/A	88	0	24	1	113
1985	N/A	84	0	29	1	114
1986	N/A	75	0	32	1	108
1987	N/A	104	0	52	1	157
1988	N/A	89	0	47	1	137
1989	N/A	141	0	79	1	221
1990	N/A	117	0	60	1	178
1991	N/A	94	6	40	1	141
1992	70	0	9	12	1	93
1993	71	0	14	17	1	103
1994	63	0	12	14	1	90
1995	61	0	12	15	1	89
1996	45	0	9	12	1	67
1997	36	0	7	10	1	54
1998	34	0	7	9	1	51
1999	22	0	4	6	1	34
2000	24	0	5	5	1	36
2001	0	27	5	9	2	42
2002	29	0	6	11	2	47
2003	22	0	4	12	2	40
2004	26	0	5	10	2	43
2005	13	0	3	4	2	21
2006	4	0	1	3	2	9
2007	28	0	6	5	2	41

Appendix table B6. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for the category 'flatfish' for Russia (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	60	0	2	3	65
1951	N/A	100	0	4	3	106
1952	N/A	160	0	6	3	169
1953	N/A	50	0	2	3	55
1954	N/A	170	0	6	3	179
1955	N/A	280	0	10	3	293
1956	N/A	130	0	5	3	138
1957	N/A	340	0	12	3	356
1958	N/A	170	0	6	3	180
1959	N/A	250	0	9	3	263
1960	N/A	340	0	12	4	356
1961	N/A	220	0	8	4	232
1962	N/A	130	0	5	4	138
1963	N/A	170	0	6	4	180
1964	N/A	230	0	8	4	242
1965	N/A	130	0	5	4	139
1966	N/A	130	0	5	4	139
1967	N/A	60	0	2	4	66
1968	N/A	150	0	5	4	160
1969	N/A	210	0	8	4	222
1970	N/A	150	0	5	4	160
1971	N/A	150	0	5	5	160
1972	N/A	50	0	2	5	56
1973	N/A	20	0	1	5	25
1974	N/A	121	0	4	5	130
1975	N/A	565	0	21	5	591
1976	N/A	145	0	5	5	155
1977	N/A	66	0	2	5	73
1978	N/A	162	0	6	5	173
1979	N/A	186	0	7	5	198
1980	N/A	227	0	8	5	241
1981	N/A	115	0	4	6	125
1982	N/A	218	0	8	6	232
1983	N/A	301	0	11	6	318
1984	N/A	157	0	6	6	169
1985	N/A	232	0	8	6	247
1986	N/A	399	0	15	7	420
1987	N/A	672	0	25	7	703
1988	N/A	335	0	12	7	354
1989	N/A	586	0	21	7	615
1990	N/A	406	0	15	8	428
1991	N/A	226	15	46	8	295
1992	75	71	20	57	8	230
1993	159	66	46	134	8	413
1994	173	0	47	109	8	337
1995	268	3	69	169	9	517
1996	774	0	185	477	9	1,445
1997	1,131	0	254	688	9	2,083
1998	1,188	0	250	714	9	2,161
1999	1,013	0	198	596	9	1,817
2000	1,445	0	262	842	10	2,558
2001	1,420	4	237	817	10	2,488
2002	1,364	0	207	775	10	2,356
2003	1,430	0	196	805	10	2,441
2004	1,292	0	158	719	10	2,180
2005	1,428	0	160	786	11	2,384
2006	1,237	0	139	683	11	2,069
2007	1,358	0	152	747	11	2,268

Appendix Table B7. ICES landing statistics, adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for the category 'others' for Russia (t). N/A: part of ICES category 'former USSR'.

Year	ICES landing statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	4,830	0	176	23	5,029
1951	N/A	6,260	0	228	24	6,512
1952	N/A	6,120	0	223	24	6,368
1953	N/A	6,060	0	221	25	6,306
1954	N/A	8,470	0	309	26	8,805
1955	N/A	8,410	0	307	26	8,743
1956	N/A	8,030	0	293	27	8,350
1957	N/A	5,990	0	219	28	6,236
1958	N/A	5,160	0	188	28	5,377
1959	N/A	7,800	0	285	29	8,114
1960	N/A	8,240	0	301	31	8,571
1961	N/A	6,550	0	239	31	6,820
1962	N/A	5,180	0	189	32	5,401
1963	N/A	7,650	0	279	33	7,962
1964	N/A	8,590	0	314	34	8,937
1965	N/A	9,740	0	356	34	10,130
1966	N/A	7,800	0	285	35	8,120
1967	N/A	7,240	0	264	36	7,540
1968	N/A	8,950	0	327	36	9,313
1969	N/A	6,060	0	221	37	6,318
1970	N/A	8,540	0	312	38	8,889
1971	N/A	10,550	0	385	38	10,973
1972	N/A	10,170	0	371	39	10,580
1973	N/A	11,300	0	412	40	11,752
1974	N/A	13,178	0	481	40	13,699
1975	N/A	14,780	0	539	41	15,361
1976	N/A	13,658	0	499	43	14,199
1977	N/A	13,258	0	484	44	13,785
1978	N/A	12,421	0	453	44	12,919
1979	N/A	8,950	0	327	45	9,321
1980	N/A	10,585	0	386	46	11,017
1981	N/A	8,366	0	305	47	8,718
1982	N/A	6,581	0	240	49	6,870
1983	N/A	6,977	0	255	51	7,282
1984	N/A	7,000	0	256	52	7,308
1985	N/A	6,199	0	226	55	6,480
1986	N/A	7,480	0	273	57	7,810
1987	N/A	7,729	0	282	58	8,069
1988	N/A	7,606	0	278	60	7,944
1989	N/A	8,391	0	306	62	8,759
1990	N/A	4,898	0	165	63	5,126
1991	N/A	4,483	230	222	65	5,000
1992	10,757	412	1,502	821	75	13,570
1993	4,787	0	968	454	77	6,286
1994	3,766	209	1,065	398	79	5,517
1995	3,545	0	899	351	80	4,875
1996	2,925	0	702	286	82	3,995
1997	3,719	316	909	390	84	5,418
1998	3,477	301	796	361	86	5,020
1999	2,156	450	510	246	89	3,451
2000	4,314	436	861	443	91	6,144
2001	4,695	0	784	432	93	6,004
2002	4,730	0	721	430	95	5,975
2003	4,137	0	570	371	96	5,174
2004	3,867	0	476	343	98	4,784
2005	4,139	0	465	401	101	5,106
2006	4,267	0	478	522	101	5,368
2007	3,895	0	436	353	101	4,785

APPENDIX C

Appendix Table C1. Modified ICES statistics (official ICES data apportioned to Kaliningrad oblast), adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for Kaliningrad oblast (t). N/A: part of ICES category 'former USSR'.

Year	ICES modified statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	34,050	0	1,475	84	35,609
1951	N/A	37,240	0	1,579	87	38,906
1952	N/A	33,940	0	1,411	89	35,440
1953	N/A	21,630	0	902	92	22,624
1954	N/A	30,190	0	1,283	95	31,568
1955	N/A	21,580	0	879	98	22,556
1956	N/A	23,320	0	921	101	24,342
1957	N/A	18,800	0	751	103	19,655
1958	N/A	16,450	0	674	106	17,230
1959	N/A	11,800	0	482	109	12,391
1960	N/A	17,090	0	661	112	17,863
1961	N/A	10,730	0	440	114	11,285
1962	N/A	10,360	0	445	117	10,922
1963	N/A	17,040	0	765	120	17,925
1964	N/A	18,780	0	865	123	19,768
1965	N/A	16,940	0	770	126	17,836
1966	N/A	13,570	0	625	128	14,323
1967	N/A	16,840	0	795	131	17,766
1968	N/A	23,630	0	1,075	134	24,839
1969	N/A	29,790	0	1,424	137	31,351
1970	N/A	36,900	0	1,777	140	38,817
1971	N/A	34,180	0	1,632	142	35,954
1972	N/A	32,440	0	1,564	145	34,149
1973	N/A	27,680	0	1,326	148	29,154
1974	N/A	39,620	0	1,871	151	41,642
1975	N/A	34,459	0	1,563	154	36,176
1976	N/A	27,834	0	1,281	156	29,272
1977	N/A	25,566	0	1,193	159	26,918
1978	N/A	25,399	0	1,160	162	26,720
1979	N/A	24,396	0	1,094	165	25,655
1980	N/A	26,644	0	1,137	168	27,948
1981	N/A	21,164	0	907	174	22,245
1982	N/A	19,651	0	857	181	20,689
1983	N/A	22,664	0	991	188	23,843
1984	N/A	21,421	0	938	194	22,553
1985	N/A	21,121	0	925	201	22,247
1986	N/A	21,018	0	934	208	22,159
1987	N/A	22,632	0	1,020	215	23,867
1988	N/A	22,763	0	1,045	221	24,030
1989	N/A	22,198	0	1,009	228	23,435
1990	N/A	21,172	0	977	235	22,384
1991	N/A	22,388	1,901	1,192	241	25,722
1992	33,163	1,096	5,123	2,025	253	41,661
1993	30,108	461	6,565	2,004	260	39,398
1994	31,083	222	9,363	2,141	267	43,077
1995	30,486	2	7,819	2,052	274	40,634
1996	34,082	2	7,705	2,394	281	44,463
1997	35,710	316	8,014	2,773	288	47,101
1998	35,397	301	7,838	2,745	294	46,576
1999	47,367	441	10,267	3,310	301	61,686
2000	49,912	-2	10,220	3,930	308	64,368
2001	52,741	28	10,344	3,837	315	67,266
2002	51,059	0	8,951	3,597	322	63,928
2003	43,737	0	7,777	2,645	329	54,488
2004	37,652	0	6,006	2,848	336	46,841
2005	43,240	-23	6,044	3,246	342	52,849
2006	43,701	-28	6,220	3,744	342	53,979
2007	37,789	0	5,317	3,314	342	46,762

Appendix Table C2. Modified ICES statistics (official ICES data apportioned to Kaliningrad oblast), adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for cod (Gadus morhua) for Kaliningrad oblast (t). N/A: part of ICES category 'former USSR'.

