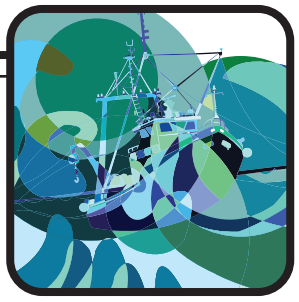

CHAPTER 6: Invisible Catch:

A century of bycatch and unreported removals in Sea Fisheries, Belgium 1929–2010

CHAPTER 6. INVISIBLE CATCH: A CENTURY OF BYCATCH AND UNREPORTED REMOVALS IN SEA FISHERIES, BELGIUM 1929-2010

Modified from the publication:
Lescrauwaet, A.-K., Torreele,′ E., Vincx,′ M., Polet, H. and Mees, J. 2013. Invisible Catch: A Century of bycatch and unreported removals in Sea Fisheries, Belgium 1929-2010. Fisheries Research (in press, 2013). 10.1016/j.fishres.2013.05.007

Note: A summary of this chapter will be included in the Global Atlas of Fisheries Total Catch Reconstruction as the contribution for Belgium. Publication by the 'Sea Around Us Project', dr. Daniel Pauly, Fisheries Centre, University of British Columbia UBC , Canada. No citation available yet.

Abstract

Publicly reported statistics on the production of fisheries available refer to 'landings' as opposed to 'catch'. However, well-informed decisions and evaluation of the impacts of fisheries on ecosystems must be based on total removals, so including the part of the catch that is discarded at sea or not reported as landings. Total removals by Belgian fisheries from all ICES fishing areas and from the Belgian part of the North Sea (BNS) from 1929-2010 were reconstructed by including unreported and misreported landings of the commercial fleet, unreported landings by the recreational and artisanal/subsistence fisheries and by estimating discards for the most important fisheries. Total reconstructed removals were estimated at 5.2 million t or 42% higher than the 3.7 million tonnes (t) publicly reported over this period. Unreported landings and discards were estimated to represent respectively 3.5% (0.2 million t) and 26% (1.3 million t) of these total reconstructed removals. The reconstructed total removals on the BNS were estimated to be 55% higher than the 0.8million t publicly reported over this period. In terms of percentages, discards on the BNS represent an average annual of 34% over the entire period. The results suggest that since the 2000s, approximately 50% of all Belgian removals from the BNS are unreported landings and discards (IUU). The unreported landings and discards are increasingly taken by non-commercial, small-scale (<12m) vessels that are not subject to reporting and not taken into consideration in planning, monitoring and enforcement. While the present paper provides a first attempt to reconstruct historical total removals for Belgium's sea fisheries, it also addresses the gaps in data and information that need to be resolved to improve the reliability of the estimates of unaccounted removals. The reconstructed time series provides a context for the wider debate about how to move to more sustainable fisheries, what the role of small-scale fisheries are, how to achieve the agreed policy targets in Belgian marine waters and in particular in the marine areas protected under the EU Habitat and Bird directives.

Key words: Catch reconstruction, IUU, Belgium, EEZ

6.1 INTRODUCTION

Well-informed decisions in support of ecosystem-based resource management in the marine environment must be based on total removals by fishing activities and not just on officially reported landings (Zeller et al. 2009). The total removals by fishing can be summarized as the publicly reported plus the total of *illegal, unreported and unregulated catches* or IUU (Pauly 1998, Bray 2000). Publicly reported statistics on fisheries generally refer to commercial landings which are only a part of the catch and hence of the total removals.
The difference between publicly reported versus total anthropogenic removals includes several components. Besides the unreported and misreported commercial landings (Zeller et al. 2006, Zeller et al. 2007), part of the catch is discarded at sea by fishers (Kelleher 2005), suffers unaccounted underwater mortality in the fishing gear (Collie et al. 2000, Rahikainen et al. 2004, Kaiser et al. 2006, Depestele et al. 2008) or is removed by recreational/artisanal fishing (Coleman et al. 2004, Zeller et al. 2008). It is widely accepted that the dumping of fish at sea is unethical and represents a substantial waste of resources (Diamond and Beukers-Stewart 2011). Resolution 57/142 (2002) of the United Nations urges states and regional organizations to develop and implement techniques to reduce and eliminate bycatch and fish discards. In many cases, there are considerable uncertainties in stock assessments as a consequence of low stock size, inaccuracies in catch data (total removals) and variability in survey indices. These uncertainties add to the challenges of setting targets for the recovery of stocks in a changing natural environment.

In the pursuit of an ecosystem-based approach in the marine environment, it has become increasingly important to document and quantify total removals. Data Collection Regulations in support of the Common Fisheries Policy CFP (EU Council Regulation 1543/2000 and Commission Regulations 1639/2001, 1581/2004 and 199/2008) require European Member States to collect data on technical, biological and economic aspects of their national fisheries, and their impact on the marine ecosystem. Regulation COM(2007) 136 requests member states to collect data and report on discards. As a follow-up of this regulation and the outcomes of the revised CFP regarding the so-called 'discard-ban', it is anticipated that from 2015 formal reporting on commercial landings will be extended with commercial discards and removals from non-commercial fishing so as to obtain a more complete view on total removals from the marine ecosystem by fisheries and improve stock assessments. Moreover, for the establishment of criteria and definition of good environmental status (GES) for the Marine Strategy Framework Directive MSFD (2008/56/EG), both the current information on total removals and the historical reference conditions are important. Besides the gaps in historical information, there is no quantitative or qualitative assessment of the small-scale fisheries (<12m) within 12 nautical miles or the territorial sea of Belgium. Historical time-series are scarce and available time-series mostly date from after the start of intensive exploitation. In Belgium, centralized reporting on landings of sea fisheries at the species level started in 1929 (Lescrauwaet et al. 2010a). As is the case for most fishing nations, the routine data collection requirements related to sea fisheries production in Belgium were - until recently - limited to landings of the commercial fleet. Discards of the commercial fleet, landings and discards of the recreational fleet, and artisanal and land-based fishing activities are not covered in systematic reporting.

The present work contributes to the reconstruction of total present and historical removals by Belgian fisheries by estimating the unreported catch and the discards, based on the best available scientific data and information. These estimates help to better inform the public on current and historical levels of fisheries removals and underline the importance of unaccounted components of total removals. They can support informed decision making towards more sustainable catch levels, in particular for the Belgian part of the North Sea. The paper also provides an overview of relevant historical sources reporting on bycatch, discards and unreported catch that can be of use for similar exercises in other countries. Finally, remaining gaps and uncertainties that need to be removed in order

to fully reconstruct the historical total removals by Belgian fisheries in the eighty-two years from 1929 until 2010, are identified.

6.2 SEA FISHERIES IN BELGIUM: CURRENT AND PAST SITUATION

Fleet, ports and employment

Belgium today has four coastal ports (Nieuwpoort, Oostende, Zeebrugge and Blankenberge) and besides the fish auctions located in Oostende, Zeebrugge and Nieuwpoort there are no other or dispersed commercial landing points. Before World War II (WWII, 1939-1945) there were important settlements in Heist and Blankenberge to the east, in the Scheldt estuary, and in De Panne, Adinkerke, Oostduinkerke and Koksijde to the west. Together with the current fishing ports they harboured more than 500 vessels of which approximately 100 had open and half-open decks. In 2011, the Belgian commercial sea fishing fleet consists of 86 ships, with a total engine capacity of 49,135 kW and a tonnage of 15,326 GT (Tessens and Velghe 2012). 46 vessels are part of the Small Fleet Segment (SFS; max 221 kW engine power) of which 2 use passive gear and the others are beam trawlers for shrimp and flatfish. Of the SFS, 21 are inshore vessels that make fishing trips of less than 48 hours within the range of 12 nautical miles. 43 vessels compose the Large Fleet Segment (LFS) with an engine power between 221 kW and a maximum of 1,200 kW. The LFS consists of 5 vessels using trammel nets, 4 using otter trawl (*bordenvisserij*) and 34 large beam trawl vessels (≥662 kW). The Belgian commercial fishing fleet has no vessels under 10m or above 40m. According to the EU definition (EC Council Regulation Nr 1198/2006), none of the vessels or fisheries operating in the Belgian fleet can be considered as small-scale fisheries, except for one 11.8m vessel operating drift and/or fixed nets. Reconstructed time-series on fleet dynamics since 1830 (Lescrauwaet et al. 2012) show a decrease of 85% in the fleet size between 1946 and today, while the fleets' overall engine power has decreased by only 5% in that same period. This 85% decrease in fleet size was compensated by a 10-fold increase in average gross tonnage and a six-fold increase in average kW per vessel. The Belgian fleet today is highly specialized: more than 68% of the effort (expressed as seadays or SD) and 77% of total landings are achieved by beam trawlers in 2010, focusing primarily on flatfish species such as plaice (*Pleuronectes platessa*) and sole (*Solea solea*).

Origin, value and composition of landings

In 2010, the Belgian fleet landed a total of 22,000 t (fresh weight), of which 80% was landed in the Belgian ports. After a maximum of 81,000 t reported (fresh weight) landings in 1947, annual landings declined steadily to only 26% of this peak today. Currently, landings are below those achieved in 1929. Considering the period 1929-2010, the most important species in terms of landings were cod (*Gadus morhua*, 17% of all landings), herring (*Clupea harengus*, 16%), plaice (14%), sole, whiting (*Merlangius merlangus*) and rays. In terms of economic value, sole (31%) and cod (15%) were the most valuable (Lescrauwaet et al. 2010a). Since reporting started, 20% of all reported landings have originated from the 'coastal waters' (section 6.4. i), while these waters contributed nearly 60% of all landed pelagic species and 55% of all landed 'molluscs and crustaceans'. The boundaries of the reporting unit 'coastal waters' approximate the area of the Belgian part of the North Sea (part of ICES subdivision IVc). North Sea (south) (ICES fishing subdivision IVc, Figure 6.1.), Iceland (Va), North Sea (central-west) and North Sea (central-east) (the last two aggregated as IVb in FAO/ICES fisheries statistics) were the next most important fishing areas in terms of reported landings. Overall, 73% of all landings originated from only 5 of the 31 fishing areas where the fleet operated historically.

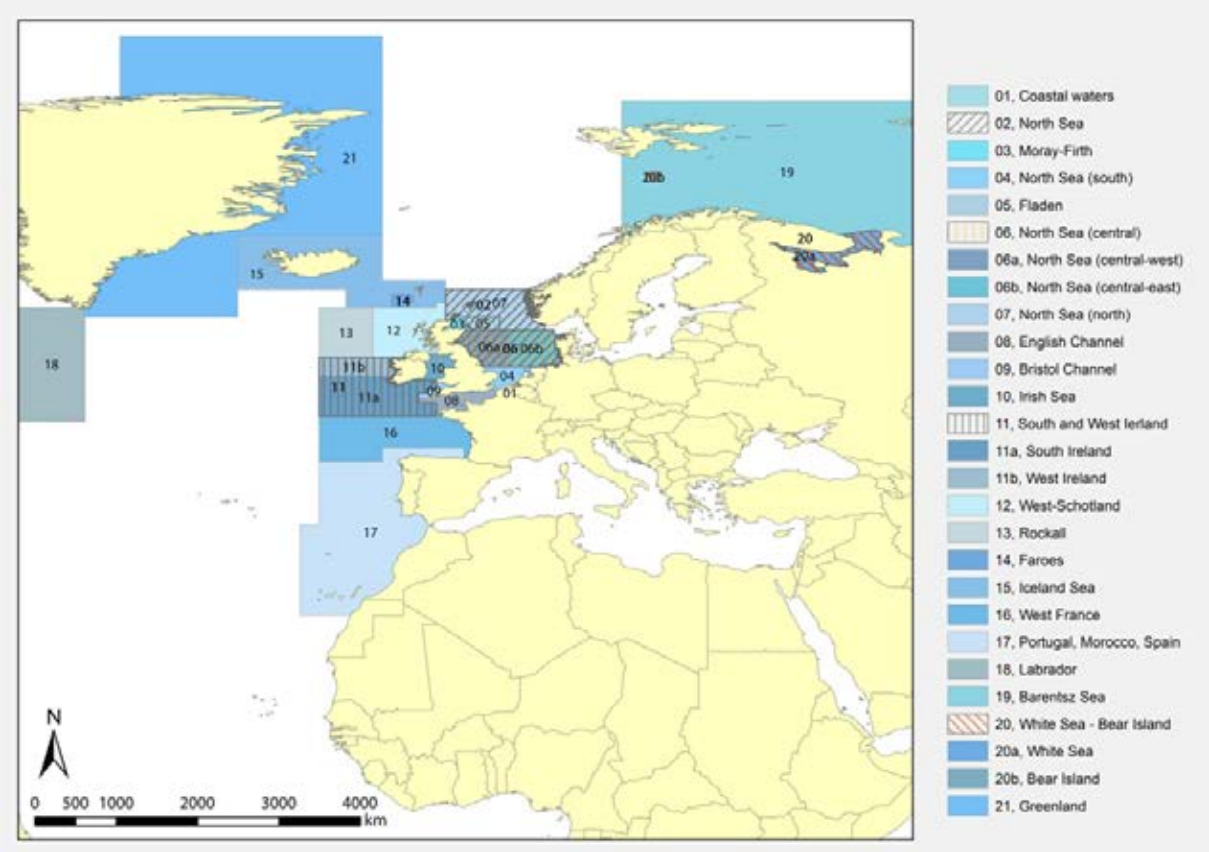

Figure 6.1.: Boundaries and names of fishing areas where the Belgian fleet was active between 1929 and 2010, as referred to in historical data sources. *Source: 'Marine Regions' www.marineregions.org (VLIZ).*

