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.

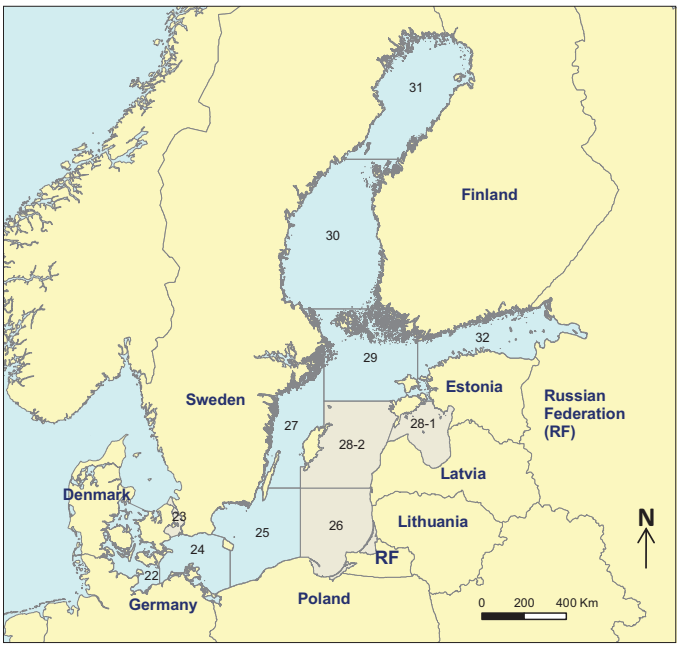

Figure 1. Map of the Baltic Sea with ICES subdivisions and surrounding countries. Denmark's coastline borders ICES subdivisions 22, 23, 24 and 25.

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.

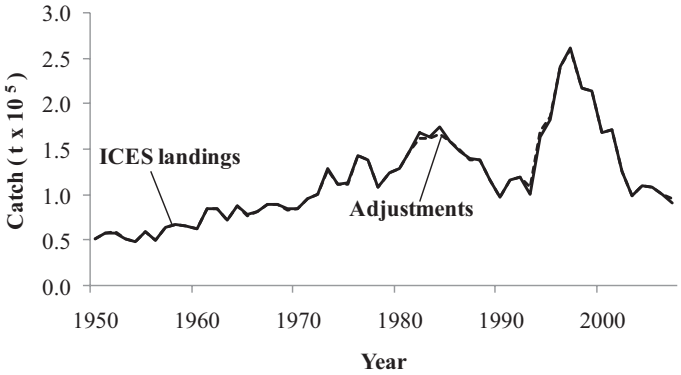

Figure 2. Adjustments to officially reported landings from the 'ICES landings statistics' for Denmark (1950-2007).

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

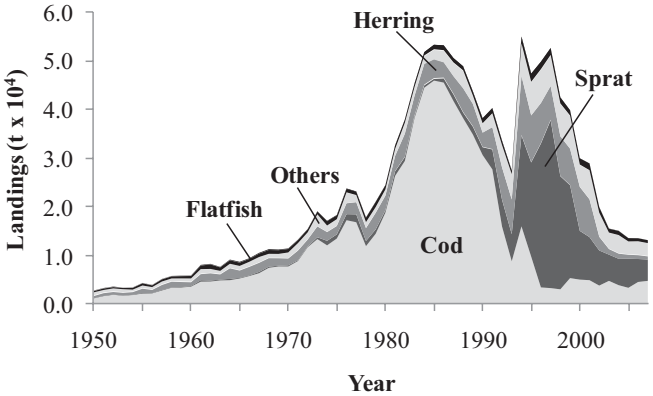

Figure 3. Total unreported catch by taxa for Denmark (1950-2007).

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).