Year	ICES modified statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	14,250	0	520	76	14,846
1951	N/A	17,050	0	622	79	17,751
1952	N/A	17,270	0	630	81	17,982
1953	N/A	8,940	0	326	84	9,350
1954	N/A	10,620	0	388	86	11,094
1955	N/A	8,400	0	307	89	8,796
1956	N/A	12,330	0	450	91	12,871
1957	N/A	9,770	0	357	94	10,221
1958	N/A	7,900	0	288	97	8,285
1959	N/A	4,380	0	160	99	4,639
1960	N/A	9,970	0	364	102	10,436
1961	N/A	3,750	0	137	104	3,991
1962	N/A	2,310	0	84	107	2,501
1963	N/A	3,000	0	110	109	3,219
1964	N/A	550	0	20	112	682
1965	N/A	300	0	11	114	425
1966	N/A	80	0	3	117	200
1967	N/A	480	0	18	119	617
1968	N/A	2,460	0	90	122	2,672
1969	N/A	1,750	0	64	125	1,938
1970	N/A	690	0	25	127	842
1971	N/A	270	0	10	130	409
1972	N/A	360	0	13	132	505
1973	N/A	360	0	13	135	508
1974	N/A	3,060	0	112	137	3,309
1975	N/A	5,899	0	215	140	6,254
1976	N/A	3,825	0	140	142	4,107
1977	N/A	2,079	0	76	145	2,300
1978	N/A	4,074	0	149	147	4,370
1979	N/A	5,536	0	202	150	5,888
1980	N/A	8,988	0	328	152	9,468
1981	N/A	5,770	0	211	159	6,139
1982	N/A	4,854	0	177	165	5,196
1983	N/A	6,523	0	238	171	6,932
1984	N/A	6,475	0	236	177	6,888
1985	N/A	7,000	0	256	183	7,438
1986	N/A	5,417	0	198	189	5,804
1987	N/A	4,250	0	155	195	4,600
1988	N/A	2,182	0	80	201	2,463
1989	N/A	1,830	0	67	207	2,104
1990	N/A	3,521	0	129	213	3,863
1991	N/A	3,299	684	165	220	4,367
1992	884	909	743	117	226	2,879
1993	483	409	553	74	232	1,750
1994	1,114	143	1,295	95	238	2,885
1995	1,612	0	484	71	244	2,410
1996	3,304	2	331	103	250	3,989
1997	2,803	0	539	186	256	3,784
1998	4,599	0	1,295	298	262	6,454
1999	5,211	-9	1,928	297	268	7,696
2000	4,669	-438	1,946	519	274	6,970
2001	5,032	0	2,393	358	280	8,063
2002	3,793	0	1,768	212	287	6,060
2003	3,707	0	2,278	269	293	6,547
2004	3,410	0	1,804	178	299	5,691
2005	3,434	-23	1,583	233	305	5,532
2006	3,747	-28	1,745	809	305	6,578
2007	3,383	0	1,460	630	305	5,778

Appendix Table C3. Modified ICES statistics (official ICES data apportioned to Kaliningrad oblast), adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for herring (*Clupea harengus*) for Kaliningrad oblast (t). N/A: part of ICES category 'former USSR'.

Year	ICES modified statistics	Ad-justments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	17,230	0	862	6	18,097
1951	N/A	16,310	0	816	6	17,132
1952	N/A	12,750	0	638	6	13,394
1953	N/A	8,350	0	418	7	8,774
1954	N/A	13,410	0	671	7	14,087
1955	N/A	6,360	0	318	7	6,685
1956	N/A	4,290	0	215	7	4,512
1957	N/A	1,940	0	97	7	2,044
1958	N/A	3,280	0	164	8	3,452
1959	N/A	1,210	0	61	8	1,278
1960	N/A	1,000	0	50	8	1,058
1961	N/A	710	0	36	8	754
1962	N/A	960	0	48	8	1,016
1963	N/A	1,230	0	62	9	1,300
1964	N/A	1,070	0	54	9	1,132
1965	N/A	1,660	0	83	9	1,752
1966	N/A	2,260	0	113	9	2,382
1967	N/A	4,060	0	203	9	4,272
1968	N/A	5,230	0	262	10	5,501
1969	N/A	6,640	0	332	10	6,982
1970	N/A	4,440	0	222	10	4,672
1971	N/A	9,800	0	490	10	10,300
1972	N/A	9,270	0	464	10	9,744
1973	N/A	13,120	0	656	11	13,787
1974	N/A	16,970	0	849	11	17,829
1975	N/A	15,916	0	796	11	16,723
1976	N/A	17,087	0	854	11	17,952
1977	N/A	16,641	0	832	11	17,484
1978	N/A	13,740	0	687	11	14,438
1979	N/A	13,992	0	700	12	14,703
1980	N/A	11,474	0	574	12	12,060
1981	N/A	9,625	0	481	12	10,119
1982	N/A	9,715	0	486	13	10,214
1983	N/A	11,974	0	599	13	12,586
1984	N/A	10,220	0	511	14	10,745
1985	N/A	10,022	0	501	14	10,537
1986	N/A	11,126	0	556	15	11,697
1987	N/A	11,900	0	595	15	12,510
1988	N/A	13,420	0	671	16	14,107
1989	N/A	12,738	0	637	16	13,391
1990	N/A	11,862	0	593	17	12,472
1991	N/A	10,987	742	586	17	12,333
1992	21,988	0	2,971	1,248	18	26,225
1993	17,699	0	3,588	1,064	18	22,369
1994	11,955	0	3,214	758	19	15,946
1995	12,756	0	3,243	800	19	16,818
1996	11,110	0	2,662	689	19	14,480
1997	8,871	0	1,996	543	20	11,430
1998	7,926	0	1,668	480	20	10,094
1999	9,589	0	1,877	573	21	12,059
2000	11,323	0	2,051	669	21	14,064
2001	11,875	0	1,977	693	22	14,566
2002	10,650	0	1,618	613	22	12,904
2003	9,087	0	1,248	517	23	10,874
2004	5,470	0	671	307	23	6,471
2005	5,848	0	655	325	24	6,852
2006	7,717	0	864	429	24	9,034
2007	6,092	0	682	339	24	7,137

Appendix Table C4. Modified ICES statistics (official ICES data apportioned to Kaliningrad oblast), adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for sprat *(Sprattus sprattus)* for Kaliningrad oblast (t). N/A: part of ICES category 'former USSR'. Dashes (—) indicate no reported statistics.

Year	ICES modified statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	0	0	0	—	0
1951	N/A	0	0	0	—	0
1952	N/A	0	0	0	—	0
1953	N/A	0	0	0	—	0
1954	N/A	0	0	0	—	0
1955	N/A	390	0	20	—	410
1956	N/A	910	0	46	—	956
1957	N/A	2,890	0	145	—	3,035
1958	N/A	2,190	0	110	—	2,300
1959	N/A	2,600	0	130	—	2,730
1960	N/A	1,760	0	88	—	1,848
1961	N/A	2,900	0	145	—	3,045
1962	N/A	3,990	0	200	—	4,190
1963	N/A	9,380	0	469	—	9,849
1964	N/A	12,200	0	610	—	12,810
1965	N/A	9,580	0	479	—	10,059
1966	N/A	7,340	0	367	—	7,707
1967	N/A	9,300	0	465	—	9,765
1968	N/A	10,510	0	526	—	11,036
1969	N/A	18,280	0	914	—	19,194
1970	N/A	27,430	0	1,372	—	28,802
1971	N/A	18,660	0	933	—	19,593
1972	N/A	18,850	0	943	—	19,793
1973	N/A	10,230	0	512	—	10,742
1974	N/A	14,500	0	725	—	15,225
1975	N/A	6,705	0	335	—	7,040
1976	N/A	2,580	0	129	—	2,709
1977	N/A	2,590	0	130	—	2,720
1978	N/A	3,481	0	174	—	3,655
1979	N/A	1,096	0	55	—	1,151
1980	N/A	710	0	36	—	746
1981	N/A	310	0	16	—	326
1982	N/A	658	0	33	—	691
1983	N/A	157	0	8	—	165
1984	N/A	1,350	0	68	—	1,418
1985	N/A	1,410	0	71	—	1,481
1986	N/A	1,200	0	60	—	1,260
1987	N/A	2,500	0	125	—	2,625
1988	N/A	2,480	0	124	—	2,604
1989	N/A	1,965	0	98	—	2,063
1990	N/A	4,288	0	214	—	4,503
1991	N/A	6,612	447	353	—	7,411
1992	8,935	0	1,207	507	—	10,649
1993	10,536	0	2,136	634	—	13,305
1994	16,394	0	4,407	1,040	—	21,841
1995	14,644	0	3,722	918	—	19,284
1996	17,931	0	4,296	1,111	—	23,339
1997	21,762	0	4,897	1,333	—	27,992
1998	20,668	0	4,349	1,251	—	26,268
1999	31,012	0	6,069	1,854	—	38,935
2000	29,779	0	5,393	1,759	—	36,930
2001	31,338	0	5,218	1,828	—	38,383
2002	32,215	0	4,893	1,855	—	38,964
2003	27,985	0	3,842	1,591	—	33,419
2004	24,467	0	3,000	1,373	—	28,840
2005	29,669	0	3,323	1,650	—	34,642
2006	27,950	0	3,130	1,554	—	32,634
2007	23,925	0	2,680	1,330	—	27,935