Fisheries and fishing gear 1929-2010

In Belgium the transition from sail to motor engines was near to completion by 1929 and after WWII the commercial fleet consisted mainly of motor engine-powered vessels. The last steamer disappeared in 1964 (Lescrauwaet et al. 2012). As was the case for the steamers, the motor engine-powered vessels used the otter trawl to catch fish. Before 1950, the otter trawl was the main fishing gear, together with drift nets (for pelagic fisheries). After 1960, the otter trawl was mainly used for roundfish (e.g. whiting and cod) fisheries and for shrimp (*Crangon crangon*). The pelagic trawl for herring and sprat was used from 1950 onwards and remained important until 1965 in terms of effort (SD) and landings (Gilis 1962). After 1960, the (re)introduction of the beam trawl (*boomkorvisserij*) – the most efficient gear for catching targeted flatfish – and the subsequent technological improvements to increase catch efficiency of the beam trawl required an increasing average engine power (Polet et al. 1998). The installment of the beam trawl was subsidized by the Belgian government and supported by royal decree 1/03/1958 (Lescrauwaet et al. 2012). In 1985 otter trawling targeting herring and sprat, shrimp, and other species represented respectively 1%, 11% and 21% of effort in SD while beam trawl targeting sole and plaice represented 62%. The remaining 5% effort was realized by twin trawling ('*spanvisserij*') for cod. With the increasing cost of diesel, recent interest has been given to the otter trawl (10% of SD) compared to the shrimp beam trawl (14% of SD) the flatfish beam trawl (68% of SD) and passive gear (1% of SD) in 2010. Passive forms of fishing that are gaining importance are angling (handlines) for cod and sea bass, trammel- and gillnetting.

6.3 Materials and Methodology

Data and information sources

ICES Fishstat database

The 'ICES Official Catch Statistics' electronically available from the ICES webpages, describes reported landings by country, species (or higher taxonomic grouping), ICES reporting area and year. The electronic database is publicly available for redistribution and used as the EU official report on fisheries 'catch' to the Food and Agriculture Organization of the United Nations (FAO). The version 2012 - with updated time-series up to 2010 - is used as a baseline in the present study and throughout referred to as 'ICES Fishstat'.

HiFiDatabase: Historical fisheries database (landings and value of landings)

Based on fragmented and disperse data sources, including previously uncovered original reporting cards, time-series for Belgian sea fisheries were standardized, quality controlled and integrated from 1929 onwards. The detailed procedures for quality control and integration of data are explained in Lescrauwaet et al. (2010b). The resulting historical fisheries database (HiFiDatabase) contains data by species (41), by port of landing in Belgium (4) and in 'foreign ports,' and by fishing area of origin (31) (Lescrauwaet et al. 2010a). Landings in the HiFiDatabase are reported as 'dead weight' and hence were converted to live weight to compare to the ICES Fishstat. Compared to the ICES Fishstat, the HiFiDatabase offers advantages in temporal coverage (data from 1929 onwards), temporal scale (monthly values), weight class (e.g., 5 to 7 weight classes for sole) and taxonomic resolution (less grouping). It also provides more detailed information at the spatial scale as it contains a reporting unit for the western central North Sea (IVb-1) and the eastern central North Sea (IVb-2), and it is the only source of historical information on landings originating from the 'coastal waters', Fladen, and Morray-Firth.

ICES baseline data do not contain statistics with spatial reference to the Belgian EEZ or to the BNS. Only from 1996 onwards, data are available for research purposes at a spatial scale that is of relevance to the BNS. An additional challenge with the data by ICES rectangles is the position of these rectangles by which the data are aggregated. Although one of the 3 relevant reporting rectangles (31F2) has a significant proportion of its area within the BNS, unknown but likely significant landings from the areas of 2 other rectangles (31F3, 32F2) should be taken into account (Figure 6.9.). The HiFiDatabase however contains data reported for the 'coastal waters' from 1929-2010. These unique historical data were used in the present estimates of total removals at the scale of the BNS. For the purpose of quality control, the reported landings for the 'coastal waters' (1929-2010) were compared to the fragmented historical source documents that report at ICES statistical rectangle. The data for the combined rectangles 31F2 and 31F3 provide a fair match (<10% difference) with the historical time-series for the 'coastal waters'. Considering the spatial scale of the BNS, this time-series is therefore considered to provide an acceptable representation of the landings originating from the BNS. Inconsistencies between the ICES Fishstat (version 2008) and HiFiDatabase – in particular for the years between 1929 and 1960 – were previously reported by Lescrauwaet et al. (2010b). The ICES Fishstat version 2008 was amended by ICES in 2012. The values included in the amended version Fishstat 2012 are closer to the values in the HiFiDatabase, compared to the Fishstat 2008 version. The Fishstat 2012 also contains updates of the landings up to 2010. The differences between the HiFiDatabase and the Fishstat 2012 (our baseline for this study) are considered as unreported removals and are included in the present reconstruction.

Historical literature and literature databases

Literature databases were searched for historical publications and references related to unreported catch (Web of Science, JSTOR, Google Scholar, IMIS). Flanders Marine Institute (VLIZ) manages the Integrated Marine Information System IMIS for Belgium, which provided crucial relevant historical information to complete the estimates (Table

6.1. and list of references). Much of this information is contained in previously unpublished manuscripts that were disclosed in IMIS to this purpose, or in publications in native languages (Dutch, French) that are not picked up by global scientific literature databases focusing on English-speaking literature. These references contain information that is potentially relevant for similar exercises in other fishing nations around the North Sea. Relevant historical legislation with an impact on sea fisheries management (fleet, effort, gear, etc.) was obtained from the historical timeline on sea fisheries application. All taxonomic references were obtained from the World Register of Marine Species WoRMS.

Adding components

The separate components were quantified or estimated and added to the baseline to reconstruct total removals (as opposed to reported landings) for Belgian sea fisheries. To structure this stepwise process, the categorizations as defined in Zeller et al. (2010) were used in the approach:
(1) 'adjustments' to the baseline ICES Fishstat, based on HiFiDatabase and considered as 'unreported' landings
(2) other unreported landings from the commercial fleet
(3) discards: mainly 'boat-based' discards resulting from fishers' behavior (e.g. the so-called high-grading)
(4) recreational removals and artisanal/subsistence fisheries, not included in the reported landings

Discard is the dumping of the un-wanted portion of the catch whereas by-catch is the part of the catch that is captured incidentally to the target species and as such may have some economic value. With regards to (3), the proposed 'discard ban' (COM(2007) 136) has revived the debate related to the need to take into account survival rates of certain species of discarded fish and invertebrates in order to achieve more accurate discard mortality estimates as part of stock assessments. The results of survival rate studies were shown to be highly dependent of the experimental design, the environmental conditions (season, fishing area, temperature, depth, etc.) and fishing conditions (gear, duration of tow or soaking time, weight of the catch, etc.) (Depestele et al. 2008). While acknowledging the potential survival rates of discarded fish and invertebrates, a precautionary approach is taken in the present reconstruction.

The baseline adjustments, unreported landings and recreational removals were added to the baseline data. Information on discards and discard rates was generally applied as a percentage rate to the reported plus the unreported catches of specific species, by type of fisheries. Any assumptions adopted in the present estimates on discarding are science-based. Estimates on recreational fisheries are founded on expert judgment from people that have >30 years experience in the field. Where insufficient information is available for the estimation of a missing component, this is indicated and identified as a challenge for future research. This stepwise and bottom-up approach is conducted for the most important fisheries in Belgium between 1929 and 2010: the otter and beam trawl *Crangon* shrimp fisheries, the pelagic trawl fisheries for herring and sprat, the otter trawl *Nephrops* fisheries, the otter trawl fisheries for cod and other roundfish, the beam trawl flatfish fisheries (sole and plaice), and recreational sea angling (section 6.4. f). Other fisheries or fishing gear such as dredges, seine nets, trammel nets etc., were not taken into account in the reconstruction because of their limited contribution to total landings and fishing effort. Mortality that was not taken into account includes underwater discards such as tow path mortality or escape mortality caused by the gear, changing or decreasing mesh size and other technological developments affecting bycatch of the gear. Ghost fishing caused by lost or abandoned trawl nets was considered negligible or zero (Depestele et al. 2012).

Approach and assumptions by type of fisheries

Estimates, variables and bibliographic sources used in the present reconstruction of total removals are summarized by type of fisheries (Table 6.1.). In a first step, the different components (reported landings, unreported catch,

discards) are added for each fishery. Although they are intermediate results of the present analysis, they provide a unique level of detail, and therefore are included in the first subsections a) to g) of the 'Results and Discussion'. These intermediate steps are necessary for understanding the overall results of the reconstruction for the Belgian fisheries in all ICES areas (subsection h) and for the Belgian fisheries in the BNS (subsection i) in Results and Discussion).

6.4 Results and Discussion

a) Shrimp fisheries (Crangon crangon):

Commercial shrimp fisheries (reported and unreported landings, and discards)

The Belgian fisheries for brown shrimp are mainly conducted by small (<221 kW) vessels that operate within the Belgian territorial sea and to a lesser extent in northern France and Dutch waters. In 1929 approximately 250 vessels participated in the shrimp fisheries, in 1950 these were 187 (otter trawlers, single net) whereas today less than 30 vessels (beam trawler, double beam, 22 mm mesh size) are full-time active in the shrimp fisheries. Part of these 30 vessels operate from foreign (Dutch) ports under Belgian flag since at least 1990 (Churchill 1990, Hoefnagel 1998) and hence report their landings in foreign (Dutch) ports as part of the Belgian statistics. Over the entire period, shrimp fisheries represented on average 10% of SD of the total fishing effort of the Belgian fleet (Annual reports 'Landings and value of landings', Flemish government Fisheries Agency). The estimation of discards in both the commercial and recreational *Crangon* fisheries are based on Leloup and Gilis (1965) for the period 1929-1970, and on Polet (2004) for later years. Both report comparable discard rates and fractions of undersize *Crangon* in commercial landings (46% and 47%, see Table 6.1.).

Recreational Crangon landings

In Belgium it is not mandatory for vessels less than 10m length over all (LOA) to report catches. Recreational shrimp fisheries operate in the Belgian coastal waters, from smaller vessels (<8m) using towed gear. Although they are locally regarded as 'semi-commercial' shrimp fisheries given their relative importance if compared to commercial *Crangon* landings, they are not part of the official fishing fleet and not included in formal reporting and data collecting systems. There is no limit to the catch of *Crangon* for the recreational fleet, but the prohibition is on commercializing the catch. The vessels can only operate within the 3nm zone and make use of only one towed net per vessel (max. 3m wide for beam trawl and 4.5m for otter trawl). Regular surveys on ships' safety regulations conducted by government officers along the ports and mooring sites in Belgium, show that approximately 60 recreational vessels are involved and operate from the 4 ports.

A conservative estimate of their catches is based on an effort of 120 SD per vessel and catches of 20kg per fishing trip, although catches of up to 100kg per fishing trip may be achieved (E. Hiele, Shipping Control Service, federal government, pers. comm.). The proportion of the recreational catch versus the commercial catch over the last 5 years was used to back-calculate recreational catches, assumed to exist at least from 1975. Other removals that were taken into account are the recreational-artisanal shrimp fisheries that operate from the beach (on foot and on horseback). We used detailed figures reported during WWII, when these artisanal fisheries were widespread practices for subsistence purposes by coastal residents, as a maximum estimate for this component. This conservative estimate indicates that the landings of this component of the recreational fleet amount to at least 8% of that of the commercial fleet. Since similar gear is used as in the commercial fleet, the same parameters were applied to estimate discards in this recreational segment.

Adding components: Crangon fisheries

Overall, 2,000 t of unreported *Crangon* landings were positively corrected for in the baseline by the local dataset (HiFiData) particularly before 1960 where underreporting existed for brown shrimp. Reported landings of shrimp by the commercial fleet average 1,350 t per year, with a maximum of 4,282 t in 1956. Nearly the same weight (i.e., 1,290 t per year) of undersized shrimp is discarded, while on average more than twice the weight of undersized fish is discarded (i.e. plaice, sole, dab, whiting). Overall, for each kg of reported shrimp landed there is at least 3.3 kg of fish and shrimp discarded. Taking into account the high discards of North Sea crab (*Cancer pagurus*) reported by Leloup and Gilis (1965), particularly towards the west of the fishing areas, these discards would amount to 5,070 t per year. This component is not taken into account in the overall reconstruction of total removals. The recreational and artisanal landings and discards of *Crangon* were added based on the estimators described above, and included in the reconstruction of total removals by the *Crangon* fisheries (Figure 6.2.).

