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Report on the eel stock, fishery and other impacts in Belgium, 2019–2020

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Reporting Period: This report was completed in September 2020, and contains data up to 2020. Some 2020 data are provisional.

1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

The table below (Table 1) presents the most recent data of escapement biomass and mortality rates. It presents the data included in the Belgian Progress Report 2018. There are no new stock indicators compared to the 2018 WGEEL Belgian Country Report (Belpaire *et al*., 2018).

For the contribution of Flanders to the Scheldt and Meuse RBD, new data were made available for the 2018-Belgian EMP progress report (data from the period 2015–2017). For the contribution of Wallonia to the Scheldt and Meuse RBD no new data are available for the 2018-Belgian EMP progress report: for this reason the data from the previous report (data from the period 2011–2014, reported in the 2015-Belgian EMP progress report) were used for Wallonia and added to the new data of Flanders for the Scheldt and Meuse RBD.

Table 1. Stock indicators of silver eel escapement, biomass and mortality rates, and assessed habitat area.

Year	EMU_code	Assessed Area (ha)	B_0 (kg)	B_{curr} (kg)	B_{best} (kg)	Bcurr/B_0 (%)	∑F	∑H	∑A
2015–2017	BE_Sche	20888*	207123	23429	27109	11.3	2260	1420	3680
2015–2017	BE_Meus	5205*	32157	2331	17949	7.2	518	15100	15618

Key: EMU_code = Eel Management Unit code; B_0 = the amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the stock (kg); B_{curr} = the amount of silver eel biomass that currently escapes to the sea to spawn (in the assessment year) (kg); B_{best} = the amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the current stock (kg); ∑F = mortality due to fishing, summed over the age groups in the stock (rate); ∑H = anthropogenic mortality excluding the fishery, summed over the age groups in the stock (rate); ∑A = all anthropogenic mortality summed over the age groups in the stock (rate); Assessed area (ha) = combined area total (ha) of transitional and inland waters.

***Areas according to 2015 Belgian EMP Progress Report.**

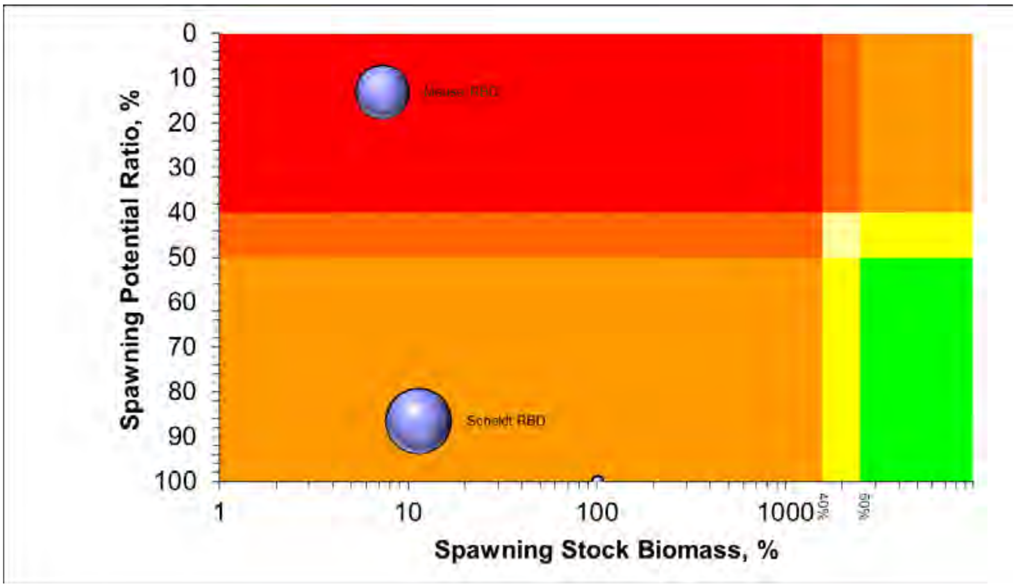

Figure 1. Precautionary Diagram for Belgium.

1.2 Recruitment time-series

The WGEEL uses these time-series data to calculate the Recruitment Indices, relative to the reference period of 1960–1979, and the results form the basis of the annual Single Stock Advice reported to the EU Commission. These recruitment indices are also used by the EU CITES Scientific Review Group in their annual review of the Non-Detriment Finding position.

Belgium submits yearly the data of the glass eel recruitment series at Nieuwpoort (river Yser), and the ascending yellow eels at Lixhe on the River Meuse. Since a few years ago **a new permanent monitoring station to estimate glass eel recruitment in Flanders is available at the Veurne-Ambacht pumping station**.

Glass eel recruitment at Nieuwpoort at the mouth of River Yser (Yser basin)

In Belgium, both commercial and recreational glass eel fisheries are forbidden by law. Fisheries on glass eel are carried out by the Flemish government. Former years, when recruitment was high, glass eels were used exclusively for restocking in inland waters in Flanders. Nowadays, the glass eel caught during this monitoring are returned to the river.

Long-term time-series on glass eel recruitment are available for the Nieuwpoort station at the mouth of the river Yser. Recently new initiatives have been started to monitor glass eel recruitment in the Scheldt basin (see below).

For extensive description of the glass eel fisheries on the river Yser see Belpaire (2002, 2006).

Figures 2A–D and Tables 2–3 present the time-series of the total annual catches of the dipnet fisheries in the Nieuwpoort ship lock and give the maximum day catch per season. Since the last report the figure has been updated with data for 2020.

Hereunder the results of the monitoring are briefly described, per year.

Fishing effort in **2006** was half of normal, with 130 dipnet hauls during only 13 fishing nights between March 3rd, and June 6th. Catches of the year 2006 were extremely low and close to zero.

In fact only 65 g (or 265 individuals) were caught. Maximum day catch was 14 g. These catches are the lowest record since the start of the monitoring (1964).

In **2007**, fishing effort was again normal, with 262 dipnet hauls during 18 fishing nights between February 22nd, and May 28th. Catches were relatively good (compared to former years 2001–2006) and amounted 2214 g (or 6466 individuals). Maximum day catch was 485 g. However this 2007 catch represents only 0.4% of the mean catch in the period 1966–1979 (mean = 511 kg per annum, min. 252–max. 946 kg).

In **2008**, fishing effort was normal with 240 dipnet hauls over 17 fishing nights. Fishing was carried out between February 16th and May 2nd. Total captured biomass of glass eel amounted 964.5 g (or 3129 individuals), which represents 50% of the catches of 2007. Maximum day catch was 262 g.

In **2009**, fishing effort was normal with 260 dipnet hauls over 20 fishing nights. The fishing was carried out between and February 20th and May 6th. Total captured biomass of glass eel amounted 969 g (or 2534 individuals), which is similar to the catches of 2008). Maximum day catch was 274 g.

In **2010**, fishing effort was normal with 265 dipnet hauls over 19 fishing nights. The fishing was carried out between and February 26th and May 26th. Total captured biomass of glass eel amounted 318 g (or 840 individuals). Maximum day catch was 100 g. Both total captured biomass, and maximal day catch is about at one third of the quantities recorded in 2008 and 2009. Hence, glass eel recruitment at the Yser in 2010 was at very low level. The 2010 catch represents only 0.06% of the mean catch in the period 1966–1979 (mean = 511 kg per annum, min. 252–max. 946 kg).

In **2011**, fishing effort was normal with 300 dipnet hauls over 20 fishing nights. The fishing was carried out between and February 16th and April 30th. Compared to 2010, the number of hauls was ca. 15% higher, but the fishing period stopped earlier, due to extremely low catches during April. Total captured biomass of glass eel amounted 412.7 g (or 1067 individuals). Maximum day catch was 67 g. Total captured biomass is similar as the very low catches in 2010. Maximal day catch is even lower than data for the four previous years (2007–2010). Overall, the quantity reported for the Yser station should be regarded as very low, comparable to the 2010 record. The 2011 catch represents only 0.08% of the mean catch in the period 1966–1979 (mean = 511 kg per annum, min. 252–max. 946 kg).

In **2012**, fishing effort was higher than previous years with 425 dipnet hauls over 23 fishing nights. The fishing was carried out between and March 2nd and May 1st. Compared to 2010, the number of hauls was 42% higher. Total captured biomass of glass eel amounted 2407.7 g (or 7189 individuals). Maximum day catch was 350 g. Both, the total captured biomass and the maximum day catch are ca. six times higher than in 2010. Overall, the quantity reported in 2012 for the Yser station increased significantly compared to previous years and is similar to the 2007 catches. Still, the 2012 catch represents only 0.47% of the mean catch in the period 1966–1979 (mean = 511 kg per annum, min. 252–max. 946 kg).

In **2013**, fishing effort included 410 dipnet hauls over 23 fishing nights. The fishing was carried out between 20 February and 6 May. Total captured biomass of glass eel amounted 2578.7 g (or 7368 individuals). Maximum day catch was 686 g. So compared to 2012, similar fishing effort (number of hauls), and similar year catches, but higher maximum day catch.

In **2014**, fishing effort included 460 dipnet hauls over 23 fishing nights. The fishing was carried out between 24 February and 25 April. Total captured biomass of glass eel amounted 6717 g (or 17 815 individuals). Maximum day catch was 770 g. So compared to 2013, same number of fishing nights, but 12% more hauls (increased fishing effort in number of hauls), and a 2.6 fold increase of the total year catches. Maximum day catch increased with 12% compared to the 2013 value.

In **2015**, fishing effort was somewhat reduced compared to previous years, with 355 dipnet hauls over 19 fishing nights. The fishing was carried out between 16 February and 29 April. Total captured biomass of glass eel amounted 2489 g (or 6753 individuals). Maximum day catch was 487 g. So compared to 2014, 17% less fishing nights and 23% less hauls, and a decrease in total year catch of 63%. Compared to 2012 and 2013 total catch was similar in 2015, but considering the reduced fishing effort, the CPUE (catch per haul) was between 11 and 23% higher. Maximum day catch was between the levels of 2012 and 2013 (Figures 3A–D, and Table 4).

In **2016**, fishing effort included 195 dipnet hauls over 11 fishing nights. The fishing was carried out between 2 February and 6 March. Total captured biomass of glass eel amounted 1023 g (or 2301 individuals). Maximum day catch was 208g. However, after 6 March, glass eel sampling had to be cancelled due to technical problems at the sluices. As such, only 11 fishing days took place, resulting in a low total catch (Table 3). The catch per unit of effort (CPUE) was lower in 2016 compared to the two previous years (Table 4). However, since sampling was cancelled early in the glass eel season, the peak had probably yet to come. Therefore, the CPUE values might be underestimations. For purposes of international stock assessment, considering the technical problems and absence of catch data during the main migration period**, the 2016 data of the Yser glass eel recruitment series should be considered as not representative and are reported as "non-available".**

In **2017**, fishing effort was rather low compared to previous years, with 270 dipnet hauls over 18 fishing nights. The fishing was carried out between 10 February and 21 April. Total captured biomass of glass eel amounted 1697 g (or 4924 individuals). Maximum day catch was 607 g. So compared to 2014, 22% less fishing nights and 41% less hauls, and a decrease in total year catch of 75%. Compared to 2012, 2013 and 2015 total catch was reduced with ca 32% in 2017, but considering the reduced fishing effort, the CPUE (mean catch per haul) was 6,3 g per haul which is similar as in the period 2012–2016 (with the exception of 2014 where a significant higher CPUE was recorded. Maximum day catch was within the range recorded in the 2012–2016 period.

In **2018**, fishing effort was rather high compared to the two previous years, with 340 dipnet hauls over 22 fishing nights. The fishing was carried out between 24 February and 27 April. From 11 March 2018 on, for a period of ca. 10 days, monitoring was not possible. Sea sluices had to be kept closed due to flooding conditions. Normal values should therefore be somewhat higher than reported. However, we advise to keep the reported values for use in international analysis. But, we should consider this important note in the discussions on the local trend. Total captured biomass of glass eel amounted 1749 g (or 4928 individuals). This is within the range reported for the five previous years. Note however that the number of fishing and catching days is higher than in previous years (22 nights). Maximum day catch was 230 g, which is low compared to two previous years. CPUE (mean catch per haul) was 5.1 g per haul which is similar as in the period 2012–2017 (with the exception of 2014 where a significant higher CPUE was recorded) (Figures 3A–D, and Tables 4–5).

In **2019**, fishing effort was somewhat lower than 2018, but higher compared to 2016 and 2017, with 325 dipnet hauls over 22 fishing nights. The fishing was carried out between 18 February and 29 April. Total captured biomass of glass eel amounted 2415 g (or 7213 individuals). This is within the range reported for the five previous years. Maximum day catch was 545 g, which is also within the range of previous years. CPUE (mean catch per haul) was 7.4 g per haul which is quite high compared to the period 2012–2018 (with the exception of 2014 where a significant higher CPUE was recorded) (Figures 3A–D, and Tables 4–5).

In 2020, monitoring started on 3 February and stopped on 5 March. On 6 March there was a malfunction at the sluice, after that water level was too high to perform the monitoring and on 19 March monitoring was not allowed any more due to Covid 19. Fishing effort was thus much lower than during other years, and fishing was only performed during start of the season. Fishing effort was 190 hauls during 12 fishing days. Total captured biomass of glass eel amounted 605 g (or 1497 individuals). Maximum day catch was 174 g. Considering the very low fishing effort and the temporal bias in fishing, comparison of the 2020 data with recruitment data of previous years is not appropriate. Due to technical problems at the sluice and to COVID-19 measures, the 2020 data of the Yser glass eel recruitment series are incomplete and not representative, and should not be used for statistical purposes, nor for international stock assessment and should be treated as “NON-AVAILABLE” for international assessments.

Table 2. Total year catches (kg) between 1964 and 2020. Data Provincial Fisheries Commission West-Vlaanderen. * The data for 2016 are incomplete and not representative, due to technical problems, and should not be used for statistical purposes, nor for international stock assessment. ** The data for 2020 are incomplete and not representative, due to technical problems and Covid measures, and should not be used for statistical purposes, nor for international stock assessment.