Appendix table C5. Modified ICES statistics (official ICES data apportioned to Kaliningrad oblast), adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for salmon (*Salmo salar*) for Kaliningrad oblast (t). N/A: part of ICES category 'former USSR'. Dashes (—) indicate no reported statistics.

Year	ICES modified statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	0	0	0	—	0
1951	N/A	0	0	0	—	0
1952	N/A	0	0	0	—	0
1953	N/A	0	0	0	—	0
1954	N/A	0	0	0	—	0
1955	N/A	0	0	0	—	0
1956	N/A	0	0	0	—	0
1957	N/A	0	0	0	—	0
1958	N/A	0	0	0	—	0
1959	N/A	0	0	0	—	0
1960	N/A	0	0	0	—	0
1961	N/A	0	0	0	—	0
1962	N/A	0	0	0	—	0
1963	N/A	0	0	0	—	0
1964	N/A	0	0	0	—	0
1965	N/A	0	0	0	—	0
1966	N/A	0	0	0	—	0
1967	N/A	0	0	0	—	0
1968	N/A	0	0	0	—	0
1969	N/A	0	0	0	—	0
1970	N/A	20	0	1	—	21
1971	N/A	0	0	0	—	0
1972	N/A	0	0	0	—	0
1973	N/A	0	0	0	—	0
1974	N/A	0	0	0	—	0
1975	N/A	0	0	0	—	0
1976	N/A	0	0	0	—	0
1977	N/A	0	0	0	—	0
1978	N/A	1	0	0	—	1
1979	N/A	6	0	0	—	6
1980	N/A	13	0	0	—	13
1981	N/A	7	0	0	—	7
1982	N/A	11	0	0	—	11
1983	N/A	10	0	0	—	10
1984	N/A	7	0	0	—	7
1985	N/A	3	0	0	—	3
1986	N/A	0	0	0	—	0
1987	N/A	0	0	0	—	0
1988	N/A	6	0	0	—	6
1989	N/A	18	0	1	—	19
1990	N/A	34	0	1	—	35
1991	N/A	50	3	4	—	57
1992	66	0	9	9	—	84
1993	67	0	13	13	—	93
1994	60	0	11	10	—	81
1995	58	0	11	11	—	80
1996	43	0	9	9	—	60
1997	34	0	7	7	—	48
1998	32	0	6	6	—	45
1999	21	0	4	4	—	29
2000	23	0	5	3	—	30
2001	0	25	5	5	—	35
2002	27	0	6	6	—	39
2003	20	0	4	4	—	28
2004	25	0	5	5	—	35
2005	12	0	2	2	—	17
2006	3	0	1	1	—	4
2007	28	0	6	5	—	39

Appendix table C6. Modified ICES statistics (official ICES data apportioned to Kaliningrad oblast), adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for the category 'flatfish' for Kaliningrad oblast (t). N/A: part of ICES category 'former USSR'.

Year	ICES modified statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	60	0	2	2	64
1951	N/A	100	0	4	2	105
1952	N/A	80	0	3	2	85
1953	N/A	50	0	2	2	54
1954	N/A	110	0	4	2	116
1955	N/A	170	0	6	2	178
1956	N/A	70	0	3	2	75
1957	N/A	90	0	3	2	95
1958	N/A	50	0	2	2	54
1959	N/A	50	0	2	2	54
1960	N/A	130	0	5	2	137
1961	N/A	0	0	0	2	2
1962	N/A	60	0	2	2	64
1963	N/A	50	0	2	2	54
1964	N/A	20	0	1	2	23
1965	N/A	20	0	1	2	23
1966	N/A	10	0	0	3	13
1967	N/A	0	0	0	3	3
1968	N/A	0	0	0	3	3
1969	N/A	0	0	0	3	3
1970	N/A	0	0	0	3	3
1971	N/A	0	0	0	3	3
1972	N/A	0	0	0	3	3
1973	N/A	20	0	1	3	24
1974	N/A	120	0	4	3	127
1975	N/A	488	0	18	3	509
1976	N/A	103	0	4	3	110
1977	N/A	22	0	1	3	26
1978	N/A	43	0	2	3	48
1979	N/A	5	0	0	3	8
1980	N/A	0	0	0	3	3
1981	N/A	6	0	0	3	10
1982	N/A	2	0	0	4	6
1983	N/A	92	0	3	4	99
1984	N/A	50	0	2	4	56
1985	N/A	136	0	5	4	145
1986	N/A	230	0	8	4	242
1987	N/A	340	0	12	4	357
1988	N/A	81	0	3	4	88
1989	N/A	429	0	16	4	449
1990	N/A	304	0	11	5	319
1991	N/A	178	12	36	5	231
1992	59	56	16	45	5	180
1993	125	52	36	106	5	324
1994	136	0	37	86	5	264
1995	211	2	54	133	5	407
1996	611	0	146	376	5	1,138
1997	892	0	201	543	6	1,642
1998	937	0	197	564	6	1,704
1999	796	0	156	469	6	1,426
2000	1,137	0	206	662	6	2,011
2001	1,116	3	186	643	6	1,954
2002	1,073	0	163	610	6	1,852
2003	0	0	0	0	6	6
2004	1,292	0	158	719	6	2,176
2005	1,428	0	160	786	7	2,380
2006	1,237	0	139	683	7	2,065
2007	1,358	0	152	747	7	2,263

Appendix Table C7. Modified ICES statistics (official ICES data apportioned to Kaliningrad oblast), adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for the category 'others' for Kaliningrad oblast (t). N/A: part of ICES category 'former USSR'. Dashes (—) indicate no reported statistics.

Year	ICES modified statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	2,510	0	92	—	2,602
1951	N/A	3,780	0	138	—	3,918
1952	N/A	3,840	0	140	—	3,980
1953	N/A	4,290	0	157	—	4,447
1954	N/A	6,050	0	221	—	6,271
1955	N/A	6,260	0	228	—	6,488
1956	N/A	5,720	0	209	—	5,929
1957	N/A	4,110	0	150	—	4,260
1958	N/A	3,030	0	111	—	3,141
1959	N/A	3,560	0	130	—	3,690
1960	N/A	4,230	0	154	—	4,384
1961	N/A	3,370	0	123	—	3,493
1962	N/A	3,040	0	111	—	3,151
1963	N/A	3,380	0	123	—	3,503
1964	N/A	4,940	0	180	—	5,120
1965	N/A	5,380	0	196	—	5,576
1966	N/A	3,880	0	142	—	4,022
1967	N/A	3,000	0	110	—	3,110
1968	N/A	5,430	0	198	—	5,628
1969	N/A	3,120	0	114	—	3,234
1970	N/A	4,320	0	158	—	4,478
1971	N/A	5,450	0	199	—	5,649
1972	N/A	3,960	0	145	—	4,105
1973	N/A	3,950	0	144	—	4,094
1974	N/A	4,970	0	181	—	5,151
1975	N/A	5,451	0	199	—	5,650
1976	N/A	4,239	0	155	—	4,394
1977	N/A	4,234	0	155	—	4,389
1978	N/A	4,060	0	148	—	4,208
1979	N/A	3,761	0	137	—	3,898
1980	N/A	5,459	0	199	—	5,658
1981	N/A	5,446	0	199	—	5,645
1982	N/A	4,411	0	161	—	4,572
1983	N/A	3,908	0	143	—	4,051
1984	N/A	3,319	0	121	—	3,440
1985	N/A	2,550	0	93	—	2,643
1986	N/A	3,045	0	111	—	3,156
1987	N/A	3,642	0	133	—	3,775
1988	N/A	4,594	0	168	—	4,762
1989	N/A	5,218	0	190	—	5,408
1990	N/A	1,163	0	29	—	1,191
1991	N/A	1,262	13	48	—	1,323
1992	1,231	131	177	100	5	1,644
1993	1,197	0	240	113	6	1,556
1994	1,424	79	401	150	6	2,060
1995	1,205	0	305	119	6	1,635
1996	1,083	0	261	106	6	1,456
1997	1,347	316	375	161	6	2,205
1998	1,235	301	324	147	6	2,012
1999	738	450	233	112	7	1,540
2000	2,982	436	620	319	7	4,363
2001	3,381	0	565	311	7	4,264
2002	3,300	0	503	300	7	4,110
2003	2,938	0	405	264	7	3,614
2004	2,988	0	368	265	7	3,628
2005	2,849	0	320	250	7	3,427
2006	3,047	0	342	267	7	3,664
2007	3,003	0	336	263	7	3,610

APPENDIX D

Appendix Table D1. Modified ICES statistics (official ICES data apportioned to Leningrad oblast), adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for Leningrad oblast (t). N/A: part of ICES category 'former USSR'.