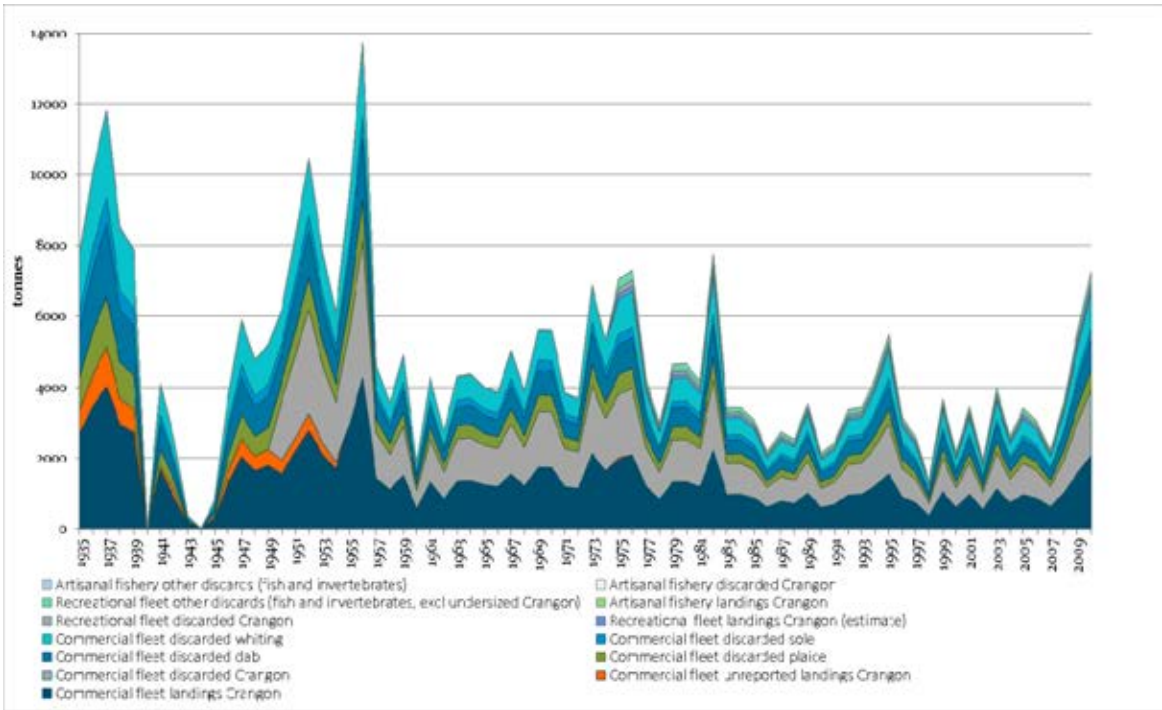

Figure 6.2.: Reconstruction of total removals in the *Crangon* fisheries: unreported landings, legal-sized and undersized *Crangon* landings and discards from the commercial, recreational and artisanal segments.

b) Herring and sprat fisheries

Commercial herring and sprat fisheries (landings and discards)

Before and during the WWII, Belgian herring fisheries mainly used drift nets and otter trawl nets. During WWII, when fishing was only allowed during daytime and within the territorial sea, unprecedented catches of herring and CPUE values were reported from Belgian coastal waters (Lescrauwaet, unpublished data). The herring fishery remained important after WWII in terms of landings in particular between 1950 and 1965. After 1965, ≤1% of the overall fishing effort expressed as SD is assigned to the pelagic (herring and sprat) trawl (Anon. 1965, Tessens and Velghe 2010, 2011). Although from 1950 onwards the pelagic trawl was gradually introduced (Gilis 1962), both the

bottom otter trawl and the pelagic trawl was used until 1965. Gilis (1961) reported and compared both gear in terms of effort, landings, LPUE and bycatch, reporting that pelagic trawl landings contained 91.8% of the targeted herring, compared to 65.3% in the otter trawl (data 1958). Gilis (1961) reported details on the bycatch by species (supporting material, Table I), however without making reference to discards in this or any of his other thorough studies on Belgian pelagic herring trawl fisheries throughout the 1940s-1960s.
There are few historical references with regards to discards in pelagic (herring) fisheries that can be used for extrapolation in the North Sea (Garthe et al. 1996). Morizur et al. (1996) refer to the Celtic Sea (winter) herring fishery as very selective with 99.5% of the total catch by weight consisting of the target species. Discards reported by Morizur et al. (1996) amounted to 4.7% (mainly herring) by weight of the total catch (Table 6.1.). Reasons for discarding were mostly due to market requirements leading to rejection of undersized and poor quality fish.

In the present study, a conservative discard rate of 4.5% was applied for the commercial herring and the sprat fisheries (Figure 6.3.) corresponding to the lower estimates in the available literature (see above). Overall, the HifiDatabase positively corrected landings of herring with approximately 10 t between 1929 and 1960 as underreported compared to the ICES baseline. For sprat, differences between the two databases were only due to rounding. Artisanal/subsistence catches from open boats in the territorial sea were carefully documented during WWII (Lescrauwaet, unpublished data). Based on these records, an average of 120t of herring and 60t of sprat was added for the period 1929-1960 as a maximum for annual artisanal/subsistence catches. We assumed no artisanal/subsistence fishing for herring occurred after 1960, and no discards were taken into account in this artisanal/subsistence component. There are no records or indications of the existence of a recreational fisheries targeting herring or sprat in this period.

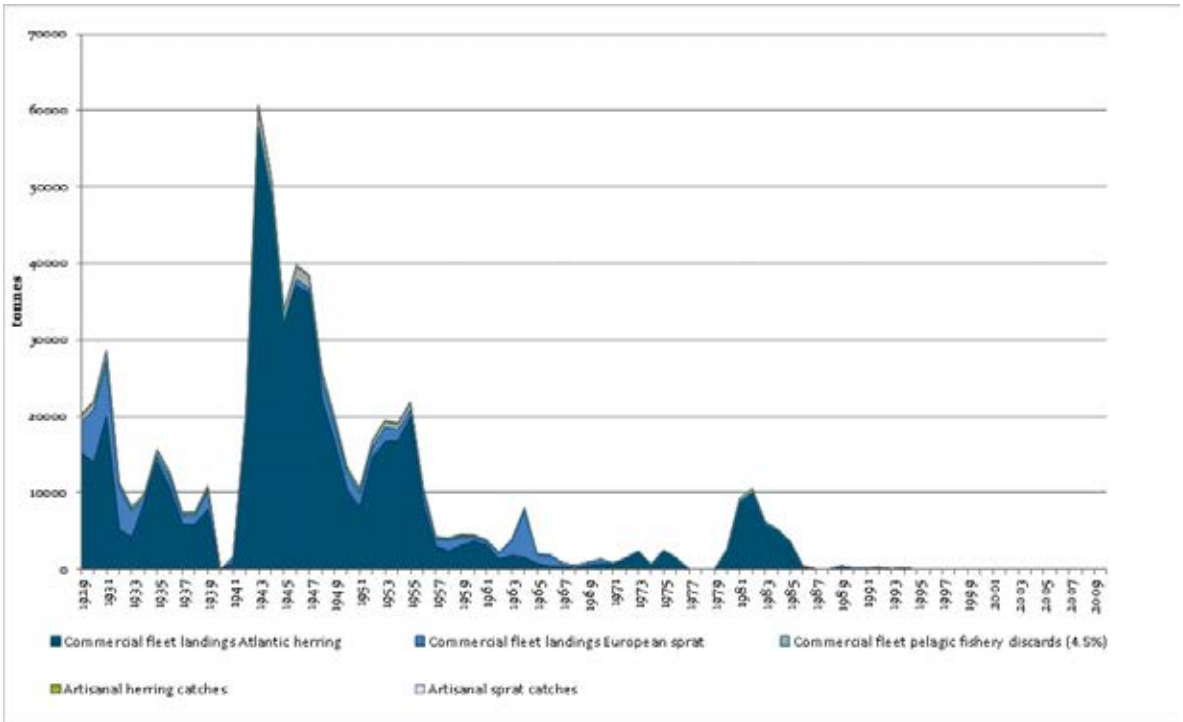

Figure 6.3.: Reconstruction of total removals in the pelagic fisheries: commercial reported landings and discarded fish in commercial landings (4.5%). Maximum estimates for artisanal catch of herring and sprat are included for 1950-1960.

The effects of changing or decreasing mesh size and other technological developments affecting bycatch of the gear, on-board discarding and underwater discard mortality, were not taken into account in the current estimates. Rahikainen et al. (2004) estimated that underwater discards or escape mortality caused by the gear for the age 0 and age 1 components is potentially similar or up to twice the amount of what is landed. However Gilis (1962) reported that these age classes made up a minor component of the herring fisheries in Belgium with age 3, 4 and 5 making up 97% of the catch. This may be due to the fact that Belgian herring fisheries targeted adult autumn-spawners (the 'disappeared' *Sandettie* herring) in the vicinity of the spawning areas. There are no indications of unreported removals due to ghost fishing or predation by birds or mammals.

Table 6.1.: Overview of discard rates, survival rates, variables used in the calculation or as reference material for the present reconstruction, with an indication of source, by type of fisheries.

FISHERY	VARIABLE	VALUE	COMMENT	SOURCE
Brown shrimp (Crangon crangon) fisheries				
Commercial *Crangon* fisheries, Belgium	Undersized Crangon	46%	Undersized *Crangon* fraction in *Crangon* total catch (1949-1964)	Leloup&Gilis (1965)
Commercial *Crangon* fisheries, Belgium	Undersized Crangon	47%	Undersized *Crangon* fraction in *Crangon* total catch. Discards composed of whiting, plaice, dab, and bib	Polet (2004)
Commercial *Crangon* fisheries, Germany	Discard rate	40-50%		Avia et al. (2011)
Recreational *Crangon* fisheries, Belgium	Annual catch	144t	120 SD*60 vessels*20kg, since 1975	This study
Artisanal *Crangon* fisheries, Belgium	Annual catch	9t	Based on data reported during WWII	This study
Crangon fisheries, Portugal	Discard survival rate	4%		Gamito&Cabral, (2003)
Crangon fisheries, Solway Firth (Scotland)	Bird predation	0.5-4.5%	Predation on *Crangon* discards	Lancaster and Frid (2001)
Herring and sprat, pelagic fisheries				
Herring fisheries, Belgium	Bycatch	35% 9%	By catch of non-target in otter trawl Bycatch of non-target in pelagic trawl	Gilis (1961)
Dutch commercial pelagic trawl fisheries	Discard rate	3,6%	38kg pelagic fish (mackerel, herring and saithe) discarded per 1,000kg marketable herring	Corten (1991)
Celtic sea winter herring fisheries	Discard rate	4.7%	Discards are mainly undersized target species	Morizur et al. (1996)
Danish pelagic trawl fisheries	Discard rate	5%	Herring as target species (if mackerel is targeted, discard rate is 20%)	Kirkegaard (1991)
Belgian pelagic trawl fisheries herring& sprat	Discard rate	4.5%		This study
Artisanal & subsistence fisheries, Belgium	Annual catch	120t herring 60t sprat	1950-1960	This study
Gadoid and other roundfish fisheries				
North Sea demersal (gadoid) fisheries	Annual discards	15,000t 10,000t	Cod Plaice	Garthe et al. (1996)

French gadoid trawlers, Celtic Sea (1997)	Discard rate	26%	Gadoid trawlers discard mainly target species: whiting& haddock (together 47%) and grey gurnard (13%). Data 1997.	Rochet et al. (2002)
Trawlers, Skagerrak and North Sea areas	Cod discard rate	14% 34% 47%	Cod in the demersal trawl >100mm mesh Cod in the demersal trawl 70-99mm, Cod in beam trawl >80mm	Horwood et al. (2006) *after STECF(2005)*
Icelandic and foreign fleet in Icelandic waters	Discard rate	1-14% 1-28%	Cod discard rates in Icelandic cod fisheries Haddock discard rate (based on all gear combined).	Forrest et al. (2001)
Flatfish fisheries (sole and plaice)				
Flatfish beam trawl, southern North Sea	Discard rate	71-95%		Catchpole et al. (2005)
German flatfish and other beam trawlers, North Sea and the NE Atlantic	Discard rate	56-72%	Discards mostly composed of dab, whiting, plaice, grey gurnard and undersized brown shrimp (Ulleweit et al., 2009).	Borges et al. (2005); EU (2008); Ulleweit et al.(2009)
UK beam trawl fleet, North Sea	Discard rate	50%	Average discard rate. Discard: mainly undersized dab& plaice, species with low market value (e.g. whiting& dab)	MRAG (2007)
Beam trawls(flatfish), English Channel, Irish Sea, Celtic Sea	Discard rate	42-67%	Discard: mainly dogfish, whiting, gurnards, common cuttlefish, plaice and dab, and undersized haddock	Borges et al. (2005); Enever et al. (2007)
French benthic trawlers, Celtic Sea (1997)	Discard rate	24%	60% of discard consist of 4 bycatch species: red gurnard, horse mackerel, boar fish and grey gurnard.	Rochet et al. (2002)
Beam trawl fisheries, Belgium 2008	Discard rate	25%		Vandendriessche et al. (2008)
Beam trawl fisheries, North Sea	Discard survival rate	0%	Higher survival rates reported for skates (42%) and rays (55%), while sole (4%) and lemon sole (7%) discard survival rates remain below 10%.	van Helmond&van Overzee, 2008 ; Lindeboom&De Groot, (1998)
Recreational flatfish fisheries Belgium	% of commercial catch	9%	Estimate for Based on 280 vessels*120SD*fishing days*20kg per fishing trip	This study
Nephrops fisheries				
French *Nephrops* trawlers, Celtic Sea	Discard rate	55%	discards % of biomass whiting (41%), target *Nephrops* (20%). Data 1997.	Rochet et al. (2002)
English&Welsh *Nephrops* trawlers, North Sea	Discard rate	36%	Discards: dab, whiting, plaice, legal-sized and undersized *Nephrop*s, gurnards, cod, long rough dab, haddock, lemon sole, Dover sole. Discards mainly due to <MLS	Enever et al. (2009)
Nephrops trawlers, Firth of Clyde (W-Scotland)	Discard rate	70%	Discard, mostly demersal fish, in particular young whiting<MLS. Typical mesh size= 80mm	Stratoudakis et al. (2001)
Sea angling Sea angling BNS	Annual catch	50t	2,000 anglers* 5seadays* 5kg catch, since 1970	This study

Note: discard rates are weight-based (biomass).

c) Gadoid and other roundfish

Commercial gadoid and other roundfish trawl fisheries (landings and discards)

The otter trawl was the main fishing gear before and during the 1950s. It was replaced by the beam trawl in the *Crangon* fisheries by the end of the 1950s and in the flatfish fisheries by 1965 in Belgium (Lescrauwaet et al. 2012).