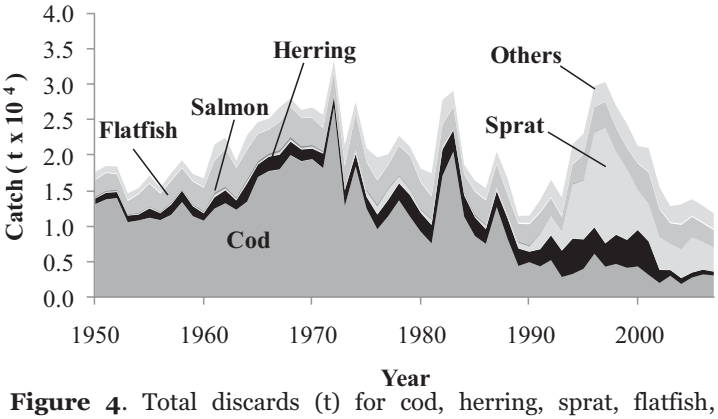

Figure 4. Total discards (t) for cod, herring, sprat, flatfish, salmon and 'others' in Denmark (1950-2007).

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).

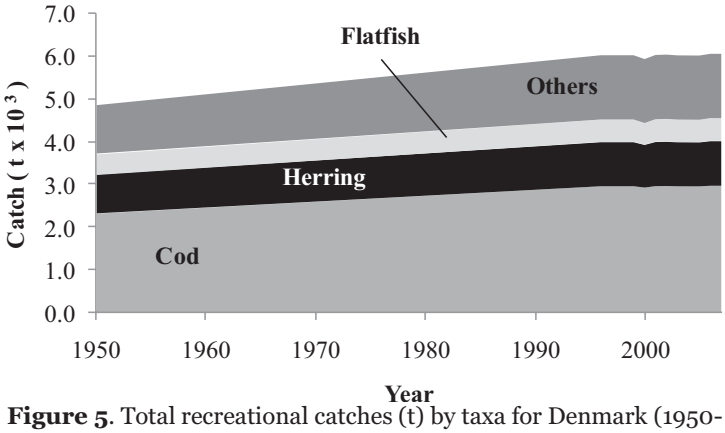

Figure 5. Total recreational catches (t) by taxa for Denmark (1950-2007).

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).

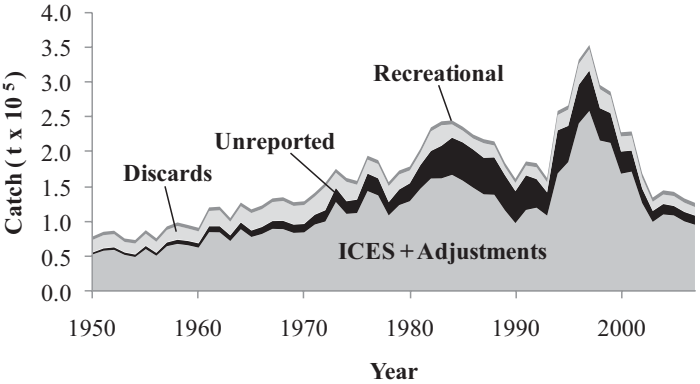

Figure 6. Total reconstruction (t) for Denmark (1950-2007) including data from 'ICES landings statistics' and all aspects of IUU: i) adjustments added to reported landings; ii) unreported landings; iii) discards; and iv) recreational catches.

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).

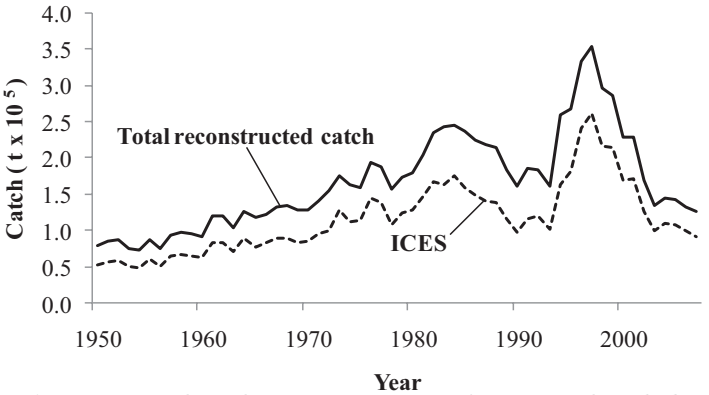

Figure 7. Total catch reconstruction (t) for Denmark including 'ICES landings statistics' and additions of IUU: i) adjustments; ii) unreported landings; iii) discards; and iv) recreational catches.

DISCUSSION

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

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