Year	ICES modified statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	8,980	0	409	29	9,418
1951	N/A	8,600	0	390	30	9,020
1952	N/A	11,310	0	505	31	11,846
1953	N/A	12,000	0	574	32	12,606
1954	N/A	15,530	0	703	33	16,265
1955	N/A	16,450	0	750	34	17,233
1956	N/A	19,220	0	866	34	20,120
1957	N/A	20,170	0	883	35	21,088
1958	N/A	20,330	0	913	36	21,279
1959	N/A	26,600	0	1,200	37	27,837
1960	N/A	25,220	0	1,148	39	26,407
1961	N/A	24,210	0	1,134	40	25,384
1962	N/A	24,820	0	1,190	41	26,051
1963	N/A	24,640	0	1,161	42	25,842
1964	N/A	27,870	0	1,340	42	29,252
1965	N/A	32,500	0	1,563	43	34,106
1966	N/A	34,400	0	1,659	44	36,104
1967	N/A	35,100	0	1,693	45	36,838
1968	N/A	39,410	0	1,912	46	41,368
1969	N/A	43,280	0	2,114	47	45,441
1970	N/A	45,950	0	2,232	48	48,230
1971	N/A	55,850	0	2,716	49	58,615
1972	N/A	58,670	0	2,843	50	61,563
1973	N/A	68,090	0	3,304	51	71,444
1974	N/A	69,549	0	3,344	51	72,944
1975	N/A	62,557	0	2,973	52	65,583
1976	N/A	65,650	0	3,140	54	68,844
1977	N/A	71,455	0	3,436	55	74,946
1978	N/A	65,267	0	3,114	56	68,437
1979	N/A	56,578	0	2,633	57	59,268
1980	N/A	54,596	0	2,413	58	57,067
1981	N/A	47,607	0	2,129	60	49,795
1982	N/A	45,537	0	2,051	62	47,650
1983	N/A	50,412	0	2,255	64	52,731
1984	N/A	50,825	0	2,277	66	53,168
1985	N/A	53,258	0	2,403	70	55,730
1986	N/A	49,529	0	2,272	72	51,873
1987	N/A	51,273	0	2,390	74	53,736
1988	N/A	49,047	0	2,319	76	51,442
1989	N/A	50,830	0	2,474	78	53,382
1990	N/A	37,297	0	1,868	80	39,245
1991	N/A	29,712	2,007	1,629	82	33,431
1992	16,986	296	2,335	1,159	87	20,866
1993	9,682	14	1,965	737	90	12,489
1994	6,656	130	1,824	546	92	9,247
1995	6,904	1	1,755	554	94	9,307
1996	6,033	0	1,445	533	96	8,108
1997	5,974	0	1,344	583	98	8,000
1998	5,523	0	1,162	551	101	7,336
1999	5,418	0	1,061	489	104	7,072
2000	5,972	0	1,082	561	106	7,721
2001	6,162	2	1,027	564	108	7,863
2002	5,879	0	894	540	111	7,424
2003	7,585	0	1,042	1,203	113	9,942
2004	2,637	0	323	181	115	3,256
2005	2,539	0	284	223	118	3,165
2006	3,658	0	410	392	118	4,578
2007	4,454	0	499	299	118	5,370

Appendix Table D2. Modified ICES statistics (official ICES data apportioned to Leningrad oblast), adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for cod (Gadus morhua) for Leningrad oblast (t). N/A: part of ICES category 'former USSR'. Dashes (—) indicate no reported ICES landing statistics.

Year	ICES modified statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	600	0	22	1	623
1951	N/A	380	0	14	1	395
1952	N/A	2,040	0	74	1	2,116
1953	N/A	60	0	2	1	63
1954	N/A	2,900	0	106	1	3,007
1955	N/A	3,050	0	111	1	3,163
1956	N/A	4,630	0	169	1	4,800
1957	N/A	7,130	0	260	2	7,392
1958	N/A	5,370	0	196	2	5,568
1959	N/A	5,180	0	189	2	5,371
1960	N/A	4,130	0	151	2	4,282
1961	N/A	2,260	0	82	2	2,344
1962	N/A	1,580	0	58	2	1,639
1963	N/A	900	0	33	2	935
1964	N/A	100	0	4	2	105
1965	N/A	140	0	5	2	147
1966	N/A	460	0	17	2	479
1967	N/A	300	0	11	2	313
1968	N/A	660	0	24	2	686
1969	N/A	550	0	20	2	572
1970	N/A	460	0	17	2	479
1971	N/A	400	0	15	2	417
1972	N/A	450	0	16	2	469
1973	N/A	110	0	4	2	116
1974	N/A	1,681	0	61	2	1,744
1975	N/A	2,031	0	74	2	2,107
1976	N/A	1,097	0	40	2	1,139
1977	N/A	1,061	0	39	2	1,102
1978	N/A	2,566	0	94	2	2,662
1979	N/A	9,105	0	332	2	9,440
1980	N/A	18,100	0	661	2	18,763
1981	N/A	13,052	0	476	3	13,531
1982	N/A	11,266	0	411	3	11,680
1983	N/A	13,231	0	483	3	13,717
1984	N/A	13,454	0	491	3	13,948
1985	N/A	13,830	0	505	3	14,338
1986	N/A	8,545	0	312	3	8,860
1987	N/A	7,490	0	273	3	7,766
1988	N/A	5,601	0	204	3	5,809
1989	N/A	1,912	0	70	3	1,985
1990	N/A	0	0	0	3	3
1991	N/A	0	0	0	3	3
1992	—	0	0	0	4	4
1993	—	0	0	0	4	4
1994	—	0	0	0	4	4
1995	—	0	0	0	4	4
1996	—	0	0	0	4	4
1997	—	0	0	0	4	4
1998	—	0	0	0	4	4
1999	—	0	0	0	4	4
2000	—	0	0	0	4	4
2001	—	0	0	0	4	4
2002	—	0	0	0	5	5
2003	—	0	0	0	5	5
2004	—	0	0	0	5	5
2005	—	0	0	0	5	5
2006	—	0	0	0	5	5
2007	—	0	0	0	5	5

Appendix Table D3. Modified ICES statistics (official ICES data apportioned to Leningrad oblast), adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for herring (*Clupea harengus*) for Leningrad oblast (t). N/A: part of ICES category 'former USSR'.

Year	ICES modified statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	6,010	0	301	3	6,314
1951	N/A	5,660	0	283	3	5,946
1952	N/A	6,830	0	342	4	7,175
1953	N/A	7,600	0	380	4	7,984
1954	N/A	10,020	0	501	4	10,525
1955	N/A	10,820	0	541	4	11,365
1956	N/A	11,680	0	584	4	12,268
1957	N/A	10,340	0	517	4	10,861
1958	N/A	11,350	0	568	4	11,922
1959	N/A	14,960	0	748	4	15,712
1960	N/A	14,360	0	718	4	15,082
1961	N/A	15,270	0	764	5	16,038
1962	N/A	16,020	0	801	5	16,826
1963	N/A	11,290	0	565	5	11,859
1964	N/A	11,240	0	562	5	11,807
1965	N/A	19,340	0	967	5	20,312
1966	N/A	20,910	0	1,046	5	21,961
1967	N/A	22,900	0	1,145	5	24,050
1968	N/A	29,300	0	1,465	5	30,770
1969	N/A	28,800	0	1,440	5	30,245
1970	N/A	27,910	0	1,396	6	29,311
1971	N/A	25,820	0	1,291	6	27,117
1972	N/A	21,230	0	1,062	6	22,297
1973	N/A	22,290	0	1,115	6	23,410
1974	N/A	22,888	0	1,144	6	24,038
1975	N/A	17,639	0	882	6	18,527
1976	N/A	14,920	0	746	6	15,672
1977	N/A	17,355	0	868	6	18,229
1978	N/A	28,204	0	1,410	6	29,621
1979	N/A	24,035	0	1,202	7	25,243
1980	N/A	23,296	0	1,165	7	24,468
1981	N/A	22,092	0	1,105	7	23,204
1982	N/A	23,425	0	1,171	7	24,603
1983	N/A	25,321	0	1,266	8	26,595
1984	N/A	23,111	0	1,156	8	24,274
1985	N/A	23,311	0	1,166	8	24,485
1986	N/A	24,810	0	1,241	8	26,059
1987	N/A	25,163	0	1,258	9	26,430
1988	N/A	24,255	0	1,213	9	25,477
1989	N/A	24,246	0	1,212	9	25,467
1990	N/A	22,580	0	1,129	9	23,718
1991	N/A	20,913	1,413	1,116	10	23,452
1992	7,263	0	981	412	10	8,666
1993	5,846	0	1,185	352	10	7,393
1994	3,949	0	1,061	251	10	5,271
1995	4,214	0	1,071	264	11	5,559
1996	3,670	0	879	227	11	4,787
1997	2,930	0	659	179	11	3,780
1998	2,618	0	551	158	11	3,339
1999	3,167	0	620	189	12	3,988
2000	3,740	0	677	221	12	4,650
2001	3,922	0	653	229	12	4,816
2002	3,518	0	534	203	13	4,268
2003	4,276	0	587	244	13	5,120
2004	1,115	0	137	63	13	1,327
2005	1,168	0	131	66	13	1,379
2006	2,063	0	231	115	13	2,422
2007	2,679	0	300	160	13	3,153