Although currently Belgium has no directed fishery for cod or gadoids, specific *métiers* such as the pair-trawlers ('*spanvisserij*') fishing for cod were important in the past. They operated in Icelandic waters until 1975, a few vessels until 1995 (Lescrauwaet unpublished data). An important part of the landings originated from the southern North Sea and in the central North Sea: first in the western part of the central North Sea from 1960 to 1975, afterwards in the eastern part. Icelandic waters were also the main fishing grounds for otter trawl fisheries targeting ling (*Molva molva*), redfish (*Sebastes sp.*), monkfish (*Lophius piscatorius*), haddock (*Melanogrammus aeglefinus*), saithe (*Pollachius virens*) and to a lesser extent whiting (Lescrauwaet et al. 2010a). Today the otter trawl has recovered some importance due to its lower fuel consumption compared to the beam trawl (Tessens and Velghe, 2008, 2009, 2010).

Historical references on the selectivity and impact of the otter trawl and data on discards in roundfish fisheries are limited. One of the variables that influence discarding in otter trawls is the mesh size of the trawl net. Horwood et al. (2006), e.g., reported a discard rate of cod in the Skagerrak and North Sea areas of 14% in the demersal trawl with mesh size >100mm, 34% in the demersal trawl 70-99mm, and 47% in the beam trawl over 80mm (after STECF, 2005b). The International Convention for the regulation of the meshes of fishing nets and the size limits of fish minimum sizes of fish nets and fish (London, 05/04/1946, entry into force 05/04/1953) set a minimum mesh size limit of 75mm with 110mm for arctic and Icelandic waters because cod tended to be larger there. The Convention regulations entered into force in 1951 in Belgium. Demersal fisheries for gadoids are carried out by all North Sea coastal nations with various gear and different sources provide estimates of discarded weight (Van Beek 1990, Anon. 1995, Garthe et al. 1996, Rochet et al. 2002). However these studies cover different survey designs and gear specifications. Rochet et al. (2002) reported for the French fleet operating in the Celtic Sea a total estimate of 30,000 t of discards in 1997, while landing about 63,000 t. Gadoid and *Nephrops* trawlers caused the majority of these discards with respectively 25% and 55% of the catch weight being discarded. Gadoid trawlers discarded mainly their target species: whiting and haddock (together 47%), and also grey gurnard (13%). Forrest et al. (2001) estimated unreported catches of cod and haddock by the Icelandic and foreign fleet in Icelandic waters over time, on a species by species basis. Based on reported distributions of fishing effort by fishing gear in Icelandic waters, the authors concluded that Icelandic cod catches may have been underestimated by between 1% and 14% at different times, and haddock catches by between 1% and 28% (based on all gear combined). It must also be noted that 'high-grading' (discarding fish of lower value in order to fill the hold or quota with fish of the greatest value) of high-valued fish species such as cod and haddock is not only related to the implementation of regulatory measures such as quota. High-grading already existed before the on-set of quota, because of technological constraints, e.g., when catching power exceeded onboard storage or processing facilities (Anderson 1994,Turner 1997).

No studies or survey reports related to discarding proportions in the demersal roundfish fisheries for Belgium or for demersal (roundfish) trawlers fishing Iceland waters were identified in screened databases. To conclude, while acknowledging the significant variability in the estimates of weight and species composition of discard fractions in the demersal whitefish fisheries (otter trawler) depending on the fishing area, season and specific gear, historical sources suggest that discarding in this fishery is not a recent practice related to the CFP and quota restrictions. Instead, in the past 50 years the weight-based proportion of discards in the catch may have decreased due to increasing mesh sizes and improvements in gear selectivity. In the present estimate, the conservative low discard estimate of 25% was applied over the sum of the landings of species targeted in this fishery (cod, ling, haddock, redfish, monkfish, saithe, whiting, see Table 6.1.). While it is recognized that this is a simplistic approach based on assumptions, it is a precautionary approach and can be justified over the less acceptable alternative of interpreting non-reported or missing data components as zero removals (Pauly 1998).

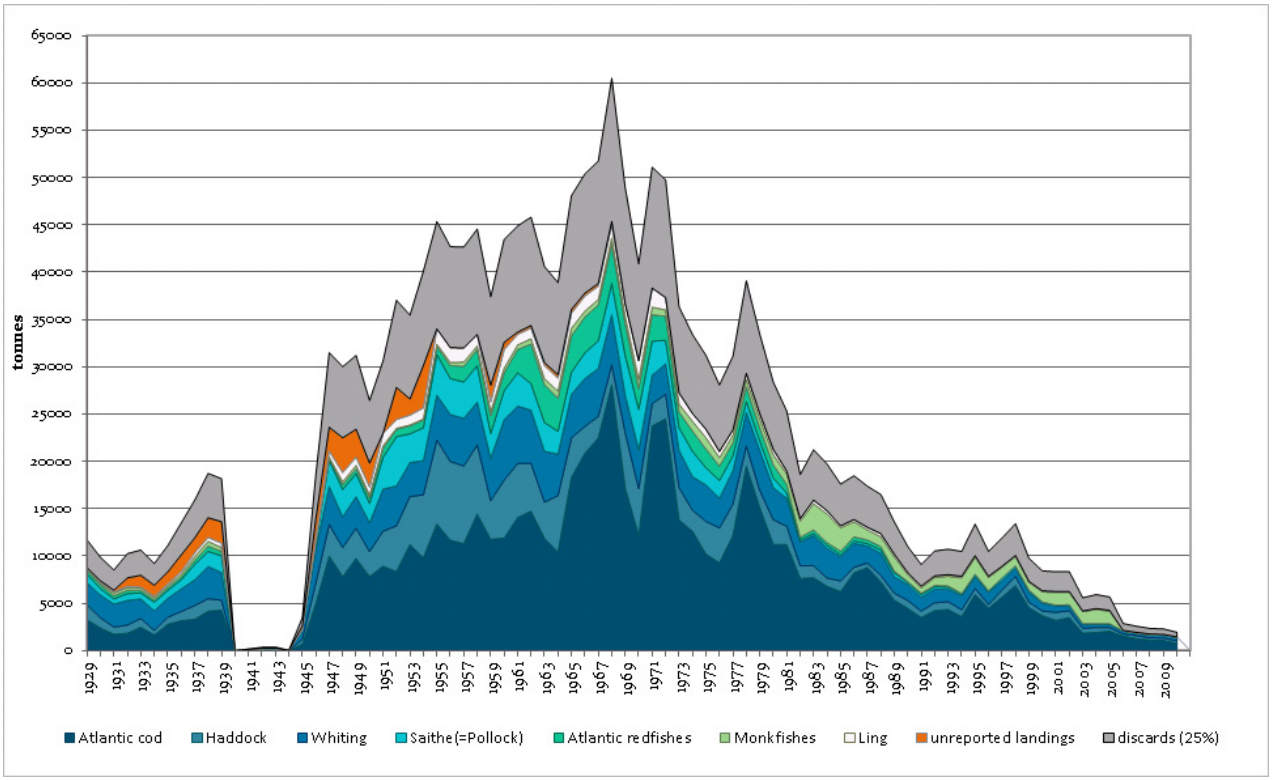

Figure 6.4. Reconstruction of total removals in the demersal gadoid and roundfish fisheries: reported and unreported landings and discarded fish by the Belgian commercial fleet.

Annual landings of the 7 taxa included (cod, haddock, whiting, saithe, redfishes, monkfishes, ling) from the commercial fleet averaged approximately 10,000t before WWII and 30,000 t between 1950 and mid 1970s. After 1975, a decline in landings set in, which is to a large extent explained by the 'cod wars' by which the foreign fleet was gradually excluded from Icelandic waters (Lescrauwaet, unpublished data). Currently less than 2000 t of fish are landed for these 7 taxa together. Overall the HifiDatabase positively corrected landings with approximately 41,600 t of unreported landings, 88% of these unreported commercial landings are before 1955. A flat discard rate of 25% was applied (Figure 6.4.) corresponding to the lower estimates in available literature (see above).
The effects of changing or decreasing mesh size and other technological developments affecting bycatch of the gear, on-board discarding and underwater discard mortality, were not taken into account in the estimates. Discard survival rates of 0% were taken into account for the species targeted in this estimate (ICES Discard Survival Table 2012). Reported landings from these species in artisanal/subsistence catches from open boats in the territorial sea during WWII were negligible, except for whiting: 11 to 13 t per year in the period 1941-1943 (Lescrauwaet, unpublished data).

d) Flatfish beam trawl fisheries (sole and plaice)

Commercial flatfish beam trawl fisheries (landings and discards)

Before 1960, the Belgian fleet of steamer and motor engine powered vessels used the otter trawl as fishing gear in the 'fresh fish' fisheries for targeted sole and plaice (Gilis 1954). By 1965, the beam trawl had become widely introduced. In 1985, beam trawling accounted for 62% of SD and by 2006, this segment of the fishing effort had further increased to 79% of total SD. In 2010, beam trawl represented 68% of the SD (Anon. 1965, Tessens and

Velghe 2010). Landings of plaice and sole from the commercial fleet averaged approximately 5000t before WWII, 10,000 t per year between 1950 and mid 1980s, and after 1995. Between 1985 and 1995 increased landings of plaice raised the annual landings of this fishery to an average of 17,700 t. Overall, HiFiData corrected the baseline with 3750 t of unreported plaice and 2100 t of unreported sole, mainly before 1955.

No quantitative information is available to estimate historical discards and survival rates for this fishery by the Belgian fleet but different values are reported in the literature concerning current levels of discarding. Catchpole et al. (2005) recorded estimates of 71-95% discarding in flatfish beam trawl fisheries in the southern North Sea, while estimates of 56-72% discarding were observed in German flatfish and other beam trawlers in the North Sea and the NE Atlantic (Borges et al. 2005, EU 2008, Ulleweit et al. 2009). These discards are mostly composed of dab, whiting, plaice, grey gurnard and undersized shrimp (*Crangon crangon*) (Ulleweit et al. 2009). The UK North Sea beam trawl fleet targeting primarily sole, plaice and dab discard 50% of catch on average. This consists of mainly undersized dab and plaice, and species with a low market value or no market, such as whiting and dab (MRAG 2007). Beam trawls in the English Channel, Irish Sea, Celtic Sea and the western approaches targeting flatfish such as sole and plaice discard 42%-67% of total catches. The dominant species discarded are dogfish, whiting, gurnards, common cuttlefish, plaice and dab, as well as undersized haddock (Borges et al. 2005, Enever et al. 2007).