Decade	1960	1970	1980	1990	2000	2010	
Year							2020
0		795	252	218.2	17.85	0.318	0.605**
1		399	90	13	0.7	0.413	
2		556.5	129	18.9	1.4	2.408	
3		354	25	11.8	0.539	2.579	
4	3.7	946	6	17.5	0.381	6.717	
5	115	274	15	1.5	0.787	2.489	
6	385	496	27.5	4.5	0.065	1.023*	
7	575	472	36.5	9.8	2.214	1.697	
8	553.5	370	48.2	2.255	0.964	1.749	
9	445	530	9.1		0.969	2.415	

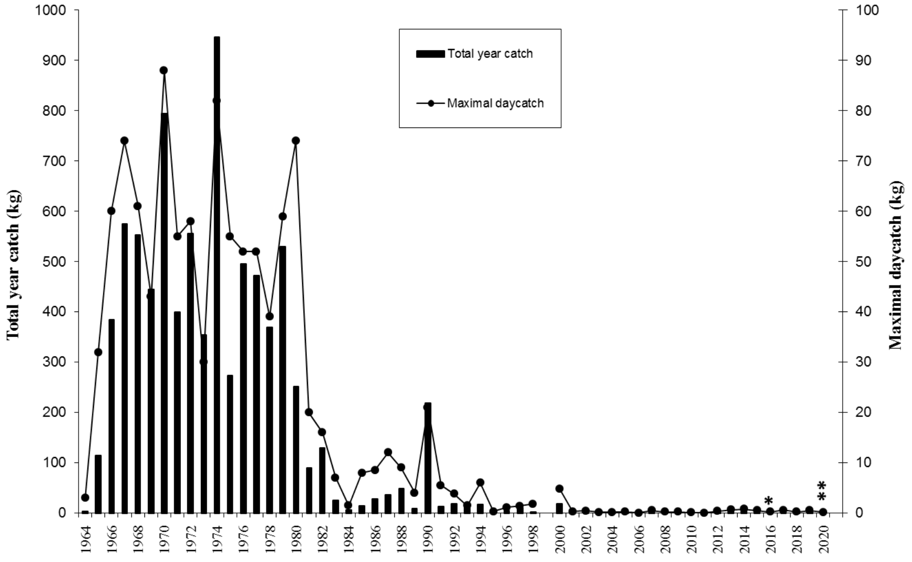

Figure 2A. Annual variation in glass eel catches at river Yser using the dipnet catches in the ship lock at Nieuwpoort (total year catches and maximum day catch per season), data for the period 1964–2018. * The data for 2016 are incomplete and not representative, due to technical problems at the sluices, and should not be used for statistical purposes, nor for international stock assessment. ** The data for 2020 are incomplete and not representative, due to technical problems and Covid measures, and should not be used for statistical purposes, nor for international stock assessment.

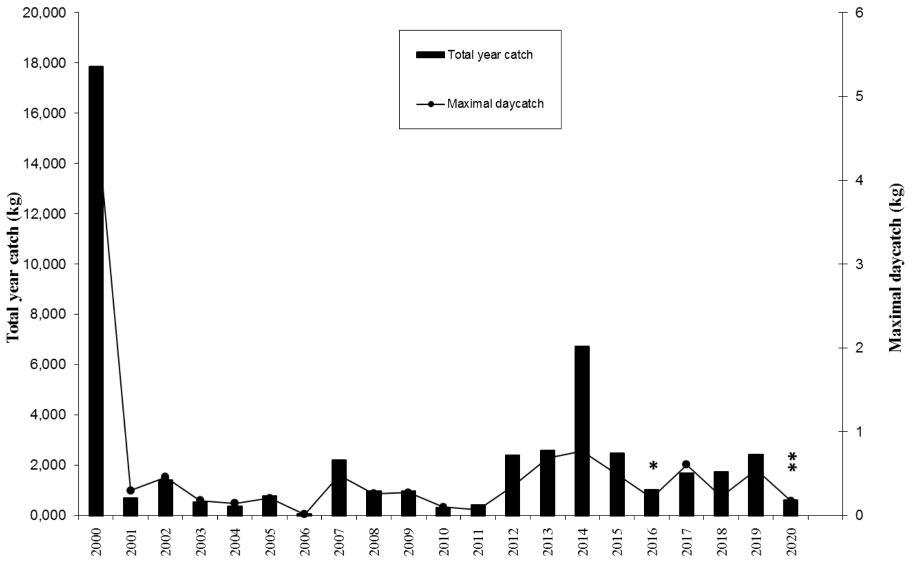

Figure 2B. Annual variation in glass eel catches at river Yser using the dipnet catches in the ship lock at Nieuwpoort (total year catches and maximum day catch per season), data for the period 2000–2018. * The data for 2016 are incomplete and not representative, due to technical problems at the sluices, and should not be used for statistical purposes, nor for international stock assessment. ** The data for 2020 are incomplete and not representative, due to technical problems and Covid measures, and should not be used for statistical purposes, nor for international stock assessment.

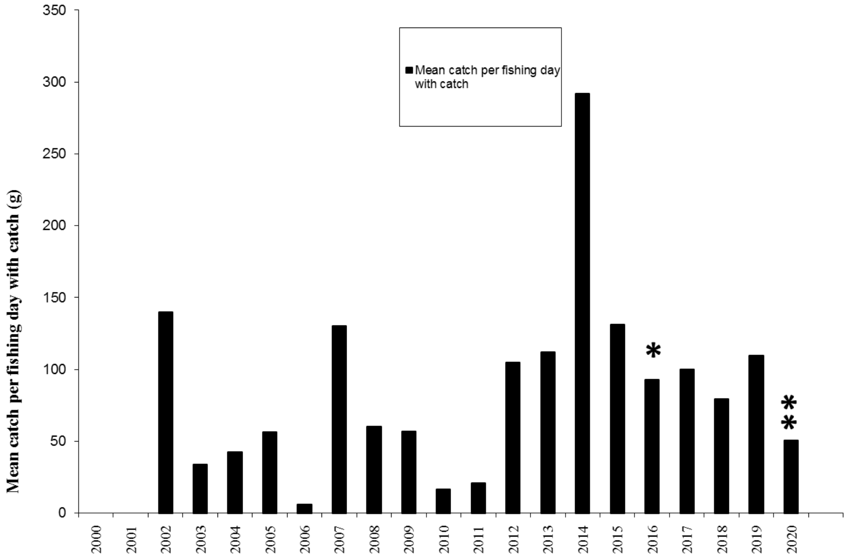

Figure 2C. Annual variation in glass eel catches at river Yser using the dipnet catches in the ship lock at Nieuwpoort) expressed as mean catches per fishing day with catch in g. * The data for 2016 are incomplete and not representative, due to technical problems, and should not be used for statistical purposes, nor for international stock assessment. ** The data for 2020 are incomplete and not representative, due to technical problems and Covid measures, and should not be used for statistical purposes, nor for international stock assessment.

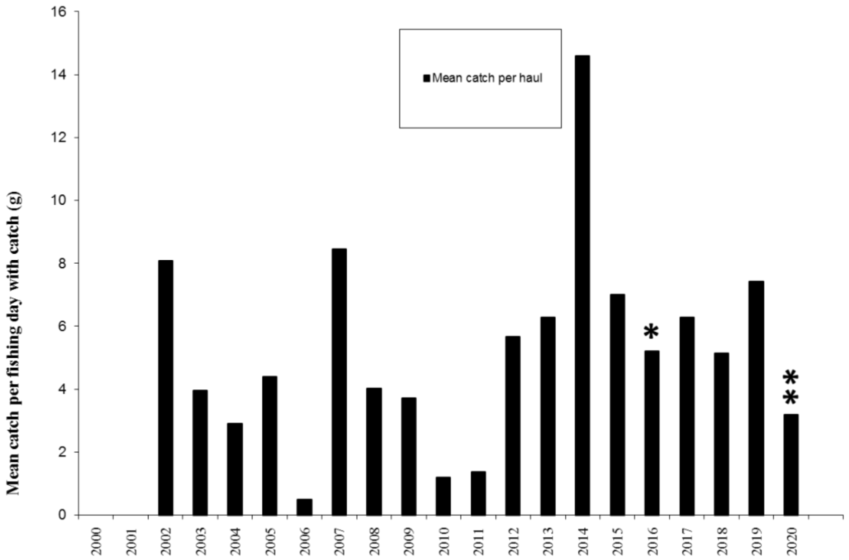

Figure 2D. Annual variation in glass eel catches at river Yser using the dipnet catches in the ship lock at Nieuwpoort), expressed as the mean catches per haul in g. * The data for 2016 are incomplete and not representative, due to technical problems, and should not be used for statistical purposes, nor for international stock assessment. ** The data for 2020 are incomplete and not representative, due to technical problems and Covid measures, and should not be used for statistical purposes, nor for international stock assessment.

Table 3. Temporal trend in catch per unit of effort for the governmental glass eel monitoring by dipnet hauls at the sluices in Nieuwpoort (River Yzer, 2002–2017). CPUE values are expressed as Kg glass eel caught per fishing day with catch and as Kg glass eel per haul. * The data for 2016 are incomplete and not representative, due to technical problems, and should not be used for statistical purposes, nor for international stock assessment. ** The data for 2020 are incomplete and not representative, due to technical problems and Covid measures, and should not be used for statistical purposes, nor for international stock assessment.

Year	Total year catch	Max day-catch	Total year catch/Number of fishing days with catch (Kg/day)	Total year catch/Number of hauls per season (Kg/haul)
2002	1.4	0.46	0.140	0.0081
2003	0.539	0.179	0.034	0.004
2004	0.381	0.144	0.042	0.0029
2005	0.787	0.209	0.056	0.0044
2006	0.065	0.014	0.006	0.0005
2007	2.214	0.485	0.130	0.0085
2008	0.964	0.262	0.060	0.004
2009	0.969	0.274	0.057	0.0037
2010	0.318	0.1	0.017	0.0012
2011	0.412	0.067	0.021	0.0014
2012	2.407	0.35	0.105	0.0057
2013	2.578	0.686	0.112	0.0063
2014	6.717	0.77	0.292	0.0146
2015	2.489	0.487	0.131	0.0070
2016*	1.023*	0.208*	0.093*	0.0052*
2017	1.697	0.607	0.100	0.0063
2018	1.749	0.230	0.080	0.0051
2019	2.415	0.545	0.110	0.0074
2020**	0.605	0.174	0.050	0.0032

New permanent monitoring station to estimate glass eel recruitment in Flanders: Glass eel recruitment at the Veurne-Ambacht pumping station (Nieuwpoort, Flanders)

Adjusted barrier management (ABM: limited barrier opening during tidal rise) is currently applied in Belgium as a measure to improve glass eel passage through sluice complexes at the salt/freshwater interface. The success of ABM in improving glass eel upstream migration was evaluated in the Veurne-Ambacht canal, a small artificial waterway (800 m length) used to spill excess water from a ± 20 000 ha polder area into the Yser estuary (Nieuwpoort) by means of a sluice complex. Glass eel migration was weekly monitored (March–June) in spring 2016 (without applying ABM), 2017 and 2018 (with ABM) by means of two eel ladders installed on both sides of a pumping station, the next migration barrier located in the upstream part of the canal. In comparison to 2016 (23 677 individuals caught), substantially higher catches were realized in 2017 (66 963 ind.) and 2018 (42 417 ind.) indicating that glass eels make use of this passage opportunity. Mark/recapture experiments (using rhodamine B stained glass eels) in spring 2018 revealed that both eel ladders obtain a high capture efficiency (recapture rate of 55%). Since spring 2019, **this location acts as a permanent monitoring station for glass eel recruitment** to 1. estimate the glass eel recruitment at this locality and 2. guide glass eel migrants around the pumping station (catch and carry). Once or twice a week, volunteers quantify the amount of glass eels that had been caught with both eel ladders and concordantly release the animals in the polder area (54 112 ind. in 2019). Catches are presented in Table 4.

In 2020, monitoring started on 3 February and stopped on 19 March. After 19 March, the monitoring was not allowed any more due to Covid 19. Fishing effort was thus much lower than during other years, and fishing was only performed during start of the season. Considering the very low fishing effort and the temporal bias in fishing, comparison of the 2020 data with recruitment data of previous years is not appropriate. Due to COVID-19 measures, the 2020 data of theVeurne-Ambacht recruitment series are incomplete and not representative, and should not be used for statistical purposes, nor for international stock assessment and should be treated as "NON-AVAILABLE" for international assessments.

Table 4. Temporal trend in catch per unit of effort for the glass eel monitoring at the at the Veurne-Ambacht pumping station (2016–2020, but see important notice below the table).

Year	Number of trapping days	Total year catch (Biomass in Kg)	Total year catch (in numbers)	Max week catch (Biomass in Kg)
2016*	86	7.171	23677	3.575
2017	97	19.265	66963	8.985
2018	89	11.321	42417	5.109
2019	109	15.692	54112	4.444
2020**	16	1.417	4836	0.979

*** 2016 is not comparable with following years since no adjusted barrier management (ABM: slight opening of 1–2 sluice doors during tidal rise) was executed at the tidal barrier at that time.**

**** The data for 2020 are incomplete and not representative, due to Covid measures, and should not be used for statistical purposes, nor for international stock assessment.**

Under development: Glass eel recruitment at the Caemerlinckxgeleed migration barrier (Oostende, Flanders)

The Caemerlinckxgeleed is a small artificial, largely subterranean canal used to spill excess water form a ± 4000 ha polder area into the harbour of Oostende by means of a sluice complex (gravitary outflow) and a pumping station. To monitor the current glass eel migration (without applying ABM at the sluice complex) through this canal an eel ladder was installed in spring 2019 on a complex of flap gates, functioning as a second migration barrier, situated about 1 km upstream the tidal barrier. Additionally, three floating artificial substrates were placed in front of the flap gates. From March to June 2019, a total of 516 glass eels were caught with the eel ladder and 330 with the artificial substrates showing that at least some glass eels were not only capable of passing the (closed) sluice gates at the tidal barrier but also of actively swimming counter current through the subterranean canal towards the next barrier. Based on this knowledge, ABM will be applied in the coming years at the tidal barrier to improve the intake of glass eels while the eel ladder will be used as a method to 1. monitor glass eel recruitment and 2. surpass the migration barrier (catch and carry).

This year (2020) monitoring experiments have been temporarily stopped due to Covid-19 pandemic.

