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).

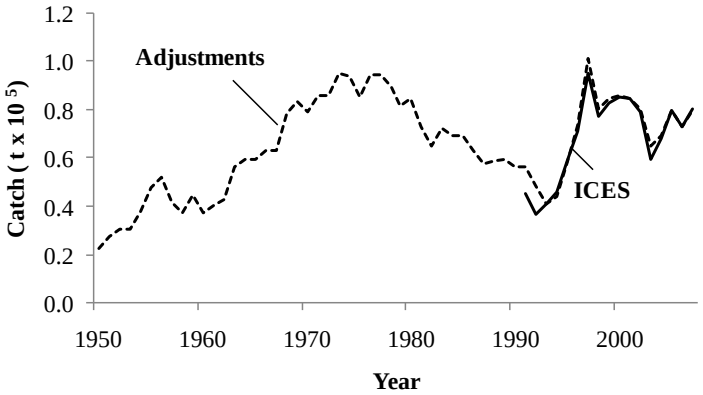

Figure 2. ICES landing statistics and adjustments to ICES landing statistics for Estonia from 1950-2007.

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).

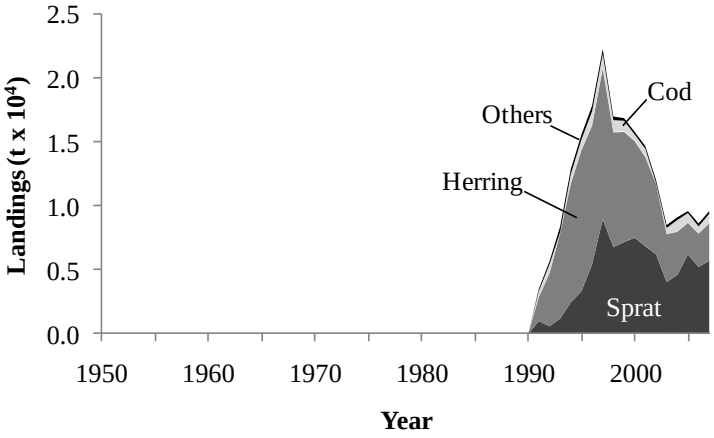

Figure 3. Unreported landings by taxa for Estonia, 1950-2007

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.

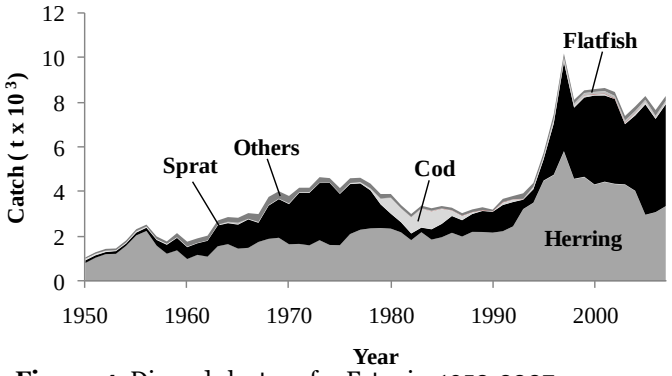

Figure 4. Discards by taxa for Estonia, 1950-2007.

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

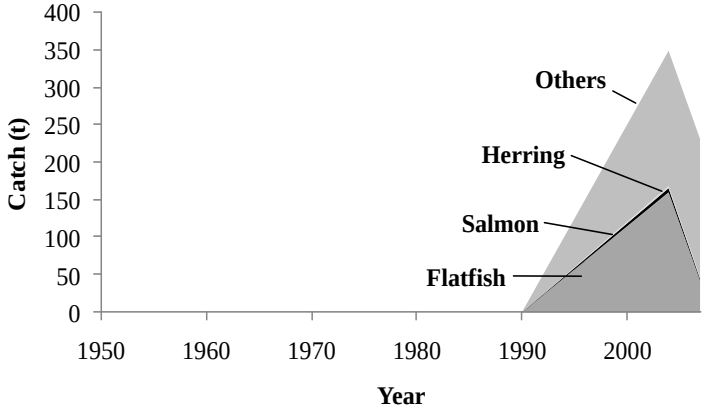

Figure 5. Estonia's recreational catches by major taxa, 1950-2007

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.

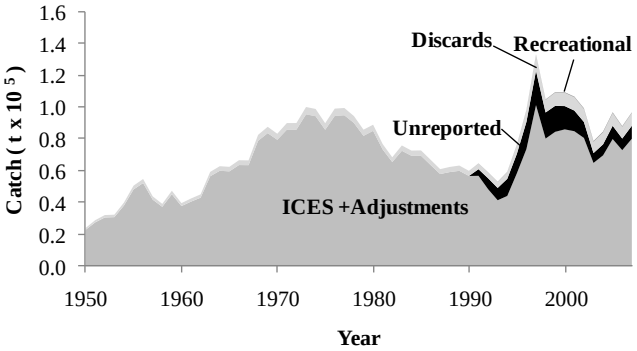

Figure 6. Area graph of Estonia's total reconstructed catch by component for 1950-2007.

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.

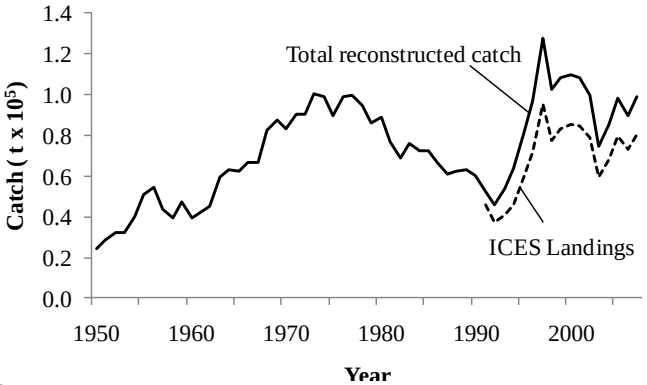

Figure 7. ICES landings statistics vs. total reconstructed catch for Estonia from 1950-2007.

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