Vandendriessche et al. (2008) estimated the current levels of discarding and discard rates in the Belgian beam trawling. In this study, 30% of a total of 109 sampled hauls was located in fishing areas in the southern and central North Sea, where approximately 30% of the reported landings of sole were caught that year. The authors found that on average 25% of the catch weight in this fishery is discarded. The conclusions are specific for the Belgian beam trawlers and reflect the current as opposed to the historical situation. It must be noted however that the current core of the spatial distribution of the Belgian beam trawling fleet has moved away from the North Sea and towards the western waters (Irish and Celtic Sea, Bristol Channel, English Channel). Whereas in the mid 1950s nearly all of the sole (97%) was caught in the North Sea, this proportion decreased to 40% in the 1980s and even to 30% after 2000, in favour of the western waters. This may help explain why current discard rates reported for the Belgian flatfish beam trawling fleet (Vandendriessche et al. 2008) are lower than those reported for the Dutch, German and UK fleet operating mainly in the North Sea (see above), but similar to the discard rate value of 24% reported by Rochet et al. (2002) for the French benthic trawlers in the Celtic Sea. Vandendriessche et al. (2008) reported the composition of the discarded weight as follows: 2% of sole, 13% of plaice, 7% of dab, 10% of bib, 4% of cod, 3% of anglerfish, 13% of gurnards, 7% of rays, 22% of sharks. These proportional values 'by-species' were accounted for in the present reconstruction. For the reconstruction of the historical discards, a time variant discard rate was applied. The time-variant discard-rate takes into account the proportion of landings originating from the North Sea (50% discard rate as the lower value in reported North Sea flatfish beam trawl discard rates) and the proportion of landings originating from the western waters (25% discard rate, as reported by Vandendriessche et al. 2008).

Unreported flatfish catch by 'recreational' or semi-commercial fisheries

As reported for the *Crangon* fisheries (section a), recreational flatfish fisheries exist in Belgium, which operate from smaller vessels that are not part of the official or commercial fishing fleet. Although flatfish are targeted today, it is acceptable to believe that other species may have been targeted over the last decades depending on their relative abundance on economic value. These fisheries have existed for at least 30 years (E. Hiele, pers. comm.) and for the current estimate it was assumed that they started in the 1970s. Regular surveys conducted by government officers along the ports and mooring sites in Belgium confirm that approximately 280 small vessels are involved in this recreational activity and operate from the 4 ports.

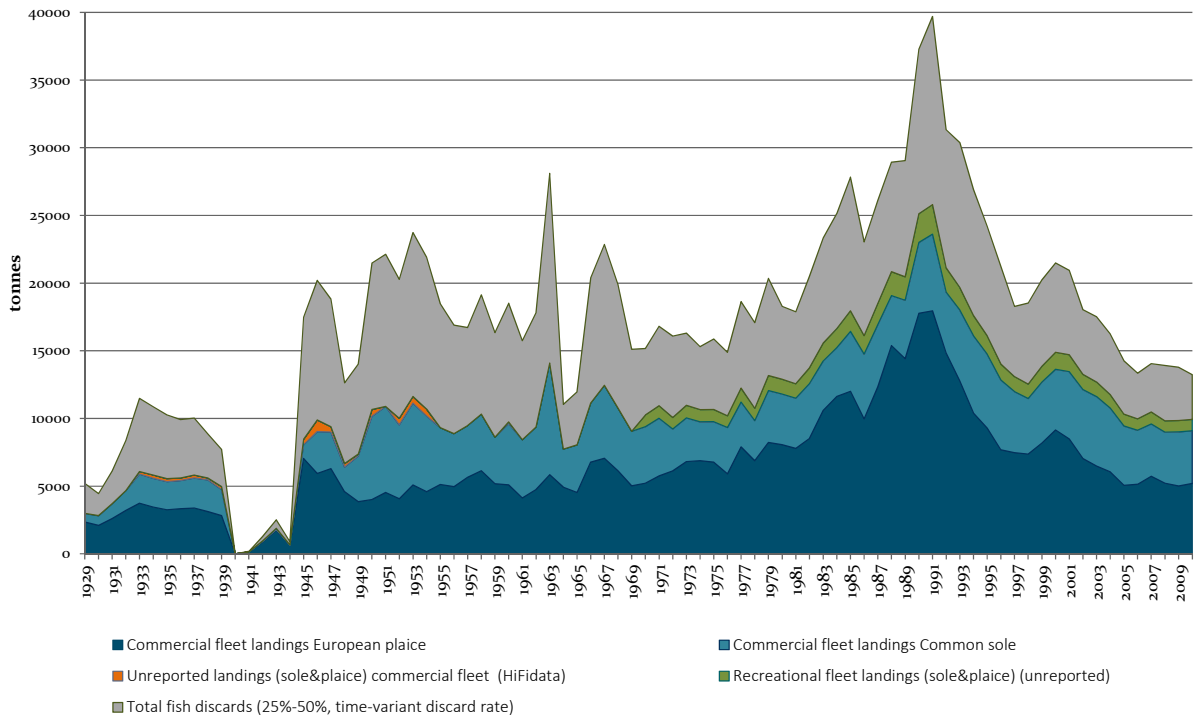

Figure 6.5.: Reconstruction of total removals in the beam trawl flatfish fisheries (sole and plaice): reported and corrected (baseline) commercial landings (green), and estimates of recreational fisheries (orange) and discards (grey).

A conservative estimate was derived based on an average effort of 120 fishing days per vessel, 280 vessels and average catches of 20kg per fishing trip. The parameters applied to estimate discards by the commercial fleet were applied to estimate discards in the recreational segment. Reported landings in artisanal/subsistence catches during WWII were negligible for sole (less than 0.5t per annum) and amounted to 2-19t of plaice between 1941-1943 (Lescrauwaet, unpublished data). Ghost fishing caused by lost or abandoned trawl nets was considered negligible or zero (Depestele et al. 2012).

Effects of changing or decreasing mesh size and other technological developments affecting bycatch of the gear (e.g., the short-lived introduction of the Vigneron-Dahl system, tickler chains, sumwing etc.), underwater discard mortality (e.g., Chopin 1995), and predation and infection mortality (Broadhurst et al. 2006) were not taken into account in the estimates. According to these sources, such mortalities can be substantial, and should be considered for comprehensive stock assessments for all gear-types and fisheries. Discarding practices for plaice and sole were found to be mainly driven by Minimum Landing Size (MLS) regulations (Vandendriessche et al. 2008), which are established by law Nr. 56/12/1950 (see full text of this royal decree and modified by royal decree Nr. 425/02/1964). An important part of the cod discards in these fisheries are not explained by MLS but by high-grading (Vandendriessche et al. 2008). Reported discard survival rates in beam trawl fishing gear can strongly vary according to experimental design, fishing techniques and environmental parameters (Van Beek et al. 1990, Berghahn et al. 1992, Lindeboom and De Groot 1998, Lapithovsky 2004, Rodriguez-Cabello et al. 2005, Enever et al. 2009). In the current exercise, the precautionary approach leads to assume a survival rate at or near of zero for cod, whiting, pouting, dab, plaice and gurnards. Higher survival rates are reported for skates (42%) and rays (55%)

(Enever et al. 2009), while sole (4%) (Lindeboom and De Groot 1998) and lemon sole (7%) discard survival rates remain below 10%.

e) Nephrops fishery

Commercial Nephrops fisheries (landings and discards)

Today, Norway lobster (*Nephrops norvegicus*) in the North Sea is commonly caught using a twinrig trawler, which is composed of two nets towed by one vessel along the seabed. Between the two nets a heavy weight keeps the net at the bottom, while otter boards are used to keep the mouth of the net open while trawling. The twinrig trawl is lighter than the beam trawl and is towed at lower speed (4 knots), which results in lower fuel costs and less bottom disturbance (van Helmond and van Overzee 2008). The Minimum Landing Size (MLS) of Norway lobster in the North Sea (ICES area IV) is 25 mm of carapace length.

Differences between the ICES Fishstat baseline and the local HiFiDatabase amounted to 2300t and mainly before WWII. Landings of Belgian fisheries for Norway lobster peaked in 1959 with 970 t, and averaged 450 t per year (st. dev. = 192 t) over the period 1950-2010 (Figure 6.6). Historically, the Belgian *Nephrops* landings mainly originated from Botney Gut – Silver Pitt (ICES area IVb,c). Currently (i.e., 2010), landings have dropped to a historical low of 133 t. Efforts are now underway to reactivate this fishery in the context of diversification in the fishery coupled with regeneration of coastal economies.

Trawls targeting *Nephrops* are typically smaller meshed (80–90 mm) than trawls used to target whitefish which results in higher proportions of discards (Catchpole et al. 2005). Enever et al. (2009) reported discard rates of 36% in English and Welsh *Nephrops* trawl fisheries in the North Sea. Discards were mostly dab, whiting, plaice, legal-sized and undersized *Nephrops*, gurnards, cod, long rough dab, haddock, lemon sole and Dover sole, the majority of which were discarded due to being undersized. *Nephrops* trawlers off the Firth of Clyde (West of Scotland) discard 70% of total catch, mostly consisting of undersize demersal fish, in particular young whiting (Stratoudakis et al. 2001). No dedicated studies on discards and survival rates exist for Belgian *Nephrops* fisheries. However, Belgian vessels participated in Dutch-led studies exploring lower fuel and less discards in this fishery (Steenbergen et al. 2012). Hence, the estimates of discards in the present study are based on the Dutch *Nephrops* fishery, which uses similar gear, engine power and fishing grounds. Discard estimates (weight-based) in *Nephrops* fisheries in the North Sea range between 76.5% and 84.2% (Belgian vessel and gear) (Steenbergen et al. 2012). According to van Helmond and van Overzee (2008), discards were composed of 30% *Nephrops* (90% of which were legal-sized), 27% dab, 18% whiting, 15% plaice, 2% cod and 8% other fish. These weight proportions were applied to the reported *Nephrops* landings.

There are no written reports or other communications on the existence of a recreational fishery for this species. This can be explained by the distance of the traditional fishing grounds.

Most fish species discarded will not survive the catching and sorting process (van Beek et al. 1990). For the *Nephrops* fishery in particular, the survival of captured species (including *Nephrops*) are thought to be close to 0% (Evans et al. 1994). Ridgway et al. (2006) indicated that survival rate of *Nephrops* fifteen days after capture is less than 30% for long trawls (5 hours). Specific survival experiments with *Nephrops* in the Belgian or Dutch twinrig fishery have not been carried out so far (van Helmond and van Overzee 2008) and therefore no corrections are conducted for survival of discarded *Nephrops* in the current estimates.

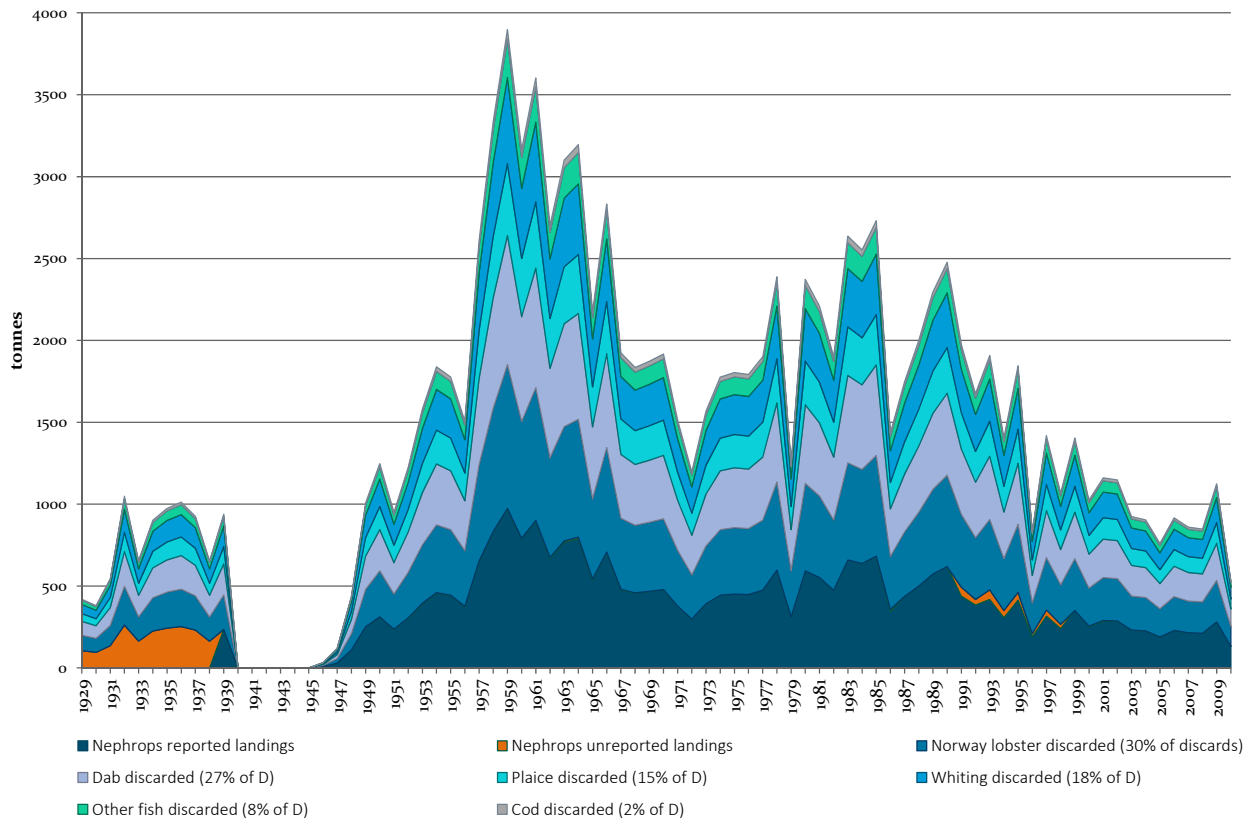

Figure 6.6.: Reported landings of *Nephrops norvegicus* by Belgian fisheries (dark blue), discards of *Nephrops* (light blue) and other species, 1929-2010.