Ascending young yellow recruitment series at Lixhe (Meuse basin)

On the Meuse, the University of Liège is monitoring the amount of ascending young eels in a fish pass. From 1992 to 2019 upstream migrating eels were collected in a trap (0.5 cm mesh size) installed at the top of a small pool-type fish pass at the Visé-Lixhe dam (built in 1980 for navigation purposes and hydropower generation; height: 8.2 m; not equipped with a ship-lock) on the international River Meuse near the Dutch–Belgium border (323 km from the North Sea; width: 200 m; mean annual discharge: 238 $m^3 s^{-1}$; summer water temperature 21–26°C). The trap in the fish pass is checked continuously (three times a week) over the migration period from March to September each year, except in 1994. A total number of 37 415 eels was caught (biomass 2461 kg) with a size from 14 cm (1992 and 2001) to 88 cm (2012) and an increasing median value of 28.5 cm (1992) to 41 cm (2015) corresponding to yellow eels. The study based on a constant year-to-year sampling effort revealed a regular decrease of the annual catch from a maximum of 5613 fish in 1992 to minimum values of 21–324 in 2010–2016) (Figure 3, Table 5). In 2008, 2625 eels were caught. This sudden increase might be explained by the fact that a new fish pass was opened (20/12/2007) at the weir of Borgharen-Maastricht, which enabled passage of eels situated downward the weir in the uncanalized Grensmaas. Nevertheless the number of eels were very low again in 2009 (n=584), 2015 (n = 92) and 2016 (n=21). The figure for 2012 (n= 324) is a bit more than the two previous years. In 2013, 265 eels were caught (size range 19.6-76.5 cm, median 39.1 cm), the data for 2014 are similar with 255 individuals (size range 23.4-69.8 cm, median 40.1 cm). In 2015 92 eels were caught (size range 23.1-85 cm, median 41 cm). In 2016 22 eels were caught (size range 21.1-64.2 cm, median 35.2 cm) which is the lowest number of eels ever recorded since the start of the monitoring (1992, n = 5613). In 2017 up to September 28 yellow eels were recorded (size range 24.0-72.0 cm, median 40.1 cm).

In 2018, total captured number of eels amounted 67 (biomass 9447 g). Maximum CPUE was 33 individuals per day. Sizes of eels caught ranged from 10 cm to 76 cm (median 41.1 cm). With this lower minimum length in eels, there are clearly eels from restocking involved in the group of ascending eels through the fish pass of Lixhe in the Meuse River.

Hereunder, in bold we update the data for 2019 (as reported in the 2019 Belgium Country Report) and present incomplete data for 2020.

In 2019, 118 eels (biomass 24 779 g) were caught (size range 12.2–100.0 cm, median 29.1 cm). Maximum CPUE was 42 individuals per day. This number includes wild and stocked eels since the Belgian Meuse, downstream of Lixhe, was stocked in 2018.

In 2020, up to 17 August, 84 eels were caught (biomass 2352.2 g). Sizes of eels caught ranged from 12.4 cm to 67.3 cm (median 22.8 cm). Maximum CPUE was 40 individuals per day. This observed number of eels caught has been impacted by the Covid-19 pandemic. Due to Covid, the monitoring of the fish pass started late (from June 10, 2020). The reported number of eels includes both wild and restocked eels. On 9 March 2018, the Belgian Meuse was restocked with a great quantity of imported glass eels (110 kg, 70 sites). This figure for 2020 may be incomplete. <u>While the 2020 data may be underestimated due to Covid, they may be used in the international analysis (considering mentioning there may be underestimation).</u>

The decreasing trend in the recruitment of young eels in this part of the Meuse was particularly marked from 2004 onwards. The University of Liège (Nzau Matondo *et al.*, 2015a, 2017; Nzau Matondo and Ovidio 2016) is continuing a research program financed by EFF-EU to monitor the status of ascending yellow eel stocks at Lixhe since 1992, to follow the dynamic of upstream movements of these eels in the upper parts of the Belgian Meuse River basin and to carry out for scientific purposes the restocking to enhance the local eel stocks. A fish pass located at the entrance of Belgium from the Dutch Meuse is regularly monitored. Since 2010, each yellow eel caught in this fish pass has been tagged and its upstream migration is monitored using fixed RFID detection stations placed in fish passes located upstream in the Meuse and in the lower reaches of the Ourthe (main tributary of the Meuse) (Nzau Matondo and Ovidio 2018).

Restocking using the imported glass eels has been conducted in 2013 and 2017 thanks to FEAMP (50% UE and 50% SPW financing) projects and the population dynamics of young eel recruits are currently being monitored by electrofishing and RFID mobile telemetry in the restocked streams. A 4-year study on the behaviour and life history of eels from restocking made in 2013 was published (Nzau Matondo *et al.*, 2019). See under Section 6 for more details on this paper.

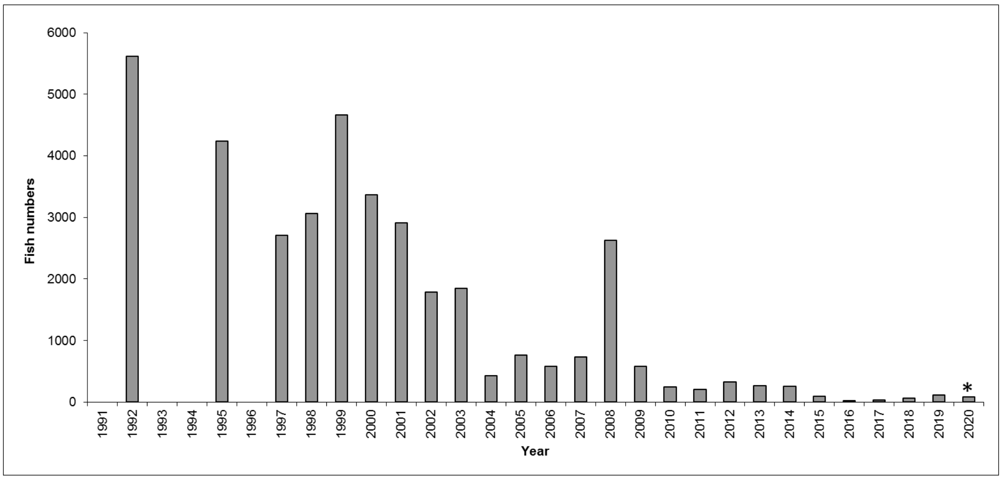

Figure 3. Variation in the number of ascending young yellow eels trapped at the fish trap of the Visé-Lixhe dam between 1992 and 2020. Data from University of Liège (Nzau Matondo *et al.*, 2015; Nzau Matondo and Ovidio, 2016). * Data for 2020 (n=84) include wild and stocked eels, and may be incomplete.

Table 5. Variation in the number of ascending young yellow eels trapped at the fish trap of the Visé-Lixhe dam between 1992 and 2020. Data from University of Liège (in Philippart and Rimbaud (2005), Philippart *et al.*, 2006, Nzau Matondo *et al.*, 2015; Nzau Matondo and Ovidio, 2016). * Data for 2020 (n=84) include wild and stocked eels, and may be incomplete.

DECADE				
Year	1990	2000	2010	2020
0		3365	249	84*
1		2915	208	
2	5613	1790	324	
3		1842	265	
4		423	255	
5	4240	758	92	
6		575	22	
7	2709	731	28	
8	3061	2625	67	
9	4664	584	118	

2 Overview of the national stock and its management

2.1 Describe the eel stock and its management

Four international RBDs are partly lying on Belgian territory: the Scheldt (Schelde/Escaut), the Meuse (Maas/Meuse), the Rhine (Rijn/Rhin) and the Seine. For description of the river basins in Belgium see the 2006 Country Report (Belpaire *et al.*, 2006). All RBDs are part of the NORTH SEA ICES ecoregion.

In response to the Council Regulation CE 1100/2007, Belgium has provided a single Eel Management Plan (EMP), encompassing the two major river basin districts (RBD) present on its territory: the Scheldt and the Meuse RBD.

Given the fact that the Belgian territory is mostly covered by two internationals RBDs, namely the Scheldt and Meuse, the Belgian Eel Management Plan was prepared jointly by the three Regional entities, each respectively providing the overview, data and measures focusing on its larger RBDs. The Belgian EMP thus focuses on the Flemish, Brussels and Walloon portions of the Schelde/Escaut RBD, and the Walloon and Flemish portions of the Meuse/Maas RBD.

The three Belgian authorities (Flanders, Wallonia or Brussels Regions) are responsible for the implementation and evaluation of the proposed EMP measures on their respective territory.

In the next years, all eel-related measures proposed in the Belgian EMP will be fine-tuned according to the existing WFD management plans and implemented in such manner by the responsible regional authorities.

The Belgian EMP has been approved by the European Commission on January 5th, 2010, in line with the Eel Regulation.

In June 2012, Belgium submitted the first report in line with Article 9 of the eel Regulation 1100/2007 (Vlietinck *et al.*, 2012). This report outline focuses on the monitoring, effectiveness and outcome of the Belgian Eel Management Plan.

The second Belgian Progress Report in line with Article 9 of the eel Regulation 1100/2007, was submitted in June 2015 (Vlietinck and Rollin, 2015).

The third Belgian Progress Report in line with Article 9 of the eel Regulation 1100/2007, was submitted in June 2018.

A general overview of specific actions and approaches to assessing the status of eel, to quantifying the human impacts by fisheries and other human impacts, has been presented in the last Belgian country report, see Section 2.1 (Belpaire *et al.*, 2018).

2.2 Significant changes since last report

No significant changes since the last country report. But, see Section 2.2 of the last Belgian country report (Belpaire *et al.*, 2019), apart from following action.

Evaluation of small-scale Adjusted barrier management (ABM) to improve glass eel migration at the tidal barrier (Maertensas) of the Noordede (Oostende, Flanders)

The Noordede is a heavily modified waterway currently used to drain ± 5200 ha polder area in the vicinity of Oostende. About 3 km inland, it contains a tidal barrier (Maertensas), preventing free fish migration. This barrier consists of a sluice complex with seven gravitary outflow channels that are only opened to spill excess polder water at low tide into the harbour of Oostende.

This complex was refurbished and automatized in 2017 at which time the outflow channel bordering the right riverbank was established as a fish-migration-channel where a small-scale ABM is applied during the glass eel season. Around equal water level (+/- 20 cm) between the sea and the polder area, the sluice door of this channel is temporally opened (20 cm) for about 30 minutes allowing the in- and outflow of water and biota. Due to the specific polder water level management, this time window is situated close to ebb tide and occurs twice each tidal cycle, during tidal rise and during tidal fall. The success of this mitigation measure was evaluated in spring 2019. The glass eel intake was quantified during ten selected tidal cycles, both under day- and night-time conditions, using a fykenet that filtered the complete inflow of the fish-migration-channel. The results show that glass eels mainly make use of this passage opportunity during tidal rise (12 283 ind. caught), the majority (98%) during nighttime. In contrast and counterintuitive to common knowledge, also 570 individuals passed the barrier during tidal fall, again mainly during nighttime (70%). These results indicate that even short time passage windows located early during tidal rise might substantially increase glass eel intake at tidal migration barriers.

There was no further information available compared to last year’s report.

3 Impacts on the national stock

3.1 Fisheries

3.1.1 Glass eel fisheries

There are no commercial glass eel fisheries. A recent feasibility study to assess the possibilities for commercial glass eel fisheries on the River Yser, did not indicate significant potential (Pauwels *et al*., 2016).

There are no recreational glass eel fisheries.

3.1.2 Yellow eel fisheries

There is no commercial fishery for yellow eel in inland waters in Belgium. Commercial fisheries for yellow eel in coastal waters or the sea are negligibly small.

Recreational fisheries in Flanders

The number of licensed anglers was 60 520 in 2004, 58 347 in 2005, 56 789 in 2006, 61 043 in 2007, 58 788 in 2008, 60 956 in 2009, 58 338 in 2010, 61 519 in 2011, 62 574 in 2012, 64 643 in 2013, 67 554 in 2014, 66 105 in 2015, 64 336 in 2016, 63 545 in 2017, 62 143 in 2018 and 57 388 in 2019. The time-series shows a general decreasing trend from 1983 (Figure 4), till 2006. However in 2007 there was again an increase in the number of Flemish anglers until 2014 when the number of anglers was 19% higher than in 2006. Since 2015, numbers are slightly decreasing again.

Only eels above the size limit of 30 cm are allowed to be taken home (since 2013). In 2013, a new legislation on river fisheries went into force (Agentschap Natuur en Bos, 2013). An amendment of the fisheries legislation entered into force in Flanders on the 1st of January 2019. Since then, **the total number of eels that an angler can keep in Flanders has been reduced from five to three**. There is no indication to what extent **this new bag limit** will have an impact on the total recreational biomass of eel retrieved by recreational fisheries.

An inquiry among Flemish fishermen was organized in 2016 (Agentschap Natuur en Bos, 2016). 10 000 fishermen were contacted, and the inquiry got a response of 28.8%. Data refer to the year 2015. The results indicated that 7% of the Flemish recreational fishermen prefer eel fishing. This is identical as in previous inquiry.

73% of the recreational fishermen fishing with a rod on eel, indicated that they take home their catch for consumption (despite advice not to do this due to contamination and associated human health risks). Eels are the second highest ranked species (after pikeperch) with respect of amounts taken home for consumption. It was estimated that over Flanders 29 523 kg of eels are retrieved annually from Flemish public water bodies to take home for consumption (as assessed for the year 2015, for a total of 66 105 recreational fishermen). This estimation is 12.1% lower than in 2008, when the retrieved yield was estimated at 33 600 kg of eels (Agentschap Natuur en Bos, 2016).