Appendix Table D4. Modified ICES statistics (official ICES data apportioned to Leningrad oblast), adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for sprat *(Sprattus sprattus)* for Leningrad oblast (t). N/A: part of ICES category 'former USSR'.

Year	ICES modified statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	0	0	0	0	0
1951	N/A	0	0	0	0	0
1952	N/A	0	0	0	0	0
1953	N/A	2,490	0	125	0	2,615
1954	N/A	30	0	2	0	32
1955	N/A	230	0	12	0	242
1956	N/A	470	0	24	0	494
1957	N/A	520	0	26	0	546
1958	N/A	1,320	0	66	0	1,386
1959	N/A	2,000	0	100	0	2,100
1960	N/A	2,500	0	125	0	2,625
1961	N/A	3,270	0	164	0	3,434
1962	N/A	5,000	0	250	0	5,250
1963	N/A	8,060	0	403	0	8,463
1964	N/A	12,660	0	633	0	13,293
1965	N/A	8,550	0	428	0	8,978
1966	N/A	8,990	0	450	0	9,440
1967	N/A	7,600	0	380	0	7,980
1968	N/A	5,780	0	289	0	6,069
1969	N/A	10,780	0	539	0	11,319
1970	N/A	13,210	0	661	0	13,871
1971	N/A	24,370	0	1,219	0	25,589
1972	N/A	30,730	0	1,537	0	32,267
1973	N/A	38,340	0	1,917	0	40,257
1974	N/A	36,767	0	1,838	0	38,606
1975	N/A	33,475	0	1,674	0	35,149
1976	N/A	40,171	0	2,009	0	42,180
1977	N/A	43,971	0	2,199	0	46,170
1978	N/A	26,016	0	1,301	0	27,317
1979	N/A	18,063	0	903	0	18,966
1980	N/A	7,826	0	391	0	8,218
1981	N/A	6,670	0	334	0	7,004
1982	N/A	5,002	0	250	0	5,252
1983	N/A	4,256	0	213	0	4,469
1984	N/A	6,616	0	331	0	6,947
1985	N/A	8,718	0	436	0	9,154
1986	N/A	7,419	0	371	0	7,790
1987	N/A	9,668	0	483	0	10,152
1988	N/A	11,632	0	582	0	12,214
1989	N/A	16,107	0	805	0	16,913
1990	N/A	10,797	0	540	0	11,337
1991	N/A	5,487	371	293	0	6,151
1992	177	0	24	10	0	212
1993	209	0	42	13	1	264
1994	325	0	87	21	1	434
1995	290	0	74	18	1	383
1996	356	0	85	22	1	463
1997	432	0	97	26	1	556
1998	410	0	86	25	1	521
1999	615	0	120	37	1	773
2000	590	0	107	35	1	733
2001	621	0	103	36	1	762
2002	639	0	97	37	1	773
2003	678	0	93	39	1	810
2004	642	0	79	36	1	757
2005	80	0	9	4	1	94
2006	374	0	42	21	1	437
2007	883	0	99	49	1	1,032

Appendix table D5. Modified ICES statistics (official ICES data apportioned to Leningrad oblast), adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for salmon (*Salmo salar*) for Leningrad oblast (t). N/A: part of ICES category 'former USSR'.

Year	ICES modified statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	50	0	2	0	52
1951	N/A	80	0	3	0	83
1952	N/A	80	0	3	0	83
1953	N/A	80	0	3	0	83
1954	N/A	100	0	4	1	104
1955	N/A	90	0	3	1	94
1956	N/A	70	0	3	1	73
1957	N/A	50	0	2	1	52
1958	N/A	40	0	1	1	42
1959	N/A	20	0	1	1	21
1960	N/A	10	0	0	1	11
1961	N/A	10	0	0	1	11
1962	N/A	10	0	0	1	11
1963	N/A	0	0	0	1	1
1964	N/A	10	0	0	1	11
1965	N/A	0	0	0	1	1
1966	N/A	0	0	0	1	1
1967	N/A	0	0	0	1	1
1968	N/A	0	0	0	1	1
1969	N/A	0	0	0	1	1
1970	N/A	0	0	0	1	1
1971	N/A	10	0	0	1	11
1972	N/A	0	0	0	1	1
1973	N/A	0	0	0	1	1
1974	N/A	4	0	0	1	5
1975	N/A	6	0	0	1	7
1976	N/A	1	0	0	1	2
1977	N/A	0	0	0	1	1
1978	N/A	1	0	0	1	2
1979	N/A	5	0	0	1	6
1980	N/A	21	0	1	1	23
1981	N/A	55	0	5	1	60
1982	N/A	46	0	7	1	54
1983	N/A	83	0	19	1	102
1984	N/A	81	0	24	1	106
1985	N/A	81	0	29	1	111
1986	N/A	75	0	32	1	108
1987	N/A	104	0	52	1	157
1988	N/A	83	0	47	1	131
1989	N/A	123	0	78	1	202
1990	N/A	83	0	59	1	143
1991	N/A	44	3	36	1	83
1992	4	0	0	4	1	9
1993	4	0	1	4	1	10
1994	3	0	1	4	1	9
1995	3	0	1	4	1	9
1996	2	0	0	3	1	7
1997	2	0	0	3	1	6
1998	2	0	0	3	1	6
1999	1	0	0	2	1	5
2000	1	0	0	2	1	5
2001	0	1	0	4	2	7
2002	2	0	0	5	2	8
2003	2	0	0	8	2	12
2004	1	0	0	5	2	7
2005	1	0	0	1	2	4
2006	1	0	0	2	2	5
2007	0	0	0	0	2	2

Appendix table D6. Modified ICES statistics (official ICES data apportioned to Leningrad oblast), adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for the category 'flatfish' for Leningrad oblast (t). N/A: part of ICES category 'former USSR'.

Year	ICES modified statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	0	0	0	1	1
1951	N/A	0	0	0	1	1
1952	N/A	80	0	3	1	84
1953	N/A	0	0	0	1	1
1954	N/A	60	0	2	1	63
1955	N/A	110	0	4	1	115
1956	N/A	60	0	2	1	63
1957	N/A	250	0	9	1	260
1958	N/A	120	0	4	1	126
1959	N/A	200	0	7	1	209
1960	N/A	210	0	8	1	219
1961	N/A	220	0	8	1	229
1962	N/A	70	0	3	1	74
1963	N/A	120	0	4	2	126
1964	N/A	210	0	8	2	219
1965	N/A	110	0	4	2	116
1966	N/A	120	0	4	2	126
1967	N/A	60	0	2	2	64
1968	N/A	150	0	5	2	157
1969	N/A	210	0	8	2	219
1970	N/A	150	0	5	2	157
1971	N/A	150	0	5	2	157
1972	N/A	50	0	2	2	54
1973	N/A	0	0	0	2	2
1974	N/A	1	0	0	2	3
1975	N/A	77	0	3	2	82
1976	N/A	42	0	2	2	45
1977	N/A	44	0	2	2	48
1978	N/A	119	0	4	2	125
1979	N/A	181	0	7	2	190
1980	N/A	227	0	8	2	237
1981	N/A	109	0	4	2	115
1982	N/A	216	0	8	2	226
1983	N/A	209	0	8	2	219
1984	N/A	107	0	4	2	113
1985	N/A	96	0	4	3	102
1986	N/A	169	0	6	3	178
1987	N/A	332	0	12	3	347
1988	N/A	254	0	9	3	266
1989	N/A	157	0	6	3	166
1990	N/A	102	0	4	3	109
1991	N/A	48	3	10	3	64
1992	16	15	4	12	3	50
1993	34	14	10	28	3	89
1994	37	0	10	23	3	73
1995	57	1	15	36	3	111
1996	163	0	39	101	3	306
1997	239	0	54	145	3	441
1998	251	0	53	151	4	458
1999	217	0	43	127	4	391
2000	308	0	56	179	4	547
2001	304	1	51	175	4	534
2002	291	0	44	165	4	504
2003	1,430	0	196	805	4	2,435
2004	0	0	0	0	4	4
2005	0	0	0	0	4	4
2006	0	0	0	0	4	4
2007	0	0	0	0	4	4

Appendix Table D7. Modified ICES statistics (official ICES data apportioned to Leningrad oblast), adjustments to ICES landing statistics, unreported landings, discards, recreational catch, and reconstructed total for the category 'others' for Leningrad oblast (t). N/A: part of ICES category 'former USSR'.