f) Sea angling: cod *(Gadus morhua),* **European sea bass** *(Dicentrarchus labrax),* and other species

Recreational fisheries include all forms of fishing that do not pursue commercial objectives. Little information exists on recreational fisheries in most North Sea countries (Zeller et al. 2011). Recreational fisheries in Belgium include recreational *Crangon* fishing (section a), fishing from the coastline (angling from the beach, shrimp fishing on feet or on horseback, and the setting of passive nets along the low watermark) and sea angling. Except for the use of fixed (passive) nets from the beaches, recreational fisheries are not subject to licensing. Sea anglers are not allowed to fish at night and are allowed a daily maximum of 20kg per angler, of which cod is not allowed to exceed 15kg. The magnitude of recreational angling on the Belgian part of the North Sea (BNS) has so far only been addressed in a pilot study which estimated recreational angling for cod on the BNS at 100-200t per annum (ILVO-Fisheries 2007). The pilot study was based on the outcomes of angling contests organized by the Associations of Anglers (VVHV), which counts approximately 2000 members as active sea anglers in 2006. In the present estimate, a low of 50t per annum was applied (2000 anglers, 5 days at sea, 5kg catch), assuming this form of sea angling existed at least since 1970. These estimates are in the same order of magnitude as those for the Dutch recreational sea angling for cod and eel (Zimmerman et al. 2007, Van der Hammen and de Graaf 2012). Systematic sea bird counts by the Institute for Nature and Forest Research (INBO) recording the presence of sea anglers, have shown a clear overlap between the position of anglers and shipwrecks (E. Stienen *in* Goffin et al. 2007).

g) Unaccounted removals

A number of other gears which are not accounted for in the present estimates have been used in Belgian fisheries, however with much lower intensity and spatial coverage than those presented in a) to f) in this section. These include seine nets, bottom dredges (1980's), trammel nets and other passive gear used in commercial fisheries but not covered here, and angling and netting from land (jetties, piers). The use of trammel nets in commercial fisheries is rather recent (since 2000) and discards are limited. Depestele et al. (2012) studied the impact of trammel nets on different components of the marine ecosystem of the BNS (sea birds, benthos, fish stocks, and marine mammals). Sea bird and marine mammal by-catch was investigated through strandings data, questionnaires and independent observers, and in cooperation with fishers. The results indicate there is a potential danger for diving seabirds and harbour porpoises (*Phocoena phocoena*). Haelters and Kerckhof (2005) found that a significant part of the dead strandings on Belgian beaches was caused by drowning in trammel nets, in particular in the first quarter of the year when nets are set for sole and plaice. The coastal municipalities issue licenses for passive beach nets and in 2006 approximately 250 licenses were issued in 4 municipalities (Goffin et al. 2007). Regulations prohibit the use of trammel (multi-layered gillnets) as well as the use of gillnets below low watermark, sets maximum lengths and total number of nets, and enforces the minimum landing sizes of species (royal decree KB 1989-08-14, KB 2001-12-21 and ministerial decision 2006-12-21). In the Scheldt estuary, other fisheries, e.g., targeting eel were important in the past. However, no landing or catch statistics are available upon which to reconstruct total removals. The dynamics of the Scheldt fleet was reconstructed for the period 1930-2010 (Lescrauwaet et al. 2012); this information can be used as a basis for catch reconstruction in a next step.

h) Reconstructing total removals by the Belgian sea fisheries 1929-2010s

Total removals by Belgian fisheries from 1929-2010 were reconstructed by including the unreported or misreported landings of the commercial fleet, the unreported (here: estimated) landings by the recreational and artisanal fisheries and by estimating discards for 6 of the most important fisheries based on the estimators described above. The reported landings for these 6 fisheries together represent approximately 80% of all reported landings over 1929-2010. Publicly reported landings over the period 1929-2010 amounted to 3.7 million t, with a peak of 81,000t in 1947 (ICES Fishstat) and gradually decreasing to 22,000t in 2010 (Figure 6.7). However, total reconstructed removals were estimated at 5.2 million t or 42% higher compared to the 3.7 million t publicly reported over this period. Table 6.2. gives an overview of the amounts (t) and proportions (%) of the unreported landings and of the estimated discards for each of the 6 reviewed fisheries considered in this reconstruction. Overall, unreported landings were estimated to represent 3.5% (0.2 million t) and discards 26% (1.3 million t) of these total reconstructed removals.

Unreported landings

Overall, the unreported landings amounted to 0.2 million t with a median annual value of approximately 1300t and a maximum of 9300t in 1948. The unreported landings were particularly important between 1935 and 1955 and mostly due to under- or misreporting in the baseline. The unreported landings of sole and plaice in commercial and recreational fisheries (55,100t) and the unreported landings of the commercial fisheries for gadoid and roundfish in bottom trawlers (41,600t) made up the major part of these unreported landings between 1929-2010 with respectively 30% and 23%. Most of the unreported landings of *Crangon* by the commercial fleet (8100t) are explained by underreporting before 1955; the recreational shrimp fisheries contributed to unreported landings with an estimated 3800t and these fisheries were assumed to have started in 1975. Together they represent 11,900t or 6.5% of the unreported landings overall. Underreporting for the commercial pelagic fisheries was negligible (10t herring). 120t of herring and 60t of sprat - estimated from artisanal/subsistence fishing between 1929 and 1960 - explain for 3% of the total unreported landings.

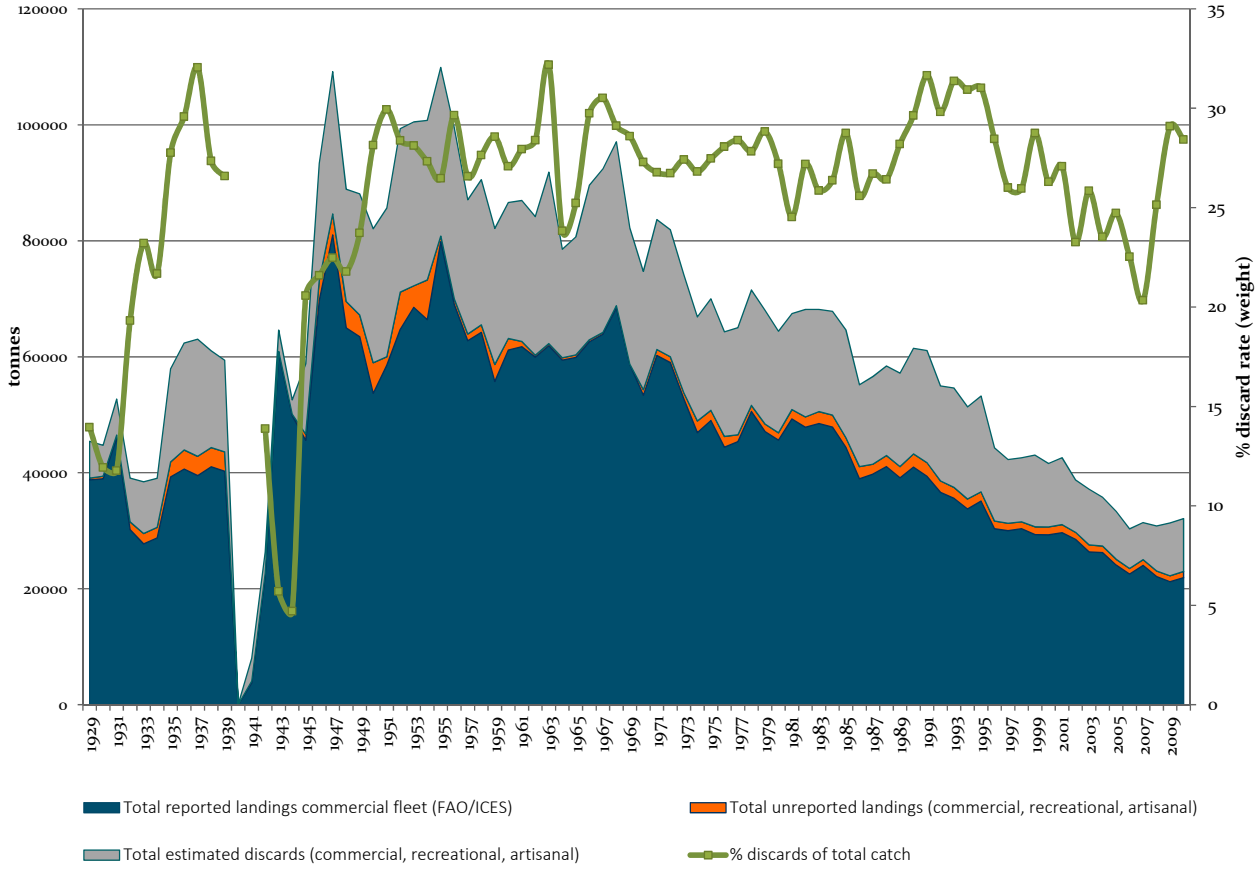

Figure 6.7.: Total reported landings of the commercial fleet (ICES baseline 2012), unreported landings (unreported commercial landings, landings from recreational, artisanal fisheries) and discards in t (t, left-hand axis), by the Belgian sea fisheries 1929-2010. The right-hand axis shows the annual discards as a percentage of the reconstructed total removals. See text for details.

For the 7 taxa included in the present reconstruction of landings and discards from the Belgian commercial fleet targeting gadoid and roundfish (section 6.4.c), the underreporting before 1968 explains nearly all of the unreported landings in this fishery, while 23% of overall unreported landings refers to this fishery (Table 6.2.). Reported landings for this fishery from 1950 to 1975 averaged 30,000t per year. After 1975 the decline in the landings is to a large extent explained by the 'cod wars' which gradually excluded the foreign fleet from Icelandic waters. Currently less than 2000t of fish are landed for these 7 taxa together.

Landings of plaice and sole from the commercial fleet averaged approximately 5,000t per year before WWII and 10,000t per annum between 1950 and mid 1980s. Between 1985 and 1990, the annual landings of sole and plaice in this fishery increased and peaked to nearly 23,600t in 1991. The recreational fisheries for sole and plaice, which were assumed to have started in 1970, explain the largest portion of total unreported landings. Underreporting of sole and plaice landings occurred before 1960 and amounted to 5,800t.

There are no recreational *Nephrops* fisheries and the 2315t of unreported *Nephrops* landings correspond to underreported *Nephrops* from the commercial fleet mainly before WWII. Sea angling was not included in public reporting and the estimated recreational landings of 50t per year from 1970 to 2010 amount to 1% of all unreported landings. The unreported landings and the estimated discards by recreational and artisanal fisheries are mainly from the BNS and are discussed in further detail (section i).

Table 6.2.: Overview of the amounts (t or 1,000kg) and proportions (%) of the reported and unreported landings and of the estimated discards for 6 fisheries in the Belgian sea fisheries 1929-2010

	Reported landings (x1000kg)	% of total reported landings	Unreported landings (x1000kg)	% of total unreported landings	Discards	% of total discards
Crangon fisheries	106,053	2.9	11,900	6.5	254,281	18.6
Pelagic fisheries (herring&sprat)	619,924	16.7	5,580	3.0	27,897	2.0
Nephrops	28,085	0.8	2,315	1.3	91,199	6.7
Flatfish beam and otter trawl (plaice and sole)	827,198	22.3	55,069	29.9	528,918	38.8
Gadoid (otter trawlers)	1,342,631	36.3	41,600	22.6	461,410	33.8
Sea angling	-	-	2,050	1.1	-	-
Other species	777,846	21.0	65,358	35.5	-	-
Total all reported landings Belgian sea fisheries	3,701,737 (70.5%)	100	183,873 (3.5%)	100	***1,363,705***	100

Discards

Discards were estimated for each of the 6 fisheries covered in the present reconstruction (Figure 6.8). The major components of the discards since 1929 were the discards in flatfish fisheries (528,900t or 39% of the total discards) and the discards in gadoid and roundfish fisheries (461,400t or 34% of the total discards). The discards in the *Crangon* fisheries (254,300t or 19% of the total discards for the 6 fisheries) and *Nephrops* fisheries (91,200t or 7% of total discards) consisted mainly of their target species: respectively 39% of all discards in *Crangon* fisheries and 30% of all discards in *Nephrops* fishery are target species. Plaice, dab and whiting make up significant proportions of the discards in the directed fisheries for *Crangon, Nephrops* and flatfish (sole and plaice).