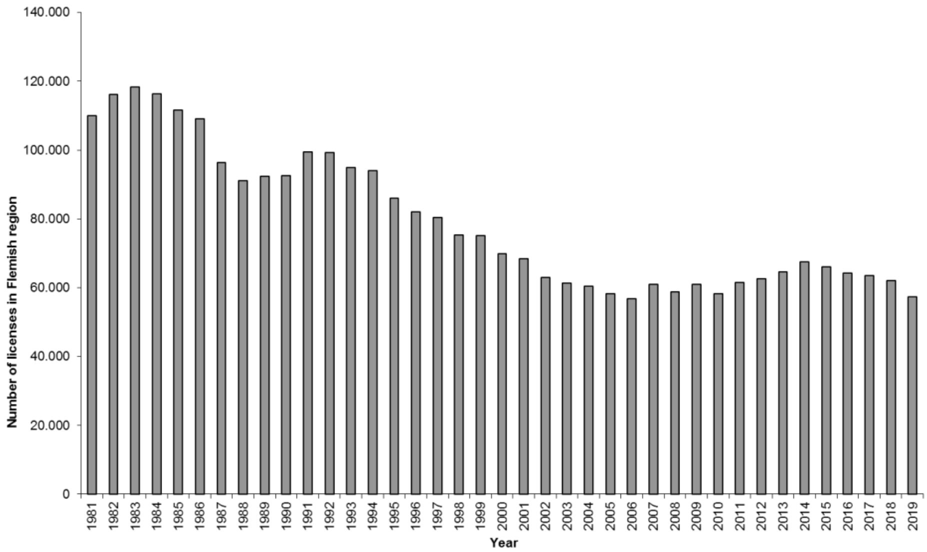

Figure 4. Time-series of the number of licensed **anglers in Flanders since 1981 (Data Agency for Nature and Forests).**

Estuarine fisheries on the Scheldt

The trawl fisheries on the Scheldt was focused on eel, but since 2006 boat fishing has been prohibited, and only fyke fishing was permitted until 2009, which is as a measure of the Eel Management Plan of Flanders to reduce catches. In 2010 a Decree (Besluit van de Vlaamse Regering van 5 maart 2010) was issued to regulate the prohibition of fyke fishing in the lower Seascheldt.

According to the fisheries legislation fishing with five fykes in de lower Scheldt estuary is allowed for fishermen who are in possession of a special fishing licence. In practice since 2009, no more fishing licences were issued because this type of fisheries did not comply with the Belgian Eel Management Plan. An amendment of the fisheries legislation entered into force in Flanders on the 1st of January 2019. This amendment implies that the licence system for the lower Scheldt river is abolished and that fykes are now permanently prohibited.

For a figure of the time-series of the number of licensed semi-professional fishermen on the Scheldt from 1992 to 2009 (Data Agency for Nature and Forests) we refer to Belpaire *et al.*, 2011 (Belgian Eel Country Report 2011).

Recreational fisheries in Wallonia

In Wallonia, the number of licensed anglers was 65 687 in 2004, 63 145 in 2005, 59 490 in 2006, 60 404 in 2007, 56 864 in 2008, 59 714 in 2009, 54 636 in 2010, 55 592 in 2011, 55 632 in 2012, 55 171 in 2013, 58 379 in 2014, 59 294 in 2015, 57 171 in 2016, 58 284 in 2017, 62 581 in 2018 and 62 561 in 2019 (Figure 5). The time-series shows a general decreasing trend from 1986. However in 2014, there was again an increase in the number of anglers in Wallonia (+6.9% compared to the minimum in 2010). The result of 2018 confirms this slight increase (+14.5% compared to the minimum in 2010). The proportion of eel fishermen in Wallonia is not documented, but is probably very small since it is forbidden to fish eels.

Between 2006 and 2016, captured eels were not allowed to be taken at home and have to return immediately into the river of origin. Furthermore, since 2017, the eel is considered by the new Walloon recreational fisheries legislation (Arrêté du Gouvernement wallon du 8.12.2016 relatif aux conditions d'ouverture et aux modalités d'exercice de la pêche. Published in the "Moniteur Belge" on 29.12.2016) as a fish species that is forbidden to fish all year long and everywhere in Wallonia (except in private ponds where the species is usually not present).

Therefore, yellow eel landing in Wallonia is estimated as zero, except for poaching.

Control actions of fishermen are focused specifically on navigable waterways during day and night. In the "Plan Police Pêche" control programme in 2017, the number of control actions was much increased (78 operations, 457 during the day and 271 during the night) compared to 2014 for a total of 2562 controlled fishermen. Numerous illegal fishing equipments were seized. Regarding Fisheries Act Violation, the offence rate was of 7.5% during the day in 2017, but of 20.8% during the night of the same year. Offence rate is the ratio between the number of fishermen with a report (at least one offence (infraction)) and the total number of fishermen controlled, multiplied by 100. These values were stable compared to 2016. During the 2010–2016 period, the annual offence rate during the night decreased by about 5% per year and was highly correlated to control intensity (Rollin and Graeven, 2016).

Only a small minority of violations concerned eel poaching, mostly illegal eel detention and utilisation as live bait for silurid fishing. From 2017, the number and frequency of eel poaching is monitored in the annual "Plan Police Pêche". Eel poaching was estimated in 2017 by multiplying the number of recreational fishermen in Wallonia (58 284 in 2017 and 62 581 in 2018) by the proportion of controlled anglers that illegally detained yellow and silver eels (0.2% in 2017 and 0.03% in 2018). This gave a rough estimation of the annual number of anglers that detained illegally eels in Wallonia in 2017 (114) and in 2018 (20). This number was then multiplied by an estimation of the mean weight of illegally caught eels (0.5 kg/fisherman) to give an estimated biomass of illegally caught eels in Wallonia for 2017 (57 kg) and 2018 (10 kg), a rather negligible value.

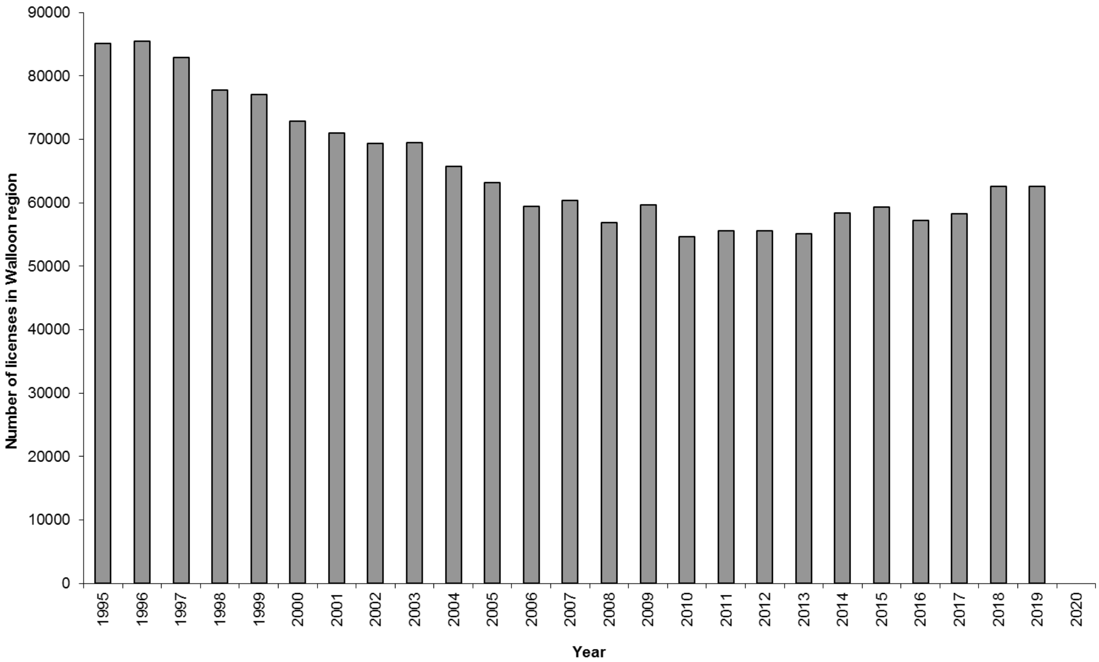

Figure 5. Time-series of the number of licensed **anglers in Wallonia since 1995 (Data : Nature and Fish Service of the Nature and Forests Department (DNF – DGARNE - SPW)).**

Recreational fisheries in Brussels capital

The number of licensed anglers is approximately 1400 (Data Brussels Institute for Management of the Environment).

There is no limiting regulation for the fishing for eel (no bag limit – no size limit – no closing season).

3.1.3 Silver eel fisheries

Commercial

There is no commercial fishery for silver eel in inland waters in Belgium. Commercial fisheries for silver eel in coastal waters or the sea are negligibly small.

Recreational

No time-series available. Due to the specific behaviour of silver eel, catches of silver eel by recreational anglers are considered low.

3.2 Restocking

3.2.1 Amount stocked

Restocking data per management unit are not available.

All glass eel used for the Flemish and Walloon restocking programs are purchased from foreign sources (usually UK or France). There are no quarantine procedures. Nowadays, no bootlace eels, nor ongrown cultured eels are restocked.

Stocking in Flanders

Glass eel and young yellow eels were used for restocking inland waters by governmental fish stock managers. The origin of the glass eel used for restocking from 1964 onwards was the glass eel catching station at Nieuwpoort on river Yser. However, due to the low catches after 1980 and the shortage of glass eel from local origin, foreign glass eel was imported mostly from UK or France.

Also young yellow eels were restocked; the origin was mainly the Netherlands. Restocking with yellow eels was stopped after 2000 when it became evident that also yellow eels used for restocking contained high levels of contaminants (Belpaire and Coussement, 2000). So only glass eel is stocked from 2000 on (Figure 6). Glass eel restocking is proposed as a management measure in the EMP for Flanders.

In some years, the glass eel restocking could not be done each year due to the high market prices. Only in 2003 and 2006 respectively 108 and 110 kg of glass eel were stocked in Flanders (Figure 6 and Table 6). In 2008, 117 kg of glass eel from U.K. origin (rivers Parrett, Taw and Severn) was stocked in Flemish water bodies. In 2009, 152 kg of glass eel originating from France (Gironde) was stocked in Flanders. In 2010 (April 20th, 2010) 143 kg has been stocked in Flanders. The glass eel was originating from France (area 20–50 km south of Saint-Nazaire, small rivers nearby the villages of Pornic, Le Collet and Bouin). A certificate of veterinary control and a CITES certificate were delivered.

In 2011 (21 April 2011) 120 kg has been stocked in Flemish waters. The glass eel was originating from France (Bretagne and Honfleur). A certificate of veterinary control and a CITES certificate were delivered.

In 2012, 156 kg has been stocked in Flemish waters. The glass eel was supplied from the Netherlands but was originating from France.

In 2013, 140 kg has been stocked in Flemish waters. The glass eel was supplied via a French compagny (SAS Anguilla, Charron, France).

In 2014, the lower market price allowed a higher quantity of glass eel to be stocked. 500 kg has been stocked in Flemish waters. The glass eel was supplied via a French company (Aguirrebarrena, France).

In 2015, Flanders ordered 335 kg glass eel for stocking in Flemish waters (price 190 €/kg). However, the supplier was not able to supply the glass eel. Apparently, due to shortness of glass eel, suppliers prioritize fulfillment of their orders towards the more lucrative orders (e.g. by the aquaculture sector). As a result, no glass eel could be stocked in Flanders in 2015.

In 2016, Flanders purchased 385 kg glass eel for stocking in Flemish waters (price 180 €/kg). These glass eel were stocked on March 18th, 2016. Origin of the glass eel was France (sarl Foucher-Maury).

In 2017, Flanders bought 225 kg glass eel for stocking in Flemish waters (price 233.33 €/kg, without taxes). These glass eel were stocked on March 29th, 2017. Origin of the glass eel was France (sarl Foucher-Maury).

In 2018, Flanders bought 280 kg glass eel for stocking in Flemish waters (price 265 €/kg, without taxes). These glass eel were stocked on March 14th, 2018. Origin of the glass eel was France (SAS Foucher-Maury).

In 2019, Flanders bought 300 kg glass eel for stocking in Flemish waters (price 180 €/kg, without taxes). These glass eel were stocked on February, 26th, 2019. Origin of the glass eel was France (EURL AGUIRREBARRENA, St Vincent de Tyrosse, France).

In 2020, Flanders bought 300 kg glass eel for stocking in Flemish waters (price 185 €/kg, without taxes). These glass eel were stocked on March, 11th, **2019. Origin of the glass eel was France (EURL AGUIRREBARRENA, Zac Casablanca, 5 rue de la Cotterie – 40230, St Vincent de Tyrosse, France).**

The cost of the glass eel per kg (including transport but without taxes) is presented in Table 7.

Glass eel restocking activities in Flanders are not taking account of the variation in eel quality of the restocking sites.

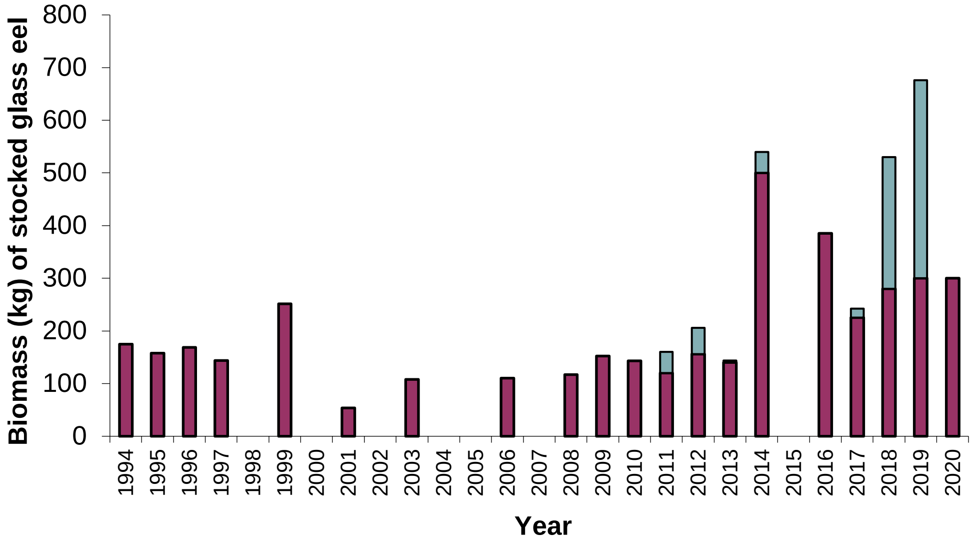

Figure 6 and Table 6. Restocking of glass eel in Belgium (Flanders and Wallonia) since 1994, in kg of glass eel. Flanders is represented in red and Wallonia in blue in the figure. * left Flanders/right Wallonia.

Decade Year	1980	1990	2000	2010	2020
0			0	143	300/0*
1			54	120/40*	
2			0	156/50*	
3			108	140/4*	
4		175	0	500/40*	
5		157,5	0	0/0*	
6		169	110	385/0*	
7		144	0	225/17.3*	
8		0	117	280/250*	
9		251,5	152	300/376*	

Table 7. Prices of restocked glass eel in Belgium (2008–2020).