Year	ICES modified statistics	Adjust-ments	Un-reported	Dis-cards	Re-creational	Total
1950	N/A	2,320	0	85	23	2,427
1951	N/A	2,480	0	91	24	2,594
1952	N/A	2,280	0	83	24	2,387
1953	N/A	1,770	0	65	25	1,860
1954	N/A	2,420	0	88	26	2,534
1955	N/A	2,150	0	78	26	2,255
1956	N/A	2,310	0	84	27	2,421
1957	N/A	1,880	0	69	28	1,976
1958	N/A	2,130	0	78	28	2,236
1959	N/A	4,240	0	155	29	4,424
1960	N/A	4,010	0	146	31	4,187
1961	N/A	3,180	0	116	31	3,327
1962	N/A	2,140	0	78	32	2,250
1963	N/A	4,270	0	156	33	4,459
1964	N/A	3,650	0	133	34	3,817
1965	N/A	4,360	0	159	34	4,553
1966	N/A	3,920	0	143	35	4,098
1967	N/A	4,240	0	155	36	4,430
1968	N/A	3,520	0	128	36	3,685
1969	N/A	2,940	0	107	37	3,084
1970	N/A	4,220	0	154	38	4,412
1971	N/A	5,100	0	186	38	5,324
1972	N/A	6,210	0	227	39	6,476
1973	N/A	7,350	0	268	40	7,658
1974	N/A	8,208	0	300	40	8,548
1975	N/A	9,329	0	341	41	9,711
1976	N/A	9,419	0	344	43	9,805
1977	N/A	9,024	0	329	44	9,397
1978	N/A	8,361	0	305	44	8,710
1979	N/A	5,189	0	189	45	5,423
1980	N/A	5,126	0	187	46	5,359
1981	N/A	5,629	0	205	47	5,882
1982	N/A	5,582	0	204	49	5,835
1983	N/A	7,312	0	267	51	7,629
1984	N/A	7,456	0	272	52	7,780
1985	N/A	7,222	0	264	55	7,541
1986	N/A	8,511	0	311	57	8,878
1987	N/A	8,516	0	311	58	8,885
1988	N/A	7,222	0	264	60	7,546
1989	N/A	8,285	0	302	62	8,649
1990	N/A	3,735	0	136	63	3,935
1991	N/A	3,221	218	174	65	3,677
1992	9,526	281	1,325	721	69	11,926
1993	3,590	0	728	341	71	4,729
1994	2,342	130	664	247	73	3,457
1995	2,340	0	595	232	74	3,241
1996	1,842	0	441	180	76	2,539
1997	2,372	0	534	229	78	3,213
1998	2,242	0	472	214	80	3,008
1999	1,418	0	277	134	82	1,911
2000	1,332	0	241	124	84	1,781
2001	1,314	0	219	121	86	1,740
2002	1,430	0	218	130	88	1,865
2003	1,199	0	165	108	89	1,560
2004	879	0	108	78	91	1,155
2005	1,290	0	144	151	94	1,679
2006	1,220	0	137	254	94	1,705
2007	892	0	100	90	94	1,175

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

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ABSTRACT

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

INTRODUCTION

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

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

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

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

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

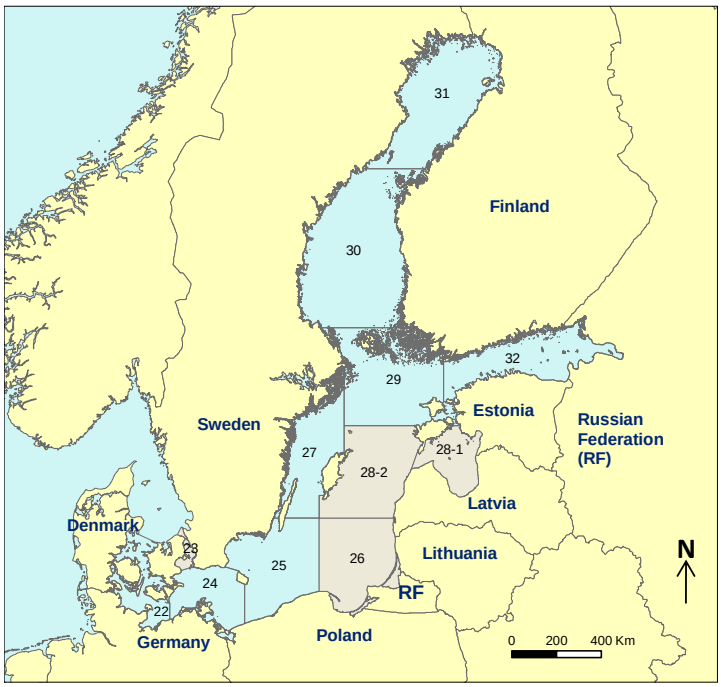

Figure 1. Map of the Baltic Sea with ICES subdivisions and surrounding countries. Sweden's coastline borders ICES subdivisions 23-25, 27 and 29-31.

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

Commercial fisheries

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

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

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

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

Recreational fishing (non commercial fishing)

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

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

METHODS

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

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

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

ICES landings statistics

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

Illegal, Unreported and Unregulated (IUU) catches

Adjustments to reported landings

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

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

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

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

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

Unreported landings

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Discards

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

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

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

Table 4. Economic seal-damaged discard loss.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Recreational catches

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

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

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

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

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

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

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

RESULTS

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

Cod

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

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

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

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

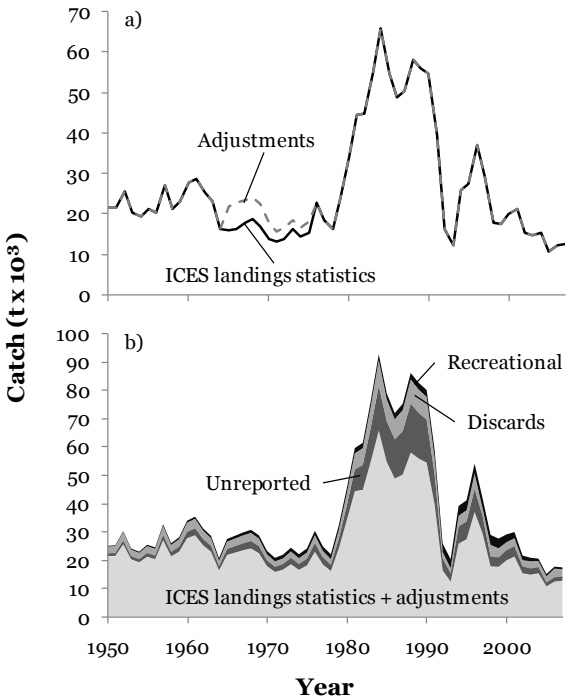

Figure 2. Swedish cod landings in the Baltic Sea: a) ICES landings statistics and adjustments; b) Sweden's reconstructed cod catches in the Baltic Sea.

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

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

Herring

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

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

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

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

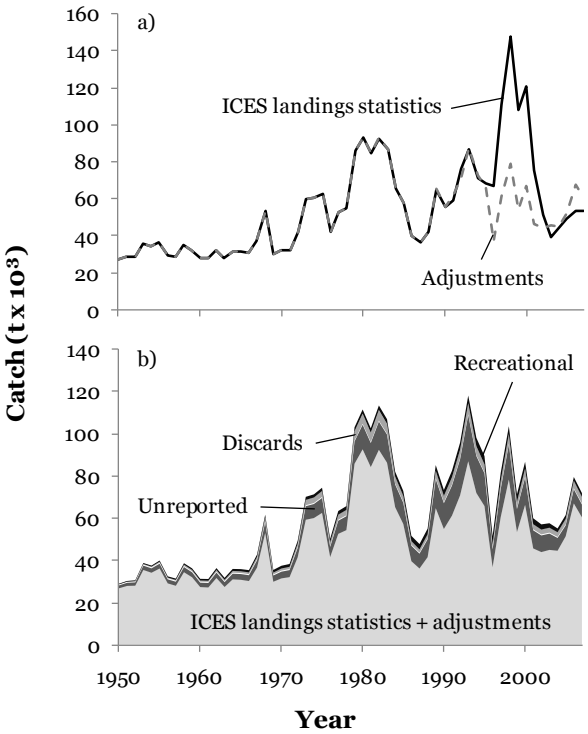

Figure 3. Swedish herring landings in the Baltic Sea 1950-2007: a) ICES landings statistics and adjustments; b) Sweden's reconstructed herring catches in the Baltic Sea.