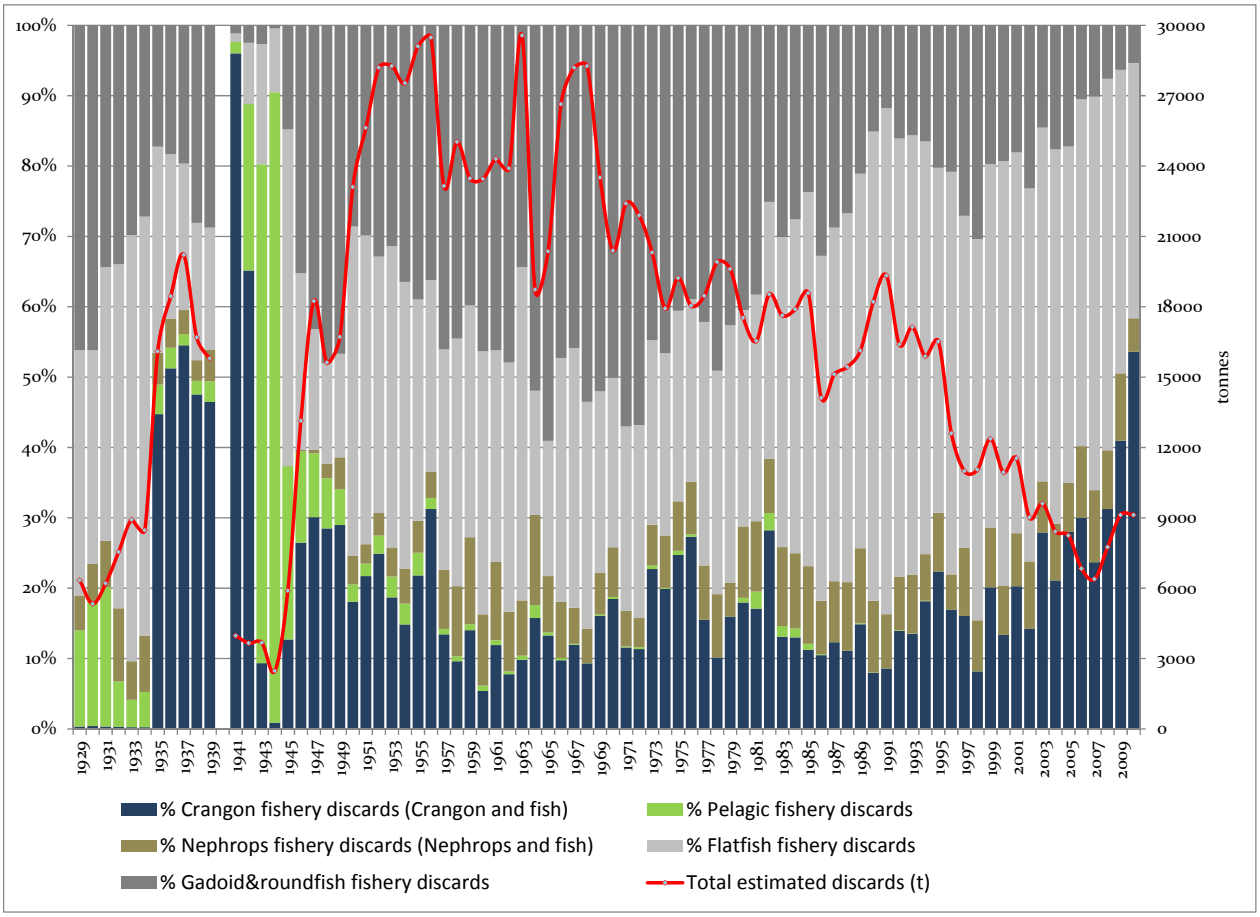

Figure 6.8.: Total estimated discards (t, right-hand axis) by the Belgian sea fisheries 1929-2010 and percentages of the discards for the 6 fisheries covered in the present reconstruction. For sea angling, no discards were considered. See text for details.

The proportion of discards from the total catch was estimated to reach a historical high of 32% in 1963 (29,500t), and a median value of 16,600t per annum. After the peak in 1963, total estimated discards gradually declined to less than 15,000t. In the early 1990s however, the discarded proportion of the total reconstructed removals was estimated to peak again around 31% (19,000t), before decreasing to 6,500t in 2007. Before 1935, no data are available for the shrimp fisheries and therefore both the discards (t) and the discarded proportion of *Crangon* fisheries in the total discards were underestimated. Between 1935 and WWII the *Crangon* fisheries constituted 45-55% of all discards (15,000-18,000t). During WWII, pelagic fisheries were the main fisheries practiced and therefore explain nearly all discards. From 1955 until 1980 the gadoid and roundfish fisheries explain the largest proportion of discards with a maximum estimate of 15,100t and up to 60% of the overall annual estimated discards. From 1980 to 2000, the beam trawl fisheries explain most of the discarded weight with up to 72% of the estimated discards in 1991. The recent increases in landings from the *Crangon* fisheries also explain the proportional increase of discards (%) since 2009 in the present estimates (Figure 6.3.). Reported landings of shrimp by the commercial fleet average 1350t per annum, with a maximum of 4282t in 1956. Nearly the same weight (i.e., 1290t per annum) of undersized shrimp is discarded, while on average more than twice the weight of undersized fish is discarded in this fishery (including plaice 6%, sole 3%, dab 10%, whiting 12%). The discard estimates in the *Nephrops* fisheries peaked in 1959 (2,900t) when highest landings were achieved (970t).

i) Reconstructing total removals from the Belgian part of the North Sea by the Belgian sea fisheries 1929-2010s

The Belgian coast is 67 km long and located in the province of West-Flanders (region of Flanders, Belgium). The Belgian part of the North Sea (Figure 6.9.) is 3,457 km² (0.5% of the North Sea area). The unique historical data reported for the 'coastal waters' from 1929-2010 (HiFiDatabase) were used in the present estimates of total removals at the scale of the Belgian North Sea (BNS). Since formal reporting started, roughly one fifth of all landings of the Belgian sea fisheries originated from the BNS, while these waters contributed nearly 60% of all landed pelagic species and 55% of all landed 'molluscs and crustaceans' (Lescrauwaet et al. 2010). Fisheries in this area has generated 1000kg/ha compared to the fishing area of the Bristol Channel (southwest UK) which is 2 times larger and generated 77kg/ha over similar time frame of exploitation. The BNS has been a continuous source of food for the local population, of economic turnover and profit, direct and indirect employment and an area for recreational fishing.

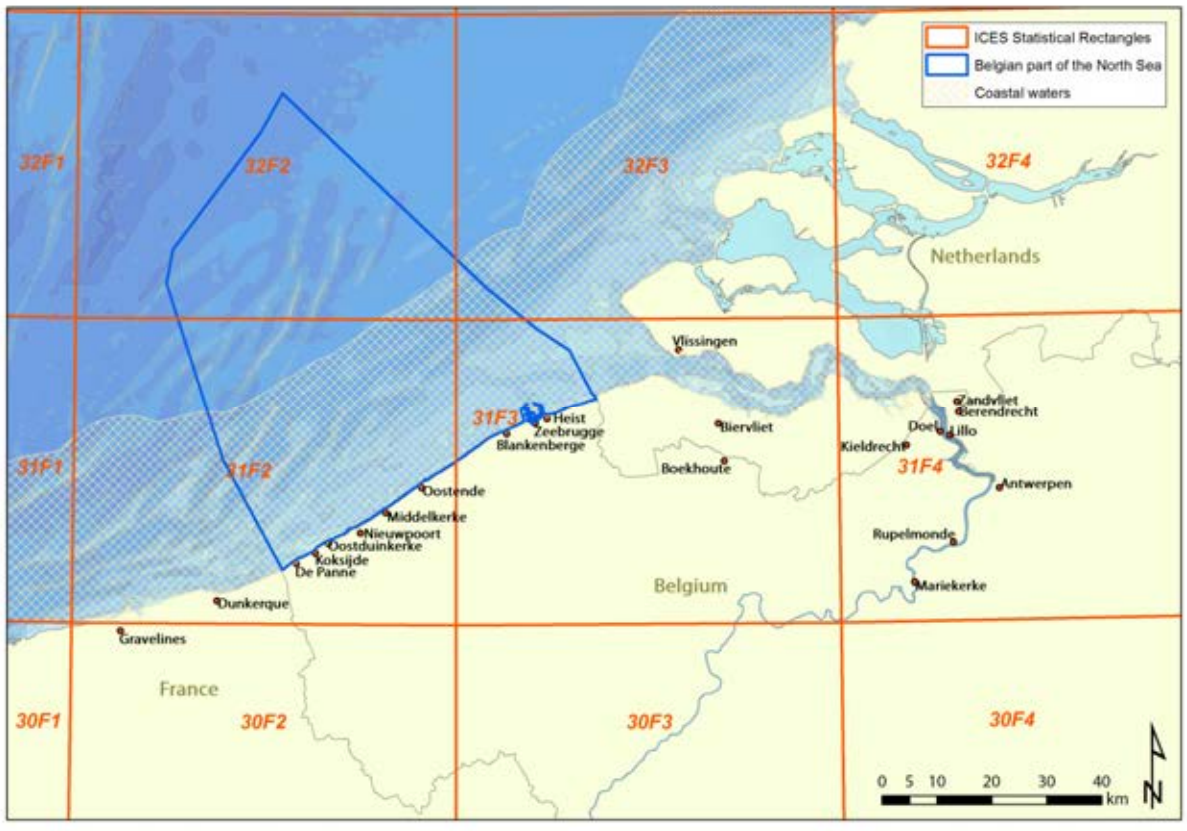

Figure 6.9.: Map of Belgium coastline and the Belgian part of the North Sea BNS (blue line), demarcation of the fishing area or reporting unit 'Coastal waters' (white shaded area), current and historical fishing ports and overlapping areas with ICES rectangles. ICES rectangle shape file layer created by the Danish Institute for Fisheries Research (DIFRES).

The reported landings from the BNS from 1929-2010 (Figure 6.10.) follow a similar pattern as that for the fisheries as a whole (Lescrauwaet et al. 2010a). A first period (1929-1940) characterized by pelagic and shrimp fisheries, is followed by a peak in landings of pelagic species during and after WWII (1942-1964). Cod is the dominant species in the reported landings from 1965-1980. After the mid 1980s the composition of the reported landings is less dominated by a single species. Herring and sprat (49%), brown shrimp (12%), cod (9%), plaice (6%), whiting (4%) and sole (3%) represent an important proportion over the entire period. Reported landings from the BNS over the entire period, amount to 841,700t (dead weight). The median of annual reported landings over the entire period is 8,100t with a peak value of 60,500t in 1943 and a minimum of 1900t in 2007 (Figure 6.10.).

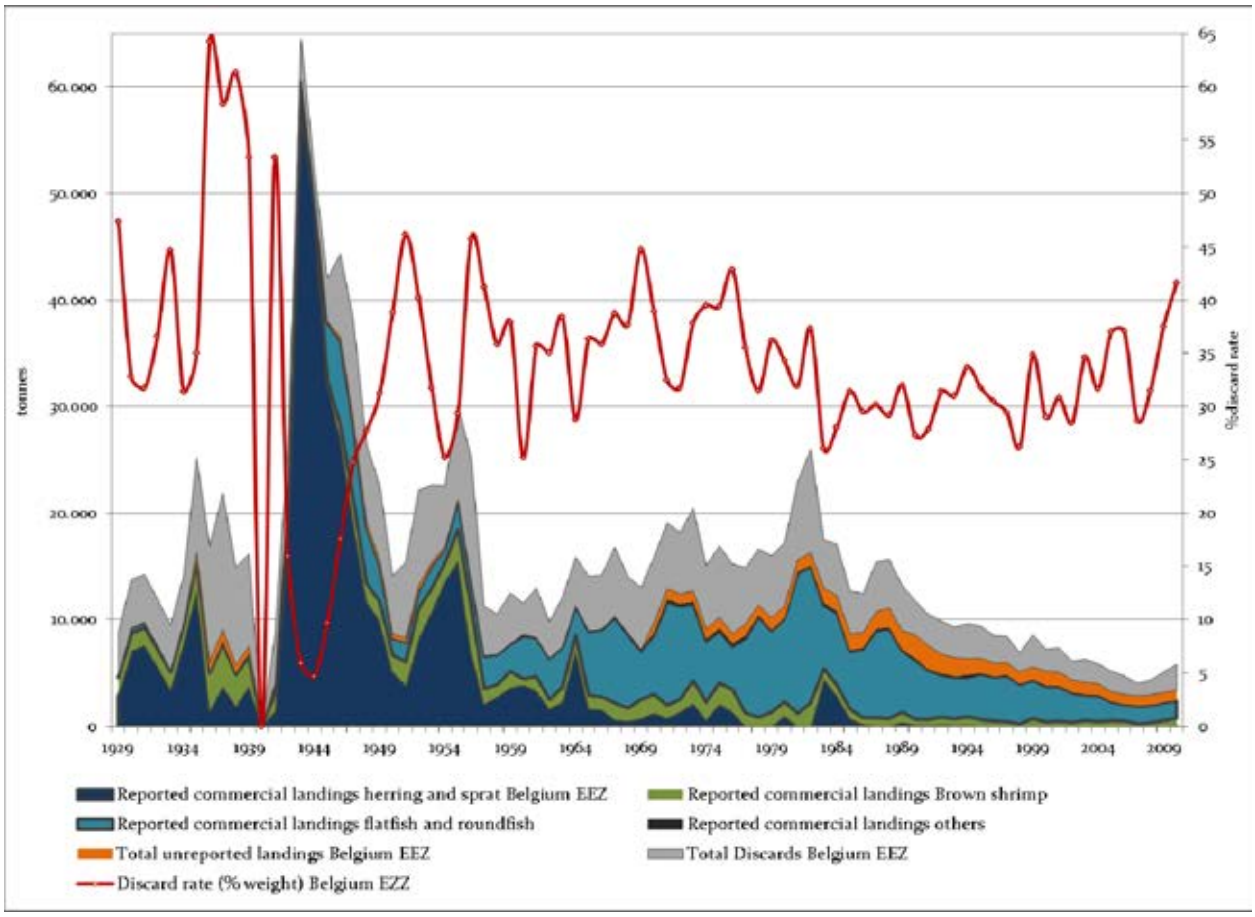

Figure 6.10.: Total reported landings of the commercial fleet (ICES baseline 2012), unreported landings (unreported commercial landings, recreational and artisanal fisheries) and discards (t, left-hand axis), by the Belgian sea fisheries 1929-2010 from the BNS. The right-hand axis shows the annual discards as a percentage of the reconstructed total removals. See text for details.