Year	Cost (€/kg)
2008	510
2009	425
2010	453
2011	470 (Flanders) 520 (Wallonia)
2012	416 (Flanders) 399 (Wallonia)
2013	460 (Flanders) 400 (Wallonia)
2014	128 (Flanders) 128 (Wallonia)
2015	190 (Flanders)(not supplied) 128 (Wallonia) (not supplied)
2016	180 (Flanders)
2017	233 (Flanders) 350 (Wallonia)
2018	265 (Flanders) 292 (Wallonia)
2019	180 (Flanders) 178 (Wallonia)
2020	185 (Flanders) 299 (Wallonia)(but not supplied)

Stocking in Wallonia

In Wallonia, glass eel restocking was initiated in 2011, in the framework of the Belgian EMP. In March 2011 40 kg of glass eel was restocked in Walloon rivers, in 2012 the amount stocked was 50 kg.

In 2013, for financial reasons no stocking was carried out in Wallonia, except for some restocking in three small rivers in the context of a research program led by the University of Liège. This research programme was financed by European fisheries Fund (EFF, project code 32-1102-002) to test the efficiency of glass eel restocking in water bodies of diverse typology. In May 2013, in total 4 kg of glass eel was stocked (1.5 kg in La Burdinale, 1.5 kg in River d'Oxhe and 1 kg in Mosbeux) (price per kg was 400 Euros). The origin of these glass eels was UK glass eels Ldt, UK Survival, dispersion, habitat and growth were followed from September on, to assess to what extent glass eel stocking is a valuable management measure to restore Walloon eel stocks. One year after stocking, elvers were found up and downstream the unique point of the glass eels release and in the complete transversal section of these streams, with preference for the sheltered microhabitats located near the banks where water velocity and depth are low (Ovidio *et al.*, 2015). Higher recruitment success of glass eels was observed in the Mosbeux because of its high carrying capacity. Recently, the mark–recapture method using the Jolly-Seber model estimated the recruitment success at 658 young eels (density 11.1 eels/m², minimal survival 15.8%) two after stocking in Mosbeux. The young eels are monitoring two times a month in Mosbeux and Vesdre using a mobile detection RFID station to study their space use and seasonal movement.

In 2014, 501 kg glass eel were ordered from a French company (Aguirrebarrena, France) with EFF 50% co-funding. Unhappily, the French supplier was unable to supply the ordered quantity and only 40 kg were restocked in 2014. Therefore, the Walloon region accepted to delay the delivery of the remaining 461 kg glass eel in 2015. However, the French supplier was again "unable" to supply the ordered glass eel. The higher prices for glass eel in 2015 probably explain this situation. The French supplier was excluded from the Walloon market for three years (between 2016 and 2018), but no glass eel stocking could take place in 2015.

In 2016, no glass eels stocking was carried out in Wallonia for financial reasons. In 2017, no glass eels stocking was carried out in Wallonia because of a (new) delivery default of a French supplier (OP Estuaires).

In 2017, in the context of a survey on the effectiveness of glass eel restocking in Wallonia, the University of Liège stocked 17.3 kg of glass eel (n=76370) imported from a French company (Gurruchaga Maree, France) in 6 rivers (Hoegne, Wayai, Winamplanche, Berwinne, Gueule and Oxhe). Glass eels were released in 43 sites (Hoëgne: 3.9 kg at six sites; Wayai: 3.6 kg at ten sites; Winamplanche: 0.6 kg at five sites; Berwinne: 4.0 kg at eleven sites; Gueule: 4.3 kg at ten sites and Oxhe: 1 kg at one site). These rivers were both hydromorphologically and physicochemically different. Assessments conducted after restocking in ten release sites (1–2 sites/river) during autumn each year revealed n = 323 individuals in 2017 and n = 464 individuals in 2018 that were captured and pit-tagged. Density of recruited young eels varied between sites and was higher in more eutrophic site with bottom substrate offering good burial and water pH slightly alkaline.

In 2018, Wallonia bought 250 kg glass eel for stocking in Walloon waters (price 291.65 €/kg, without taxes). These glass eels were stocked on March 9th, 2018 at 256 sites, in the Belgian Meuse (110 kg, 70 sites), the Ourthe-Amblève-Aisne river system (86 kg, 83 sites), the Lesse (20 kg, 20 sites), the Sambre (13 kg, 43 sites), the Mehaigne (4 kg, eight sites) and different Walloon tributaries of the Scheldt (16 kg, 22 sites in rivers Dendre, Senne, Dyle, Deux Gettes and Scheldt). Origin of the glass eel was France (SAS Foucher-Maury). A certificate of veterinary control was delivered (absence of *Pseudodactylogyrus*, *Ichthyophtirius multifiliis*, *Anguillicola crassus*). Survival at reception was very good (maximum 0.5% mortality at stocking site).

In 2019, Wallonia bought 376 kg glass eel for stocking in Walloon waters (price 178 €/kg, without taxes). These glass eels were stocked on March 13th, 2019 in 228 sites, in the Belgian Meuse (100 kg, 78 sites), the Ourthe-Amblève-Aisne river system (156 kg, 74 sites), the Lesse-Lhomme river system (56 kg, 28 sites), the Sambre (24 kg, 24 sites), the Semois (20 kg, 12 sites) and different Walloon tributaries of the Scheldt (19 kg, 12 sites in rivers Dendre and Scheldt-Lys). Origin of the glass eel was France (SAS Foucher-Maury). A certificate of veterinary control was delivered (absence of *Pseudodactylogyrus*, *Ichthyophtirius multifiliis*, *Anguillicola crassus*). Survival at reception was very good (maximum 1% mortality at stocking site).

In 2020, Wallonia ordered on 12 March 2020 to an eel trading company (UK Glass Eels Ldt, Gloucester, UK) 220 kg glass eel for stocking in Walloon waters (price 299 €/kg, without taxes). However, the supplier was not able to provide the glass eel due to the lockdown as a measure for the Covid-19 pandemic. As a result, no glass eel could be stocked in Wallonia in 2019 but this order remains valid, probably for 2021.

Trend in restocking in Wallonia is presented in Figure 6 and Table 6.

More information on stocking details for Wallonia is presented in Table 7 and 8 (Cost of the glass eel, origin).

A 4-year study on the behaviour and life history of eels from restocking was recently published (Nzau Matondo *et al.*, 2019). This study provides new knowledge of the long-term dispersal behaviour of restocked eels and the influence of seasons, barriers, and habitats on their colonization strategy changing with time. The results contribute to a better understanding of the effect of restocking practices in upland rivers. See under Section 6 for more details on this paper.

A new study was published by Nzau Matondo *et al.* (2020) on the evaluation of restocking practices (see below Chapter 6 for more details).

Table 8. Origin and amounts of glass eel restocked in Belgium (Flanders and Wallonia) between 2008 and 2020.

Year	Region	Origin	Amount (kg)
2008	Flanders	UK	125
2009	Flanders	France	152
2010	Flanders	France	143
2011	Wallonia	UK	40
	Flanders	France	120
2012	Flanders	France	156
	Wallonia	France	50
2013	Flanders	France	140
	Wallonia	UK	4
2014	Flanders	France	500
	Wallonia*	France	40
2015	Flanders**	-	0
	Wallonia*	-	0
2016	Flanders	France	385
	Wallonia	-	0
2017	Flanders	France	225
	Wallonia	France	17.3
2018	Flanders	France	280
	Wallonia	France	250
2019	Flanders	France	300
	Wallonia	France	376

Year	Region	Origin	Amount (kg)
2020	Flanders	France	300
	Wallonia***	UK	0

*** Despite an order of 501 kg, only 40 kg glass eel was supplied in 2014 and no supplies in 2015.**

**** Despite an order of 335 kg, no glass eel was supplied.**

***** Despite an order of 220 kg, no glass eel was supplied (due to Covid-19 pandemic).**

3.3 Aquaculture

There is no aquaculture production of eel in Belgium.

3.4 Entrainment

In Belgium, the eel stock is considerably impacted by a multitude of migration barriers, some of which may cause direct or indirect mortality, especially through passage through draining pumps and impingement by power stations and hydropower units.

We refer to the 2017 Belgian Country Report (Belpaire *et al*., 2017) for discussion on the results of the impact assessment of pumping stations (studies by Buysse *et al*., 2014 and 2015).

Verhelst *et al*. (2018a) investigated the impact of migration barriers on downstream migrating eels by tracking 50 acoustically tagged migrating eels between July 2012 and March 2015 in a Belgian polder area. The study area was selected due to the presence of a wide range of migration barriers, such as two pumping stations, a weir and tidal sluices. These structures regulate the water level, resulting in discontinuous flow conditions. The results showed that migration was primarily nocturnal and discharge appeared to be the main trigger for migration in the polder. We also observed substantial delays and exploratory behaviour near barriers. Delays can have a serious impact on eels since their energy resources are limited for a successful trans-Atlantic migration. In addition, delays and exploratory behaviour can also increase predation and disease risk. The obtained knowledge can contribute to efficient management such as improved fish passage and guidance solutions.

Significant progress has been made in quantifying impacts of migration barriers such as turbines and fish locks on eel migration in canals (see the items under Chapters 5.2 and 6).

3.5 Habitat Quantity and Quality

No changes compared to the 2015 Belgian country report. We refer to this report for details.

However, significant progress has been made in quantifying impacts of migration barriers such as turbines and fish locks on eel migration (see the items under Chapter 5.2).

3.6 Other impacts

No major changes compared to the 2015 Belgian country report. We refer to this report for details.

Some new information on contaminants is presented under Sections 5.4 and 6.

4 National stock assessment

4.1 Description of Method

The latest data regarding national stock assessment refer to the silver eel escapement assessment for the progress report 2018 of the EU Regulation as described in Belpaire *et al.* (2018) and the 2018 Belgian Eel Progress Tables.

We refer to these documents for detailed information.

4.1.1 Data collection

Flanders (Belpaire *et al.*, 2018)

In Flanders, the quantification of the migration of silver eel is based on model calculations. For this purpose, the total number of yellow eels per stratum *River Type * River Basin* is calculated on the basis of the estimated density of yellow eel (using electrofishing data) and the surface area of water courses in the eel management plan, including corrections for various factors of natural and anthropogenic mortality. The 2018 reporting is based on data collected between 1 January 2015 and 31 December 2017.

The data are supplied by Flanders' Freshwater Fish Monitoring Network and other monitoring programs carried out by INBO's MHAF team ("Monitoring en Herstel Aquatische Fauna").

Flanders recently started with monitoring the silver eel migration at one site (see also Section 5.2), which enables preliminary comparison of the two evaluation methods. A first analysis on a limited set of data from this test area (Polder Noordwatering Veurne) clearly shows the potential and added value of a combined approach with both model-based estimates and follow-up and quantification of direct monitoring of the silver eel. A SWOT analysis of both methods analysed the advantages and disadvantages and potentials of both methods. The silver eel production figures obtained by the two different methods confirmed each other, but the error margins in both calculations are very significant. However, this type of approach requires a specific plan-based approach with a statistically based experimental design. We recommend to further explore the comparison between the two methods through field experiments and a targeted pilot plan.

Wallonia

No new assessment available since the study of de Canet *et al.* (2014) *in* Vlietinck and Rollin (2015), except the estimation of caught eels related to poaching (see Section 3.1.2).

Based on a constant year-to-year sampling effort, a non-selective cone-trap pool retaining eels in a fish pass build in the Belgian Meuse river at Lixhe is scientifically and homogeneously monitored since 1992 to assessing the abundance of the ascending yellow eels from the Dutch Meuse. Scientific data processing make it possible to establish the trend of incoming stocks of wild eels in the Belgian Meuse (see Section 1.2 Time-series of recruitment).

4.1.2 Analysis

Flanders (Belpaire *et al.*, 2018)

The method for calculating the silver eel escapement rate was adjusted from the calculation models used in the previous reports (Stevens en Coeck, 2013, Belpaire *et al.*, 2015). In this new model, conversion of catch data to expected number per ha have been optimized, and the mortality figures from recreational fisheries and cormorants have been calculated in a different way. Mortalities due to pumps and turbines were now integrated over the stratum *River Basin* on the basis of a different allocation key (in casu the proportion of the basin drained by pumps)). For cases without CPUE data within the stratum *River Type * River Basin*, a zero-inflated negative binomial model was used to estimate the number of eels per hectare. Furthermore, the fresh, brackish and salt tidal waters (types Mlz and O1) were considered together as one river type. The R script developed during the previous report was further adapted according to the refinement of the calculation model. The changes in the calculation model are considered to have a significant influence on the results.

Wallonia

The analysis used in the ascending yellow eel assessment for the period 1992–2018 for the Belgian Meuse at Lixhe in Wallonia has been reported in Nzau Matondo and Ovidio (2016), Nzau Matondo *et al*. (2014, 2015, 2017) and Benitez *et al*. (2019). By monitoring a fish pass over 26 years, the number of ascending yellow eels has drastically declined (nearly 4% per year since 1992; abundance of eels in 2018 was 1.2% of the historical level in 1992). Similarly, the migration flux of ascending yellow eels estimated using mark-recapture method also dropped significantly (stock in 2013 was 0.5% in biomass and 1.6% in numbers of the historical level in 1993). In 2013, the silver eel production in the Meuse at Lixhe was estimated at 0.54% in numbers and 0.64% in biomass of ascending yellow eel stock using the DemCam model.

4.1.3 Reporting

Flanders

The silver eel escapement assessment for the period 2015–2017 for Flanders has been reported in Belpaire *et al*. (2018).

Wallonia

The ascending yellow eel assessment for the period 1992–2018 for the Belgian Meuse at Lixhe in Wallonia has been reported in Nzau Matondo and Ovidio (2016), Nzau Matondo *et al*. (2015, 2017) and Benitez *et al*. (2019). The results are reported every year to European Commission through the regional and national reports.

4.1.4 Data quality issues and how they are being addressed

Flanders (Belpaire *et al*., 2018)

Despite these improvements (see Section 4.1.2), serious concern remains on the representativeness of the results, as the model strongly suffers from insufficient data and for some strata data with insufficient representativeness.

The calculation model generated production figures for the canals and tidal waters. However, it is very likely that the results for these two types are highly underestimated, due to insufficient and low quality data. Here, we recommend applying specific methods for the evaluation of the yellow eel stock or for the production and escapement ratio of silver eels in these waters (considering their large ratio in the total area of the eel management area).