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

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

Sprat

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

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

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

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

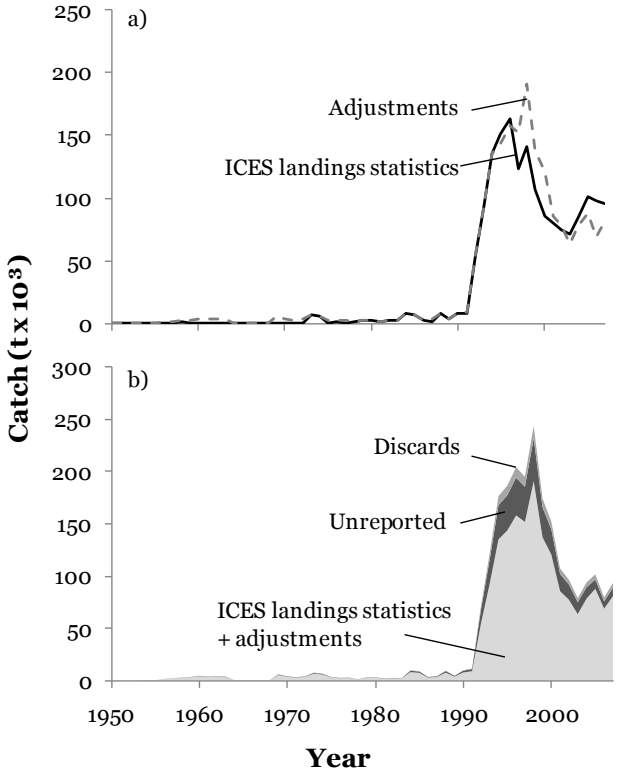

Figure 4. Swedish sprat landings in the Baltic Sea 1950-2007: a) ICES landings statistics and adjustments; b) Sweden's reconstructed sprat catches in the Baltic Sea.

Salmon

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

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

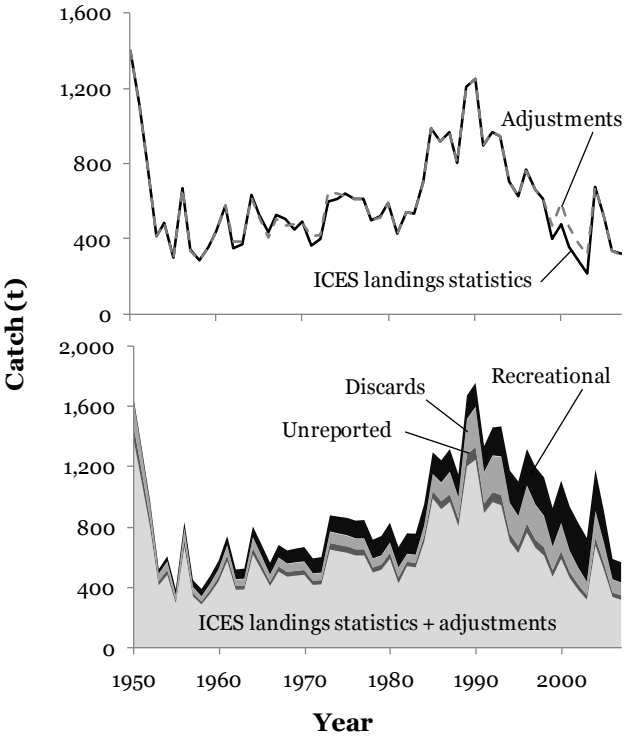

Figure 5. Swedish salmon landings in the Baltic Sea 1950-2007: a) ICES landings statistics and adjustments; b) Sweden's reconstructed salmon catches in the Baltic Sea.

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

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

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

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

Flatfishes

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

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

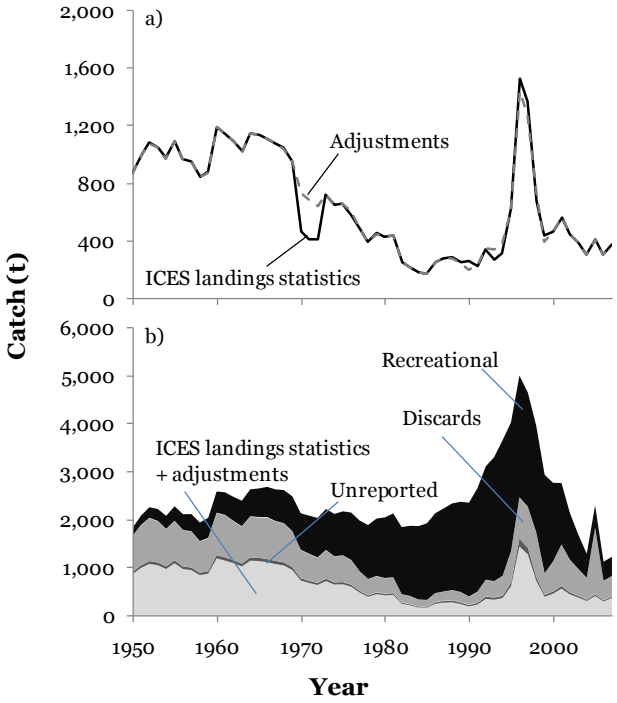

Figure 6. Swedish flatfish landings in the Baltic Sea 1950-2007: a) ICES landings statistics and adjustments; b) Sweden's reconstructed flatfish catches in the Baltic Sea.

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

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

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

Sea trout

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

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

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

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

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

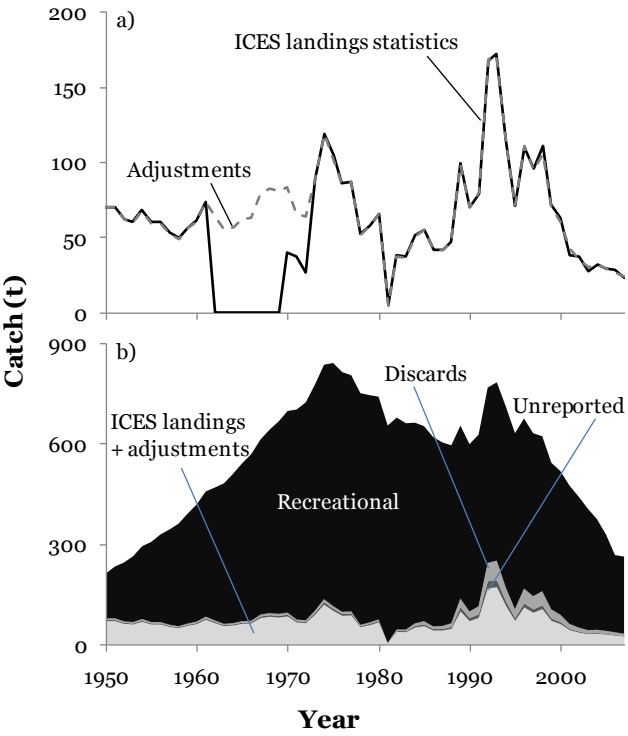

Figure 7. Swedish sea trout landings in the Baltic Sea: a) ICES landings statistics and adjustments; b) Sweden's reconstructed sea trout catches in the Baltic Sea.

Eel

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

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

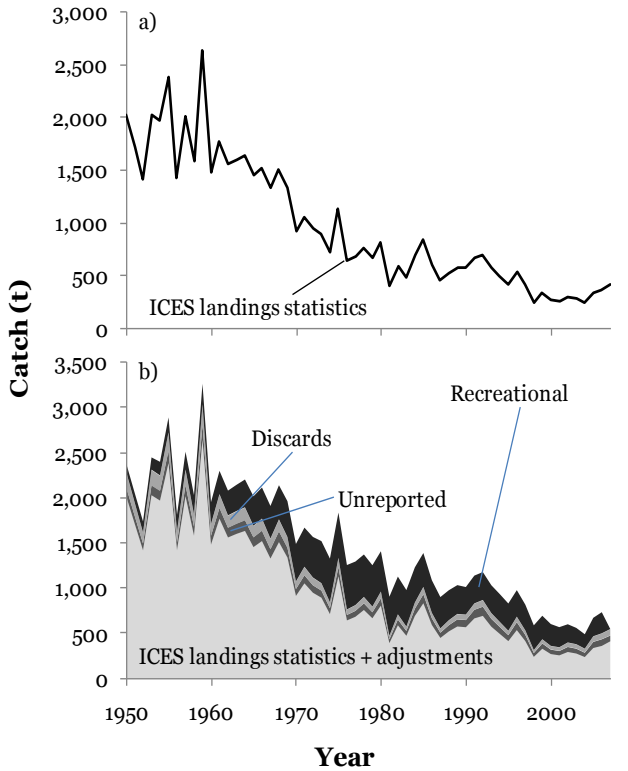

Figure 8. Swedish eel landings in the Baltic Sea 1950-2007: a) ICES landings statistics; b) Sweden's reconstructed eel catches in the Baltic Sea.

due to seal damage.