Together with the publicly reported landings, the unreported landings and estimated discards reconstruct the total removals in the BNS. Following the approach applied in 6.4.a)-g), the unreported removals for the BNS from 1929-2010 amount to 59,600t and the total discards in this period are estimated at 407,300t (Table 6.3.). The

reconstructed total removals for the BNS were therefore estimated at 1.3 million t or 55% higher than the 0.8million t publicly reported over this period. Because of the presence of recreational (hence unreported) fisheries in coastal water, and the fact that the *Crangon* fisheries are by nature coastal fisheries, these two components contribute with an important proportion to the total unreported removals from the BNS. In particular since the late 1980s this proportion is estimated to range between 15-20% of the total removals by Belgian fisheries from the BNS.

Table 6.3.: Overview of the amounts (t) and proportions (%) of the reported and unreported landings and of the estimated discards for 6 fisheries in the Belgian sea fisheries from the BNS, 1929-2010.

	% of total reported	% of total unreported	% of total discarded
Commercial fleet pelagic (herring&sprat)	48	-	4
Shrimp fisheries *Crangon crangon*	13	14	69
Beam (flatfish) and otter trawl (non-shrimp)	39	-	27
Recreational trawling (fish)	-	86	-
Total BNS(=100%) rounded numbers (in 1000t)	***842 (100%)***	***60 (100%)***	***407 (100%)***

<0,01 is not listed or indicated by '-'

The estimates of annual discarded weight on the BNS range between 4,600t and 12,800t. In terms of percentages, annual discards fluctuated between 5% and 64% of total removals from the BNS. The lower percentage coincides with the period when pelagic fisheries provided the main source of fish from the BNS (1940-1948) whereas the higher percentages coincide with the periods when brown shrimp make up an important proportion of the landings (1935-1939). It is estimated that shrimp fisheries (commercial and recreational) represents 69% of all discards on the BNS in the entire period, whereas trawling for roundfish and flatfish is estimated to represent 27% and pelagic fisheries 4%. Based on the literature sources consulted (see 6.4.a), it is expected that both historically and in recent times, whiting, plaice, dab, sharks and shrimp were the most discarded species on the BNS. To quantify the non-perceived economic value due to UU, the total hypothetical value of the unreported and discarded fish and shrimp from the BNS was calculated based on HiFiData economic information by species and by year. Expressed as prices 2010 (corrected for inflation) and based on the average price EUR/kg of the commercial landings, the calculations show that the total value of the unreported and discarded weight is approximately 90% of the value of commercial landings considering the entire period 1947-2010. This calculation may represent an overestimation since discards are mostly undersized and therefore of lower commercial value.

It is important to note however that the Dutch and French fleets also obtain substantial amount of landings from the BNS, which currently may exceed 4 times the landings achieved by the Belgian commercial and recreational fisheries covered in this section. Depestele et al. (2012) estimated the discards from different métiers from the Belgian, Dutch and French commercial fleets on the BNS, by using landings and discard sampling data and raising the outcome at the fleet level (2006-2008). Their results indicated that total discards on the BNS from all commercial fleets and métiers together may reach values around 8000t of fish and shrimp per year and up to 25,000t -30,000t per year if benthic invertebrates are included. This estimate of discarded fish on the BNS is in the

order of magnitude of reported annual landings by the total Belgian commercial sea fisheries (18,000-22,000t). Beam trawl discards - in particular from the Dutch flatfish beam trawlers- were found to be the highest source of discarding throughout the year, while discards from the sole-targeting gill net fishery were found to be significantly lower. Discards from shrimp beam trawlers are highest in the second half of the year and located closer to the shoreline, corresponding with temporal and spatial patterns of this fishery.

6.5 CONCLUSIONS

In the present exercise to reconstruct total removals by the Belgian commercial, recreational and artisanal sea fisheries for the period 1929-2010, total removals were estimated at 5.2 million t, which is 42% higher than the 3.7 million t publicly reported over this period. Unreported landings and discards were estimated to represent respectively 3.5% (0.2 million t) and 26% (1.3 million t) of these total reconstructed removals. After the peak in 1963 (29,500t) and the period of increased discard rates (31%) in the early 1990s, total estimated discards gradually decreased to 6500t in 2007.
The reconstructed total removals on the BNS (Figure 6.10.) were estimated at 1.3 million t or 55% higher than the 0.8million t publicly reported over this period. In terms of percentages, discards on the BNS represent on average of 34% over the entire period. The estimates of annual discarded weight by Belgian commercial, recreational and artisanal fisheries on the BNS range from 4600t to 12,800t. These numbers do not take into account the non-commercial benthic invertebrate species, or the landings and discarding by foreign vessels (mainly Dutch and French) from the BNS.

Historical landings data availability and reliability
The present analysis shows that after 1960 the numerical data in the baseline (ICES 2012) and the national database are comparable. Overall, approximately 80,000t were positively corrected for the period 1929-1949 and 19,000t in the 1950s. It was assumed that the national database was more accurate for this period because it is based on the original paper documents, because footnotes were taken into account and thorough quality control was effectuated based on a secondary source for local datasets (Lescrauwaet et al. 2010a). Whereas the baseline does not allow distinguishing the landings from the BNS within the broader fishing area IVc, the national database allows for an analysis at a scale comparable with the boundaries of the BNS and offers opportunities for advanced research on seasonal and annual trends in historical landings, effort, and economy of the fisheries.

Gaps in data and information on discarding
This first reconstruction of total removals by Belgian sea fisheries from 1929-2010, is largely based on historical landing statistics by type of fisheries. Although this approach is widely applied and accepted in current studies on discard estimates, expanding and refining the approach by taking into account criteria related to fleet characteristics and fishing effort and to environmental conditions (local features of fishing areas, seasonality) should improve reliability of the outcomes (Depestele et al. 2011). Time-variant discard rate estimates are needed by fishing area and discard survival rates need more focused research by fishing métier and varying environmental conditions. The historical references and data to expand this approach however are not available at present. In general, there is insufficient information regarding historical discarding in Belgian sea fisheries to allow for a validation of the discarding rates that were applied for the earlier years. Insights in the historical impact of quota and market forces on ship-board discard behaviour are also needed to improve the estimates. The effects of the

presence of observers in discard surveys must be excluded to obtain reliable estimates of discard rates, and in general caution is required when applying or extrapolating discard rates obtained from particular survey conditions. However, the estimates presented here are based on a conservative approach and lowest ranges of reported discards rates.

The estimates of landings and discards of the recreational fleet targeting brown shrimp and fish are based on assumptions and cover at least 4 decades. The estimates indicate that recreational fisheries need to be taken into account when looking at historical, current and cumulative impact of fisheries on the BNS. The catches and efforts of the recreational fleet targeting brown shrimp and flatfishes and their impact on the coastal ecosystem will be the subject of systematic surveying in the context of the national data-gathering program for the CFP and the monitoring in compliance of targeted GES. ICES and member countries need to establish regular surveys (every 4–6 years) of total recreational removal, by species, area and gear category. The Data Collection Regulations of the Common Fisheries Policy CFP require European Member States to collect data on technical, biological and economic aspects of their national fisheries and their impact on the marine ecosystem, and to collect data and report on discards. As a consequence of the 'discard-ban', formal reporting on commercial landings will be extended with commercial discards and removals from non-commercial fishing. This information must be spatially explicit and will improve stock assessments by including unaccounted removals.
Research was initiated by Depestele et al. (2012) to unravel current impacts of the main deployed fishing gears on the ecosystems of the BNS (WAKO II project). This research also takes into account the effects of fishing on species such as the harbour porpoise (*Phocoena phocoena*) which is listed on the EU habitat directive annexes (92/43/EEG) and directive 812/2004, protected by the royal decrees KB 1980-09-22 and KB 2001-12-21 and targeted by ASCOBANS. In these legally binding commitments, Belgium has agreed to monitor incidental catches of small cetaceans in both recreational and commercial sea fisheries, and to take action to reduce bycatch and protect their environment.
Also, underwater mortality such as towpath mortality and escape mortality and their effects on total mortality of commercial and non-commercial species require further studies. Finally, though anecdotal, information gathered from local ecological knowledge studies on socio-economic data on employment, income, fish consumption etc. can provide important references to support the reconstruction of missing time-series or validate the assumptions used in the historical reconstructions.

Historical reconstruction of total removals in support of integrated marine policies
The importance of the small-scale fleet is a broad policy objective and the social and cultural role of small-scale fisheries is explicitly stated in the EC Green paper on the Reform of the CFP. Policy options to support small-scale fisheries include special treatment under the European Maritime and Fisheries Fund EMFF, the exemption from particular management requirements and safeguards in a context of rights-based management systems with e.g. transferable quota. The 12nm limit that is reserved for coastal fisheries is also extended for another 10 years. It is therefore important to further quantify recreational and non-commercial fishing activities within the BNS, and their position and importance in comparison to commercial coastal fisheries. The results presented here suggest that:

- Since the 2000s, approximately 50% of all Belgian removals from the BNS are unreported landings and discards (IUU). This does not include benthic invertebrates.
- The unreported landings and discards are increasingly taken by non-commercial, small-scale (<12m) vessels that are not subject to reporting and not taken into consideration in planning, monitoring and enforcement
- The proportional importance of recreational fisheries has increased substantially in the last 4 decades, and currently may represent near to 20% of all removals by the Belgian fisheries in the BNS

- The total fish discarded by the Belgian fisheries on the BNS may range between 30-40% of all Belgian landings from the BNS. Based on estimates of fish discarded by the foreign fleet on the BNS (Depestele et al. 2012), our hypothesis is that since the 1990s, all fish and shrimp discarded by both the Belgian and the foreign fishing operations on the BNS together approximates 50% of the total reported landings (t) of Belgian commercial sea fisheries (all fisheries, all species, all fishing areas).

From an environmental perspective, this is cause for concern as it represents a waste of valuable resources of food, energy and biological diversity, and generates a non-quantified impact on the food web, seabed and ecosystem services in the coastal environment. From an ecosystem perspective this information - as well as the information on the activities of the foreign fleet on the BNS - must be included in particular to obtain reliable data in compliance of the e.g. the GES targets set forward in the MSFD (2008/56/EG), to improve stock assessments and achieving targets of maximum sustainable yield MSY in the CFP, and to achieve favourable conservation status FCS for the species and habitats protected in marine and coastal Natura 2000 sites. While not explicitly mentioned in its final statement, the UN 2002 declaration intended to also cover unregulated and unreported catches by recreational fisheries from 2004 onwards. The daily allowable catches in recreational fisheries must also be connected to EU quota regulations and recovery plans for cod and plaice. However, in terms of social, economic and cultural considerations, the unreported removals and discards represent wasted or lost opportunities for local jobs and security for the formal fishing industry, for secure food, and for leisure and tourism for the wider population. These non-perceived or non-quantified socio-economic benefits and externalized environmental costs need to be taken into account in future strategies and planning for more sustainable fisheries. Although this study refers to the particular situation of the Belgian fisheries, similar trends may exist in neighbouring countries around the North Sea. Finally, taking into account total removals is one aspect in moving towards an ecosystem-based approach and planning for future socio-economic viability of fisheries. A more integrated view takes into account aspects of energy and fuel consumption to steam towards distant grounds, employment, food safety and quality. In Belgium, the Fisheries Authority (department of Agriculture and Fisheries, Flemish government) together with the producers' organisation, the Fisheries Research Institute ILVO and an environmental NGO have taken first steps towards a more sustainable future for fisheries through a Strategy for Sustainable Fisheries, which is carried forward by its Task Force.
In spite of the remaining gaps and uncertainties, the current estimates provide a first overview of historical trends and current estimates of the IUU by Belgian fisheries, and in particular by the Belgian fleet on the BNS. As such they can support the wider debate about how to move to more sustainable fisheries, what the role of small-scale fisheries are, how to achieve the agreed policy targets in Belgian marine waters and in particular in the marine areas protected under the EU Habitat and Bird directives.

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