A number of other recommendations / action points were formulated, in response to the large uncertainties and error margins inherently linked to the chosen reporting strategy.

Wallonia

See the detailed discussion about the accuracy of the models used by de Canet *et al*. (2014) in the mid-term report of Vlietinck and Rollin (2015).

Based on a constant year-to-year sampling effort, a non-selective cone-trap pool retaining eels in a fish pass build in the Belgian Meuse river at Lixhe is scientifically and homogeneously monitored since 1992 to assessing the abundance of the ascending yellow eels from the Dutch Meuse. Scientific data processing makes it possible to establish the trend of incoming stocks of wild eels in the Belgian Meuse. However, the representativeness of the results remains a major concern, as the estimation model only concerns the migratory fraction of yellow eels over part of the Meuse without the Albert Canal (Nzau Matondo *et al*., 2015). It suffers greatly from a lack of annual data for both resident yellow eels and silver eels.

For the stocked eels, we use the Jolly-Seber method for assessing the stocks and survivals (Nzau Matondo *et al*., 2020). This method is based on the capture histories of the tagged individuals for modelling effective demographic parameters of eels. As this model requires multiple time-spaced electrofishing sessions before providing a stock history associated with each electrofishing session, it is not easy to implement on a large hydrographic network.

4.2 Trends in Assessment results

Flanders (Belpaire *et al*., 2018)

The current figures for silver eel escapement estimated with the new calculation model based on the data collected between 2015 and 2017 are 11,5% for the EMU Scheldt and 18,3% for the EMU Maas. These are the same for the EMU Scheldt as those reported in 2015, but are significantly better for EMU Maas than the figures reported in 2015. Given the use of a new calculation model, no statement can be made about the evolution of the stocks. The improvement in EMU Maas is mainly due to the application of the new calculation model.

However, on the basis of a trend analysis in which the new 2018 calculation model was applied to the data of the last two periods, the population seems to stagnate (in terms of silver eel production). Where a slight improvement for the EMU Maas is noticeable, the escapement figures for the EMU Scheldt remain at the same level (very slight decrease). The expected positive effects of the recovery measures implemented in Flanders are therefore not clearly visible in the production figures. Additional measures will have to be taken in order to achieve the objectives of the Eel Regulation (40% escapement). The introduction of a catch-and-release obligation for the recreational fisheries would contribute to an increase of about 10% of the current escapement figures.

Wallonia

The estimation of caught eels related to poaching (see Section 3.1.2) seems negligible (57 kg in 2017) compared to other pressures of anthropogenic origin on yellow and silver eels populations in Wallonia.

In the Belgian Meuse river at Lixhe ascending yellow eels are monitored (Nzau Matondo and Ovidio, 2016; Nzau Matondo *et al*., 2017; Benitez *et al*., 2019) in the old fish pass of Lixhe. For a trend analysis of incoming stocks of wild eels in the Belgian Meuse, see Section 1.2 (Recruitment time-series). Decreasing numbers of ascending yellow eels were described, as well as the frequency of catches, body size and the influence of environmental factors on upstream movement of the eels. In 2018, the number of ascending yellow eels reached 1.2% of the record level of 1992.

With the weekly survival probabilities estimated greater than 95% using the best-selected Jolly-Seber model, the imported glass eels unmistakably survive in well selected upland rivers (Nzau Matondo *et al*., 2020). Restocking may represent a beneficial management option for enhancing the local stocks in inland waters.

5 Other data collection for eel

5.1 Yellow eel abundance surveys

Trend analysis of eel catches in the Flemish Fish Monitoring Network

Flanders runs a fish monitoring programme for the water Framework Directive. See 2016 country report (Belpaire *et al.*, 2016b) for a preliminary assessment of electrofishing and fyke-fishing data from the Flemish Fish Monitoring Network showing temporal trends in eel presence and abundance (INBO data) over the periods 1994–2000, 2001–2005, 2006–2009 and 2010–2012. 303 locations on running waters were assessed in each of the four periods.

The most recent analysis of electrofishing and fyke-fishing data has been performed in the framework of the 2018 progress report for the EU Eel Regulation (Belpaire *et al.*, 2018). The evaluation of the silver eel escapement is based on modelling the yellow eel abundance data. See Section 4.1 for more details.

Estuarine fish monitoring by fykes

A fish monitoring network by INBO has been put in place to monitor fish stock in the Scheldt estuary using paired fykenets (Figure 7). Campaigns take place in spring and autumn, and also in summer from 2009 onwards. At each site, two paired fykes were positioned at low tide and emptied daily; they were placed for two successive days. Data from each survey per site were standardized as number of fish per fyke per day. Figures (Figures 8–10) below show the time trend of eel catches in six locations along the Scheldt (Zandvliet, Antwerpen, Steendorp, Kastel, Appels and Overbeke) (Data Jan Breine, INBO; Breine and Van Thuyne, 2015; Breine *et al.*, 2019b). Data are presented until autumn 2019.

Compared to last year's report the fall data for 2019 have now been included, and some summer 2019 data have been updated. Due to Covid-19 issues, data processing and reporting for the spring and summer campaign 2020 were delayed and data were not yet available.

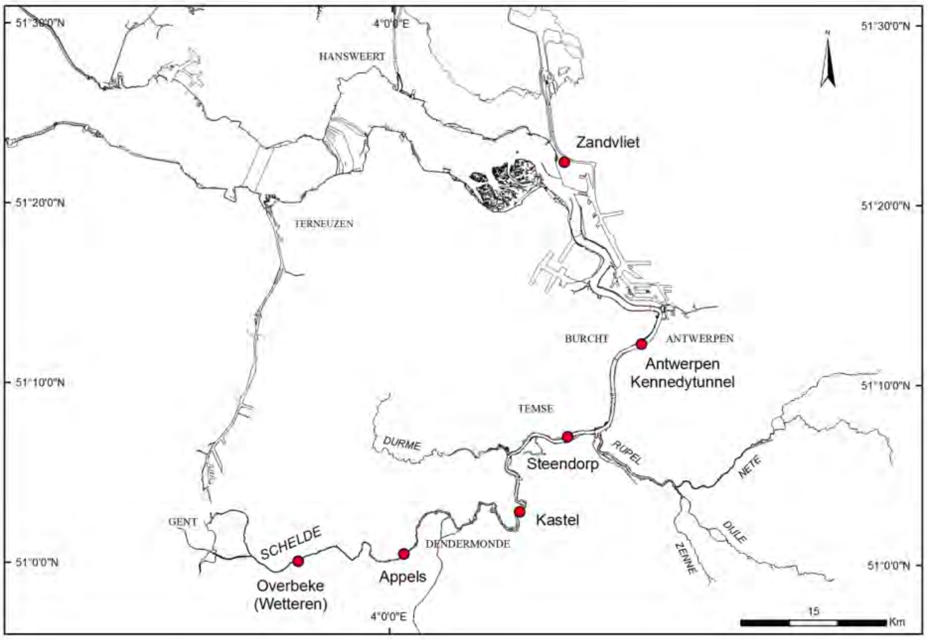

Figure 7. Locations sampled in the Zeeschelde estuary.

In the **mesohaline** zone (Zandvliet) catches are generally low. Eel is rarely caught in spring. Since 2009 eel is caught in low numbers during summer and occasionally in autumn. The most recent data for Zandvliet stay very low compared to previous years (especially for summer data).

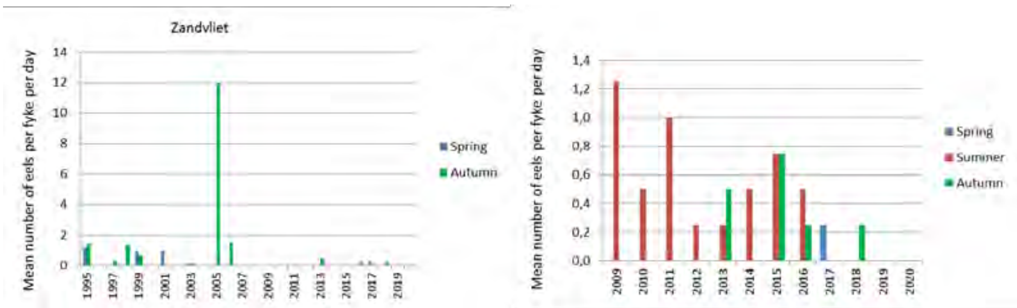

Figure 8. Time trend of fyke catches of eel in Zandvliet. Numbers are expressed as mean number of eels per fyke per day. Left, data are split up in spring catches and fall catches (1995–2019) while right, summer catches are added (2009–2019). Years without monitoring data are excluded from the X-axis.

In the **oligohaline** zone two locations are sampled (Antwerpen and Steendorp).

Eel is rarely caught in spring in the oligohaline zone. For 2017 and 2018, eel catches in the summer in Antwerpen and Steendorp are moderate and lower than 2015–2016. Autumn catches in 2017 are better than in previous years, especially for Steendorp. The new data for spring and summer 2019 are on average a bit higher than the previous year, except for the autumn 2018 catches, which were lower than the previous year.

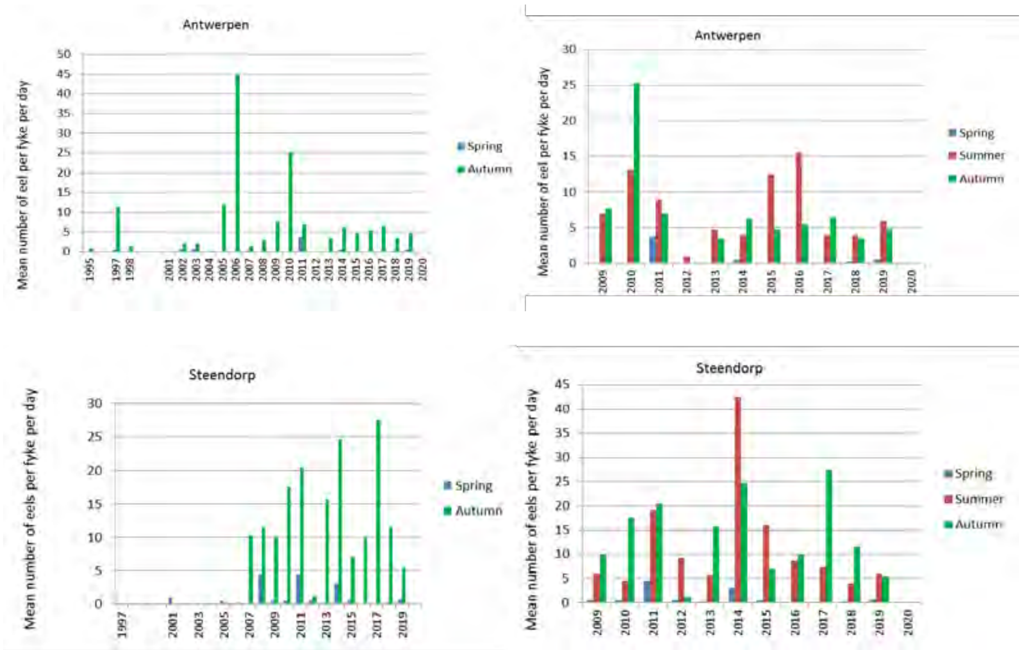

Figure 9. Time trend of fyke catches of eel in Antwerpen and Steendorp. Numbers are expressed as mean number of eels per fyke per day. On the left, data are split up in spring catches and fall catches (1995–2019) while on the right, summer catches are added (2009–2019). Years without monitoring data are excluded from the X-axis.

In the **freshwater** part of the estuary one location (Kastel) was sampled yearly since 2002. The two other sites (Appels and Overbeke) were sampled from 2008 onwards.

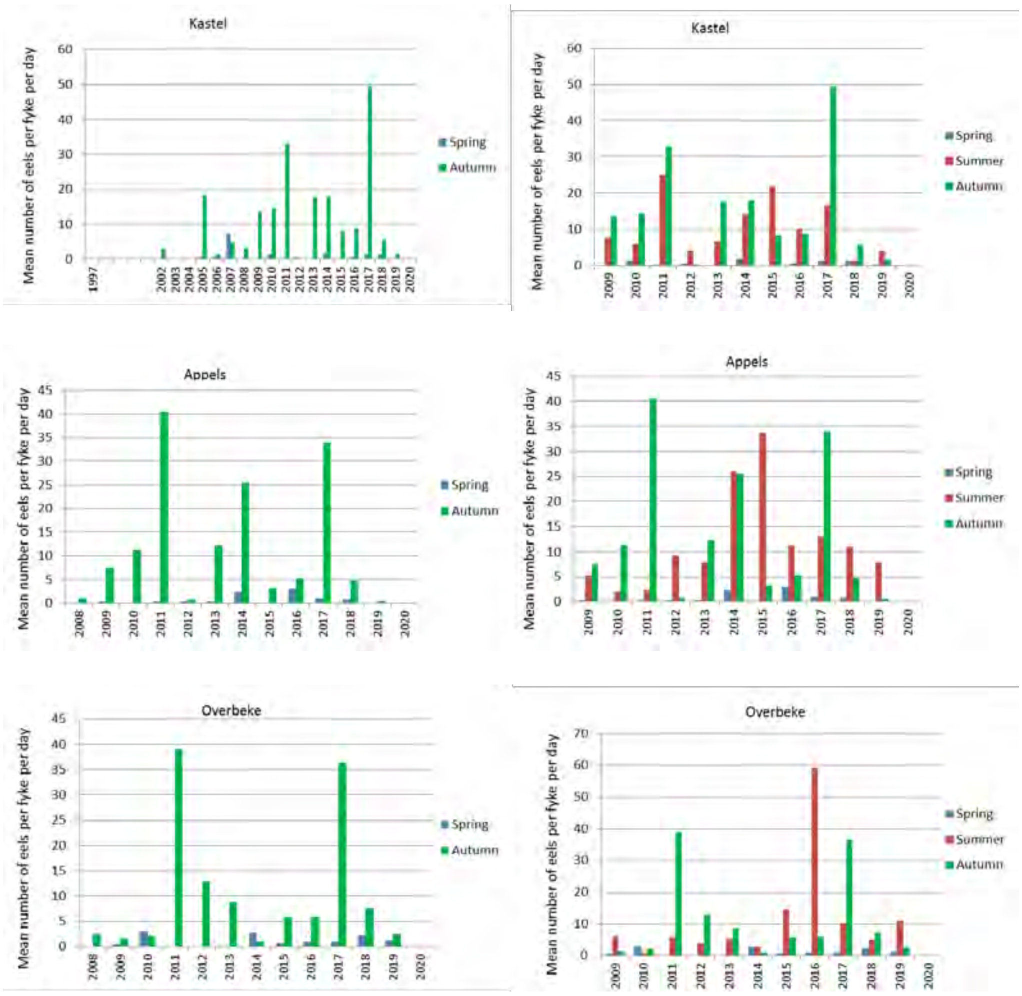

Figure 10. Time trend of fyke catches of eel in Kastel, Appels and Overbeke. Numbers are expressed as mean number of eels per fyke per day. On the left, data are split up in spring catches and fall catches (1997 or 2008–2019) while on the right, summer catches are added (2009–2019). Years without monitoring data are excluded from the X-axis.