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

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

Whitefish

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

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

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

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

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

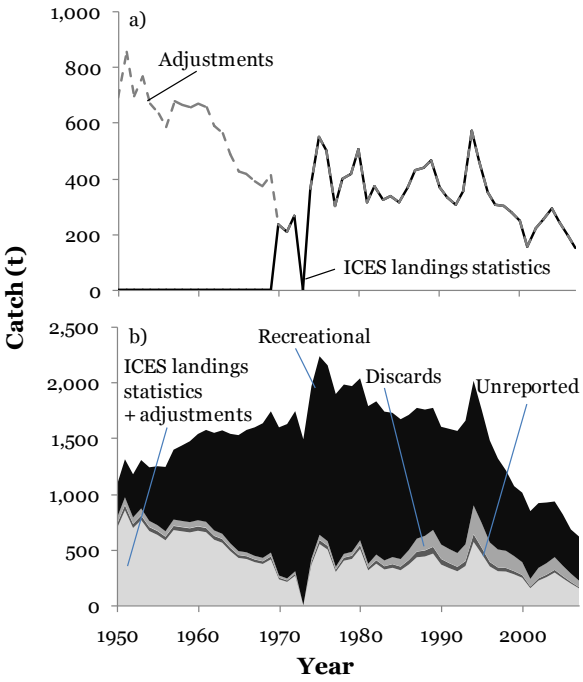

Figure 9. Swedish whitefish landings in the Baltic Sea 1950-2007: a) ICES landings statistics and adjustments; d) Sweden's reconstructed whitefish catches in the Baltic Sea.

Total reconstructed catches

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

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

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

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

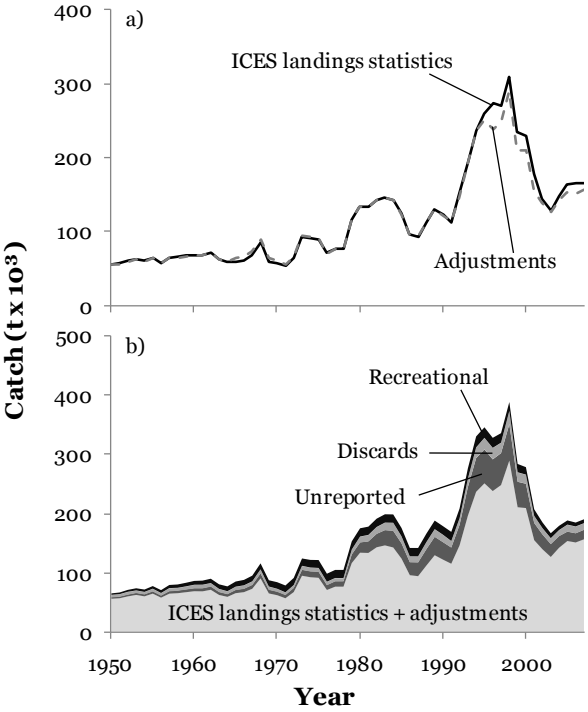

Figure 10. Swedish total landings in the Baltic Sea 1950-2007: a) ICES landings statistics and adjustments; b) Sweden's total reconstructed catches in the Baltic Sea

DISCUSSION

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

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

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

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

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

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

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

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

Unreported landings

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

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

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

Discards

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

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

'Less important' species

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

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

Issues for improvement

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

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

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APPENDIX A

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

APPENDIX B

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

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

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

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

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

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

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

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

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

Illegal, Unreported and Unregulated (IUU) catches

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

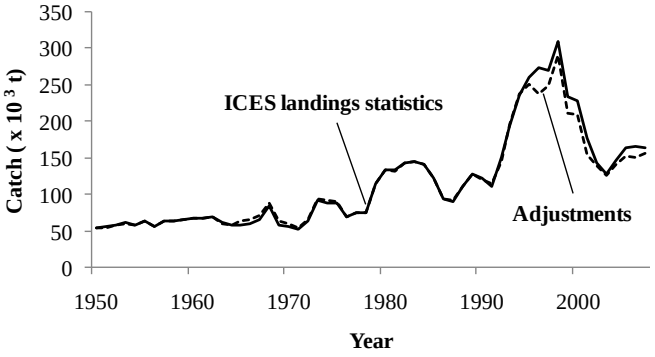

Figure B1. ICES landings statistics and adjustments to ICES landings for Sweden from 1950-2007.

Adjustments to ICES landings statistics

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

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

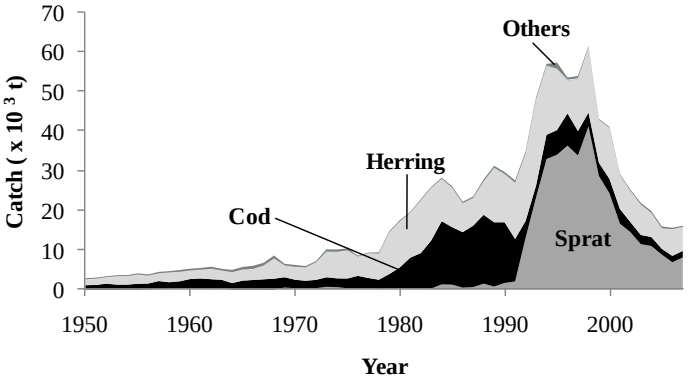

Figure B2. Sweden's unreported landings by taxa for the Baltic Sea from 1950-2007.

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

Unreported landings

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

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

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

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

Discards

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

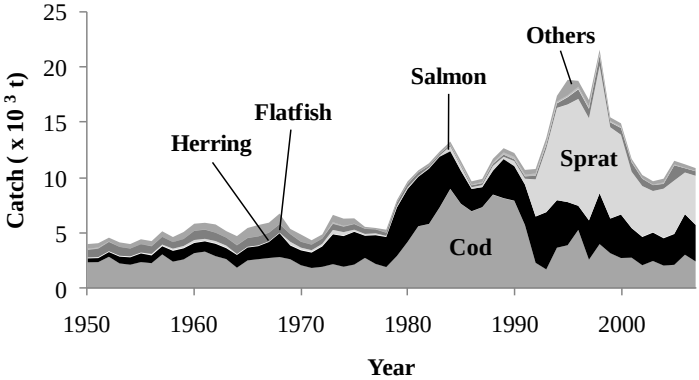

Figure B3. Sweden's discards by taxa 1950-2007.

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

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

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

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

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

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

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

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

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

Recreational catches

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

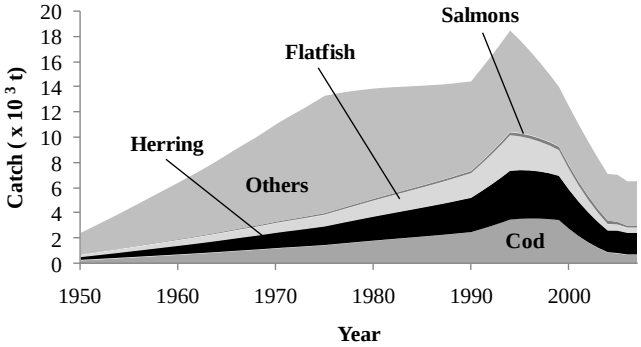

Figure B4. Sweden's recreational catches in the Baltic Sea, 1950-2007.

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

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

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

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

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

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

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

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

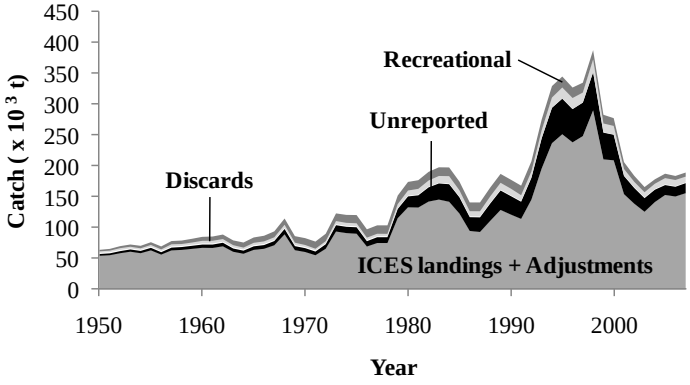

Figure B5. Sweden's total reconstructed catch by component from 1950-2007.

Total reconstructed catch

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

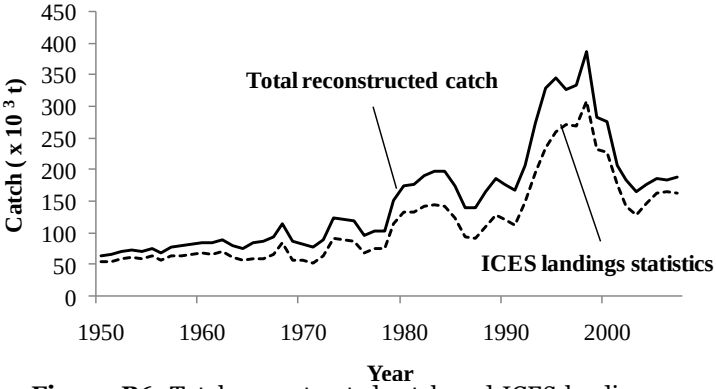

Figure B6. Total reconstructed catch and ICES landings statistics for Sweden from 1950-2007.

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

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

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

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

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

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