In this zone, the new data (autumn 2018, spring and summer 2019) are on average lower than the previous year, except for the summer 2019 catches, which are a bit higher in Kastel and Overbeke.

Anchor net monitoring along the River Scheldt estuary

Besides, each year from 2012 on, fish from the Scheldt is also monitored through fishing with a mid-water beam trawl from an anchored boat, three times a year (Spring – Summer – Fall) at four sites (Doel, Antwerpen, Steendorp and Branst)(Breine *et al*., 2019a). Temporal data between 2012 and 2019 are shown in Figure 11. The data are expressed as number of eels per hour. The data show overall low densities for 2019, even lower than in 2018 and 2017.

Compared to last year's report the fall data for 2019 have been now included. Due to Covid-19 issues, data processing and reporting for the spring and summer campaign 2020 were delayed and data were not yet available.

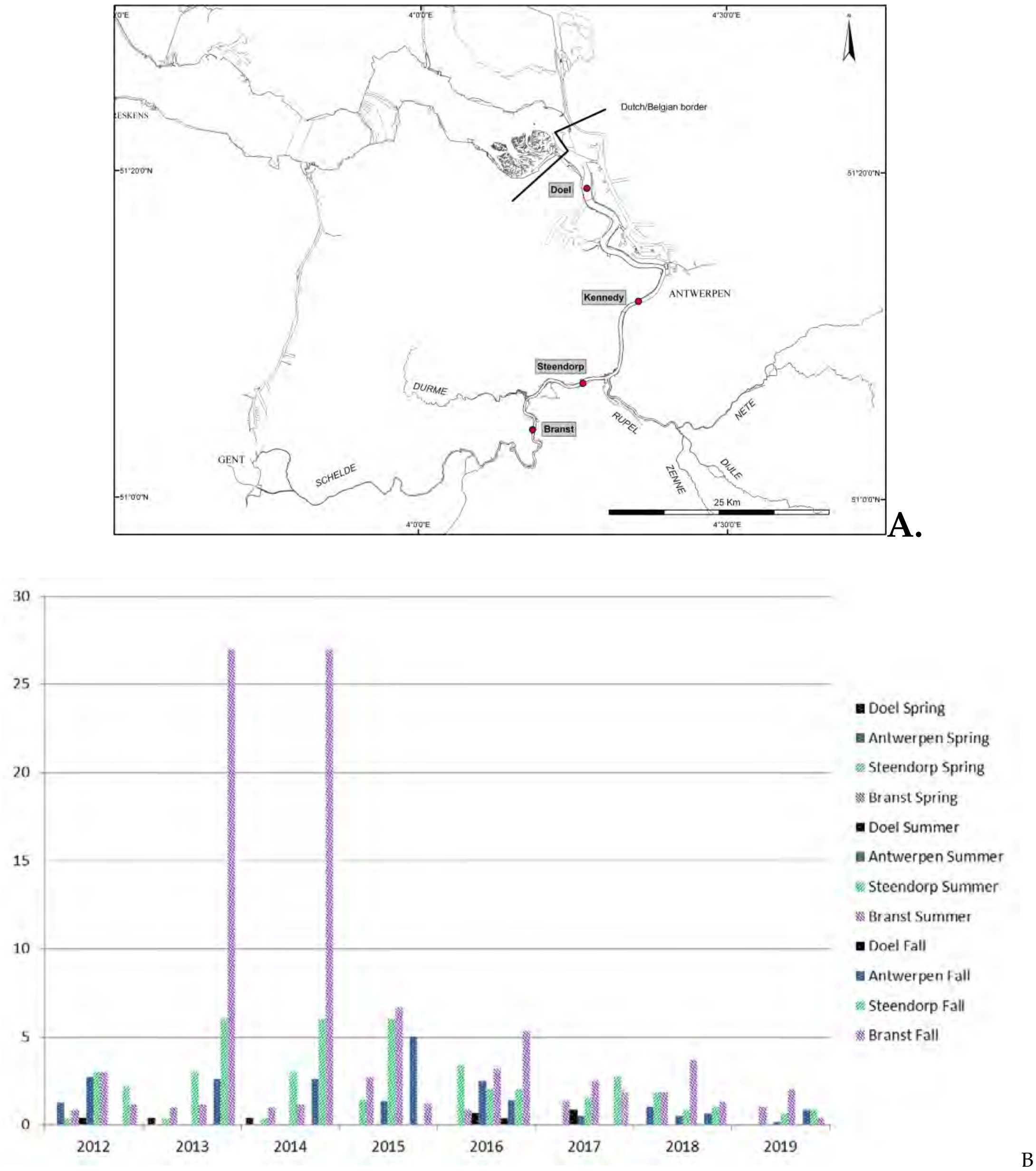

Figure 11. A. Location of the anchor net monitoring sites B. Time trend of catches of eel in a mid-water beam trawl from an anchored boat in Doel, Antwerpen, Steendorp and Branst along the Scheldt River. Numbers are expressed as mean number of eels per hour. Catch data of spring, summer and fall fishing is presented. Data source Jan Breine, INBO, unpublished.

Yellow eel abundance surveys in the Walloon Fish Monitoring Network

The yellow eel abundance surveys in the Walloon Fish Monitoring Network are based on a constant year-to-year sampling effort using a fish pass build in the Belgian Meuse river at Lixhe for the ascending yellow eels from the Dutch Meuse (Nzau Matondo and Ovidio, 2016; Benitez *et al.*, 2019). They also include electrofishing and mobile telemetry in seven rivers (Mosbeux, Hoegne, Wayai, Winamplanche, Berwinne, Gueule and Oxhe) belonging to the Meuse river basin for recruited yellow eels after stocking (Ovidio *et al.*, 2015; Nzau Matondo *et al.*, 2019). These surveys provide information on the wild and stocked eels stocks as well as on their growth, habitat use, sex and dispersal. Histological sectioning as well as an aceto-carmine squash method were used for sexing stocked juvenile eels. They reveal a drastic decline in the recruitment of wild yellow eels in the Meuse basin, while stocked eels re-colonize rivers emptied of wild eels, therefore enhancing the local stock of eels. Sex of stocked eels was observed predominantly female.

5.2 Silver eel escapement surveys

Development of a new permanent monitoring station to estimate silver eel escapement in Flanders

Silver eel escapement from the polder area was estimated at the Veurne-Ambacht pumping station in autumn 2017 and 2018. The Veurne-Ambacht canal, a small artificial waterway (800 m length) used to spill excess water from a ± 20 000 ha polder area into the Yser estuary (Nieuwpoort) by means of a sluice complex. From September until December/January silver eels were caught with fykenets placed permanently in two out of four (2017) or all (2018) gravitary outflow canals from the pumping station until the migration seized at lower (< 4°C) water temperatures. The monitoring campaign from 2017 (half of the passage ways blocked by nets) yielded 450 eels (440 silver eels, 10% males). The 2018 campaign, with all four passage ways blocked by nets, obtained 1163 eels (1132 silver eels, 9.5% males). The 2018 value corresponds to only 9.6% of the expected natural silver eel escapement which matches remarkably well with a modelled estimate (9.46%) based on electric fishery data (2015–2017) of the same area. Migration peaks were obviously triggered by heavy rain events when there is need to drain excess polder water into the estuary and water in the polder area starts to flow.

No escapement data were collected during fall 2019 and 2020. However, Flanders fisheries management services will further investigate the feasibility to develop this site as station to periodically estimate silver eel escapement.

Pop-off data storage tags to reveal marine migration routes of European eel

See under Section 6 for details or preliminary results.

Meta-analysis on European silver eel migration

See under Section 6 for details or preliminary results.

Silver eel migration from the Baltic Sea into the North Sea

See under Section 6 for details or preliminary results.

Silver eel tagging experiments in the Albert Canal (Flanders)

Last year we reported on results of tagging and migration studies at the Albert Canal connecting the Meuse River to the Scheldt Estuary, see Belgian country report 2018 and 2019 (Belpaire *et al.*, 2018; 2019). More results are available now:

Silver eel tracking

Silver eel downstream migration through the Albert canal was investigated using acoustic telemetry in previous research (Verhelst *et al.*, 2018; Vergeynst *et al.*, 2019), as mentioned in the Belgian eel country report 2019 (See under Section 6 of last year's report for the abstracts). Verhelst *et al.* (2018) observed that only one third of the downstream migrating tracked silver eels reached the sea and that they migrated downstream through the shipping canal at a very slow pace. Vergeynst *et al*. (2019) found how eels passed the ship lock complex and how they were delayed. To understand the role of flow in passage success, Vergeynst *et al*. (2020) recently compared the eels' passage routes and movement behaviour with the flow field, which was modelled with a Computational Fluid Dynamics model. Beside the behaviour in close proximity to the ship locks, the authors also investigated eel behaviour in the entire canal pond upstream. They found that in this highly regulated environment, where canal ponds are like water tanks with only small temporary flow outlets at the ship lock complexes, successful downstream migration depends on a complex interplay of intrinsic behaviour and environmental flow conditions. Even if a fish finds these outlets, timing and luck are detrimental factors in its passage success, only to arrive again in another canal pound that lacks cues to the downstream direction most of the time. Successful passage does not guarantee further migration success, because the route through the lock filling system is potentially harmful (Vergeynst *et al*., 2020). The study also revealed that 9% (five out of 58 eels that were detected near the ship lock complex, out of 64 tagged eels released further upstream) of the eels passed the complex via the hydropower plant that is installed in a by-pass channel of the ship lock complex. The harmfulness of the hydropower turbines was investigated in another study (next paragraph).

Eel mortality rate at the hydropower plant of Ham (Kwaadmechelen)

Three of the six ship lock complexes on the Albert canal are equipped with a hydropower plant, generating electricity with three 10 m head Archimedes hydrodynamic screws. Pauwels *et al*. (n.d.) assessed the rate of eel injury and mortality, and the physical conditions during downstream passage of these Archimedes hydrodynamic screws. The injury and mortality rates were investigated with life fish experiments with hatched eels, bream and roach. The averaged mortality rate of eels after forced screw passage was 3%. (This was far lower than the observed mortality rates for the two other investigated species: bream and roach.) The mortality rate is the average over the three rotational speeds of the screw, being 33, 40 and 48 Hz, and three repeating tests per rotational speed. The highest mortality rate observed over all tests performed was 8%, at 48 Hz. Apart from 2% of all recovered eels (dead and alive), dead eels were not externally injured. Internal injuries were not assessed. On average 11% of recovered eels were alive and suffered scratches over less than 25% of their body. Another 15% was alive but contused, and on average 2% was alive but scratched over almost half of their body. If we can assume that these scratches and contusions prevent successful downstream migration and reproduction, then this means that around 17% of all tested eels were lost from the population due to passage of this Archimedes hydrodynamic screw (Pauwels *et al*., (n.d.); Baeyens *et al*., 2019). Assuming that on average 9% of all silver eels which try to pass downstream near the ship lock complexes on the Albert canal pass via the hydropower plant, that around 17% of them are killed or severely injured and that this happens at every of three ship lock complexes being equipped with a hydropower plant, means that 4,5% of all silver eels migrating downstream through the Albert canal are lost from the population due to passage of the hydropower stations.

Assessment of the silver eel escapement in Flanders

Belpaire *et al*. (2018) estimated the biomass of silver eels escaping from Flanders in the framework of the 2018 progress report for the EU Regulation. See for more details Chapter 4.

Silver eel tagging in the River Meuse

An ongoing LIFE16 NAT/BE/000807 “Life4Fish” European Project is studying the downstream migration behaviour of Silver eel in the Meuse between Namur and Lixhe using acoustic telemetry. The aim of the project conducted by Luminus in collaboration with the University of Liege, the University of Namur, EDF RandD and Profish Technology is to analyse the behaviour of the silver eel when facing the different hydropower stations of the Meuse in order to mitigations measures to improve eel survival and meet the requirements of the permits.

The project started in 2017 and will be spread until 2022. The steps of the project can be summarized as follow:

1. Update the stock estimation of silver eels and its sanitary state that will migrate through the six HPP concerned by the project (UNAMUR).
2. Conduct a public tender to select fish behavioural barriers that can be used at a pilot scale to increase eel passage over spillways (Luminus).
3. Develop an eel migration model able to be run as an alarm system directly by operators, to stop turbine production during the main peaks of eel run (EDF RandD).
4. Measure the efficiency of the pilot measures that will be tested using telemetry study, in comparison with the reference state already obtained during a first telemetry survey in 2017–2018 (Profish).
5. Select the best solutions observed and deployed them among the entire river stretch concerned in order to reach a survival rate higher than 80% for the entire eel stock passing through the 6 HPP (all partners).
6. Perform a final telemetry study to verify that the eel protection target has been achieved (Profish).

Not mentioned in these actions, ULIEGE is also involved in development of surface bypass design and adapted spillage mainly targeting salmon smolts, by the use of hydraulic numerical and physical (small scale) models.

In mid-2020, the project just finished the pilot test of mitigation measures on different sites. In Namur HPP, an electrical fish fence has been tested; in Andenne HPP, the eel prediction model associated with turbine shutdown has been tested (Teichert *et al*., 2020); in Ivoz-Ramet HPP, a bubble curtain has been tested.

The reports of efficiency are being under analysis and are not yet available, but two years of telemetry (2017–2018 N = 150; 2019–2020 N = 140) brought lot of new insights relative to the silver eel migration in the Meuse. The concerned reports are being validated by the partners and will be published soon on a new web platform that will be dedicated to the LIFE4FISH project.

5.3 Life-history parameters

All eel which are caught by INBO during the Flemish fish Monitoring Network are measured and weighed, and after validation entered in a database. All data are available at https://vis.inbo.be/.

Belpaire *et al*. (2018) calculated the length–weight relationship in Flanders for 7093 eels captured through electrofishing and fyke fishing in Flanders in the period 2015–2017 (see also Belgian Country Report 2018 for a figure).

5.4 Diseases, Parasites and Pathogens or Contaminants

Diseases and parasites

With respect to diseases and parasites no new information is available (But see Bourillon *et al.*, 2020, Chapter 6). We refer to the 2015 country report (Belpaire *et al.*, 2016a) for the latest information.

Contaminants

Contaminants in silver eel

A paper was published reviewing the impact of chemical pollution on Atlantic eels, including a discussion on research needs, and implications for management (Belpaire *et al.*, 2019, see Section 6 for the abstract).

Belgium cooperated to the paper of Bourillon *et al.* (2020) where 482 silver eels from 12 catchments across Europe were analysed for three aspects of eel quality: muscular lipid content (N=169 eels), infection with *Anguillicola crassus* (N=482), and contamination by persistent organic pollutants (POPs, N = 169) and trace elements. Eels from Belgian river Scheldt were most impacted by agricultural and construction activities, PCBs, coal burning, and land use. See chapter 6 for more details on the paper.

Measuring contaminants in eel for implementation of the Water Framework Directive

Here, we summarize the results of the general findings and trends of a four-year monitoring campaign (2015–2018) set up to fulfil the requirements of the Water Framework Directive (Biota Monitoring Flanders (Belgium)) (Teunen *et al.*, 2020).

Surface waters and aquatic ecosystems are under constant pressure of chemical pollution, mainly of anthropogenic origin. Chemical pollutants in the environment may, in high concentrations, be harmful to aquatic ecosystems, causing habitat loss and a decrease in biodiversity. Additionally, they may be toxic to humans. The European Water Framework Directive forces member states to monitor pollutants in surface waters and defined environmental standards (EQS) for a number of priority compounds. These EQS were created in order to protect the environment against detrimental effects of pollution. Most chemical pollutants can be measured in water or sediment samples. A set of strong hydrophobic/lipophilic components are, however, difficult to measure in water due to their poor solubility. Additionally, they are strongly bio accumulative. Via bio magnification very high concentrations can be reached in higher trophic levels. Accordingly, the European Commission created environmental standards for biota (biota EQS) for eleven priority compounds and their derivatives (Directive 2013/39/EG). Depending on the compound, they need to be measured in fish and/or fresh water bivalves.

During biota monitoring field studies conducted between 2015 and 2018, the bioaccumulation of hexachlorobenzene (HCBz), hexachlorobutadiene (HCBd), mercury (Hg), brominated difenylethers (PBDE), hexabromo-cyclododecane (HBCD), perfluoro-octanesulfonate (PFOS), dicofol, heptachlor and heptachlorepoxide, and dioxins and dioxin-like compounds in muscle tissue of European perch (*Perca fluviatilis*) and eel (*Anguilla anguilla*), collected at 44 sampling locations in Flanders was measured. Additionally, PCBs were measured in these samples. PAHs were measured in bivalves.

PBDE (97%) and mercury (100%; Figure 12) exceeded their respective biota EQS in almost all sample locations. Furthermore, many exceedances were recorded for PFOS (76%) and dioxins in eel (69%). As for HCBz, HBCD, HCBd, heptachlor (0%>LOQ) and dioxins in perch less than 1% exceedances were detected. The human consumption standards for PCBs and dioxins in eel were exceeded in respectively 51 and 37.5% of the Flemish waterbodies.

The rivers Zenne, Demer and several parts of the Scheldt showed high pollution levels for several compounds. For most compounds, the highest pollutant concentrations were measured in eel (compared to perch). For PFOS the opposite was true, possibly caused by the high protein affinity of perfluors. A correction based on lipid content in both fish species resulted in comparable concentrations (for HCBz and HBCD) or significant higher concentrations in perch compared to eel (for Hg, PBDE, PFOS and PCB's). All pollutants showed a strong correlation between both fish species, allowing extrapolation of concentrations between perch and eel.

Concentrations in water and sediment did not show a significant relation with concentrations in biota for most pollutants. Furthermore, for a lot of the pollutants, those environmental concentration were below detection limit.

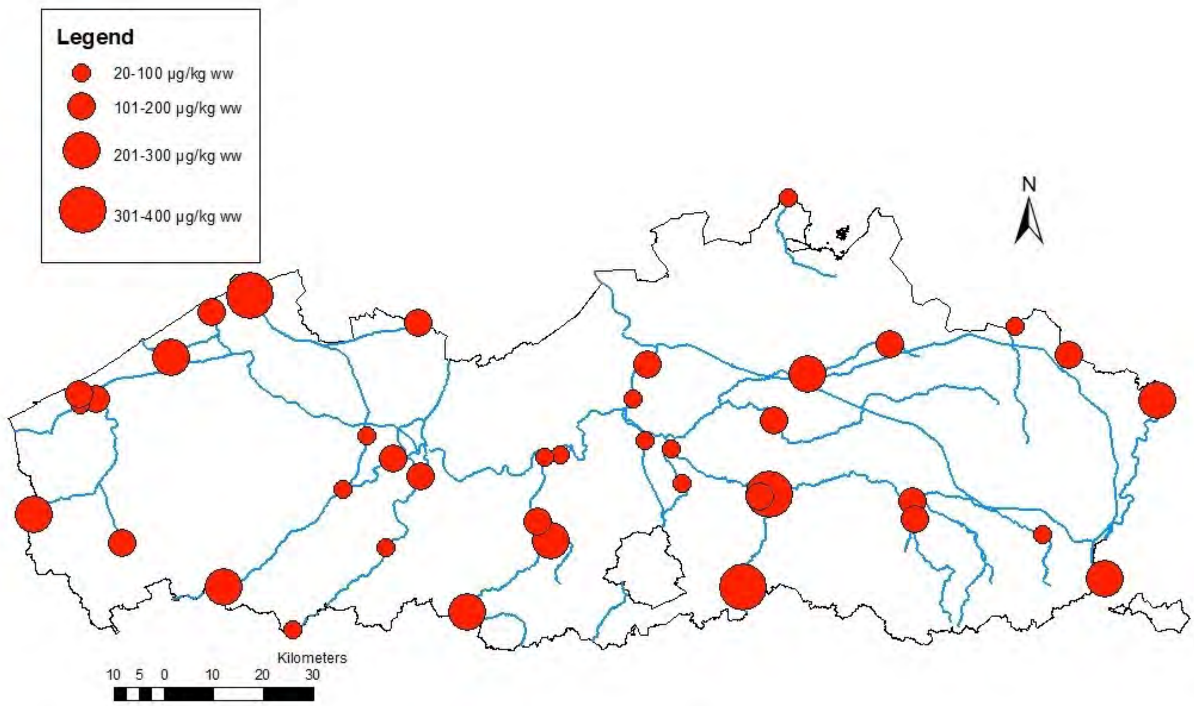

Figure 12. Map with exceedance of the biota EQS for Hg in eel on different sampling locations in Flanders (Belgium). The size of the red dots indicates the range of concentrations measured at that specific location. The biota EQS for Hg equals 20 µg kg-1 ww.

Contaminants in eel versus otter restoration

Two new reports (in Dutch) were published on the relation between the eco-toxicological quality of eels and the restoration of the otter in Flanders (Van Den Berge *et al.*, 2019 and Vandamme *et al*, 2019).

Until 1950, the Eurasian otter (*Lutra lutra*) was present in most parts of Belgium, but due to the hunting in combination with water contamination and loss of suitable habitat (riverbanks) in the 1970–1980s, the otter disappeared almost completely. In Flanders, the last otter population went extinct at the end of the 1980s. From 2012 on, however, otter were again observed in a few locations, and recent observations were suggesting local reproduction. The otter is a highly demanding species, that requires a good water quality, healthy fish populations and well-structured riverbanks. The study suggested that high concentrations of bio-accumulating contaminants present in food organisms like eel, such as PCB’s, dieldrin and mercury, however, hamper the conservation or recovery of Eurasian otter populations. Areas with high concentrations of these pollutants in fish are incapable of supporting a sustainable otter population (Van Den Berge *et al*., 2019).

In another more area-specific study, assessing the eco-toxicological burden of eel and other prey fish in the focus area of the existing otter population, revealed that the current levels of mercury and PCBs in prey fish (and especially in eel) seem to stand in the way of the development of a sustainable otter population for the time being (Vandamme *et al*., 2019).

6 New information

New papers published

New paper. De Meyer, J., P. Verhelst, and D. Adriaens. 2020. 'Saving the European eel: How morphological research can help in effective conservation management', Integrative and comparative biology. Doi: 10.1093/icb/icaa004

Understanding the European eel's morphology can play an important role in function of management measures, as functional morphological studies provide useful insights on how species perform behaviours that are vital for survival, such as feeding and locomotion. In addition, they allow us to evaluate how environmental changes can affect or limit such crucial behaviours. Consequently, when making conservation decisions, functional morphology represents an important component that should be taken into account. Hence, in this paper, an overview is given of studies on the eel's morphology that demonstrate both its relation with ecology and behaviour, but are also relevant for developing and installing specific management measures.

New paper. Steendam, C., Verhelst, P., Van Wassenbergh, S. and De Meyer, J. 2020. Burrowing behaviour of the European eel (*Anguilla anguilla*): effects of life stage. Journal of Fish Biology (in press)

Even though the European eel is known to be a burrowing species, little is known about this behaviour. Simultaneously, insights in the burrowing behaviour, such as substrate preference and burrowing performance, might provide useful information for conservation. In this study, substrate preference and burrowing performance was evaluated in three life stages: glass, elver and yellow eel, with the latter stage being subdivided in three size classes. Glass and elver eels prefer coarse gravel (diam. > 8 mm) over fine gravel (1–2 mm) and sand, as they can swim through the gaps between the grains. For actual burrowing behaviour, eels of all life stages preferred fine gravel over sandy substrates. Accordingly, burrowing efficiency was also highest in these fine gravel substrates (lower burrowing duration, less and/or lower frequency of body movements), indicating that eels chose the substrate that is most efficient for burrowing. In addition, burrowing performance increased with body size as well, with glass eels requiring more body undulations than yellow eels. Surprisingly, this increase in performance does not corroborate with the urge to hide, as this decreased with body size; glass and elver eels always hid into the substrate, whereas yellow eels showed less burrowing activity with increasing body size. This study thus provides novel information about the eel's behaviour and possible habitat use, which can contribute in developing more efficient conservation measures.

New paper. Baan J, De Meyer J, De Kegel B, Adriaens D. From yellow to silver: Transforming cranial morphology in European eel (*Anguilla anguilla*). J. Anat. 2020; 00:1–9. **https://doi.org/10.1111/joa.13259**

Upon migration towards the Sargasso Sea, the European eel undergoes a final transformation from yellow to silver eel, a process known as silvering. This process goes along with drastic changes, such as an increase of eye size, an elongation of the pectoral fins and a thickening of the skin. However, what changes take place in the cranial musculoskeletal system has not been evaluated yet. With 3D-reconstructions, we evaluated whether and how the system changes from yellow to silver eel, with eye size being used as a proxy for the silver stage. We show that size-corrected muscle volumes increase during silvering, associated with an increase in bite force, although these trends are insignificant. A significant increase was, however, found in the respiratory muscle sizes. A better performing respiratory system could be beneficial during the eel's long migration, which can include deep and potentially oxygen-poor environments. Finally, we observe that the overall skull dimensions and especially orbit size increase during silvering as well, which might be necessary to accommodate the larger eyes. In addition, we compared artificially matured eels with wild silver eels, with the latter having a narrower, less tall skull as well as smaller jaw muscles, which could be a side-effect of the hormonal injections of the artificially matured eels or be part of the natural maturation process as the wild silver eels had a lower eye index than the artificially matured eels.

New paper. Billy Nzau Matondo, Jean -Philippe Benitez, Arnaud Dierckx , Xavier Rollin and Michaël Ovidio, 2020. An Evaluation of Restocking Practice and Demographic Stock Assessment Methods for Cryptic Juvenile European Eel in Upland Rivers. Sustainability 12, 1124; doi:10.3390/su12031124.

Restocking of the critically endangered European eel *Anguilla anguilla* is widespread, but it is rarely scientifically evaluated. Methods used to assess its associated performance by estimating the survival rate and implement restocking for maximum recruitment in rivers have not yet been investigated. Based on two glass eel restocking events using a single release site/point and multiple sites per river performed in upland rivers (>340 km from the North Sea), the recruitment success of stocked eels was scientifically evaluated during a 3-year study using multiple capture-mark–recapture methods and mobile telemetry. We compared the observed data with the data estimated from the Telemetry, De Lury and Jolly-Seber stock assessment methods. For recruitment data, Telemetry was very close to Jolly-Seber, an appropriate stock assessment method for open populations. Using the best model of Jolly-Seber, survival probability was higher (>95%) in both restocking practices, but recruitment yields were higher and densities of stocked eels were lower in multiple sites compared to a single site. Our results suggest that Telemetry can help to rapidly assess cryptic juvenile eel stocks with good accuracy under a limited number of capture-mark–recapture sessions. Artificial dispersal of glass eels on several productive habitats/sites per river appears to be the better-suited practice for restocking.

New paper. Jenna Vergeynst, Ine Pauwels, Raf Baeyens, Ans Mouton, Tom De Mulder, Ingmar Nopens, 2020. Shipping canals on the downstream migration route of European eel (*Anguilla anguilla*): Opportunity or bottleneck? Ecology of Freshwater Fish https://doi.org/10.1111/eff.12565

Migrating fish species are worldwide in decline due to several global changes and threats. Among these causes are manmade structures blocking their freshwater migration routes. Shipping canals with navigation locks play a dual role in this. These canals can serve as an important migration route, offering a short cut between freshwater and the sea. In contrast, the navigation locks may act as barriers to migration, causing delays and migration failures. To better understand these issues for downstream migrating fish, we studied the behaviour of European eels (*Anguilla anguilla*) in the Albert Canal at two scales. The mid-scale contained a 27 km canal pound confined by two navigation lock complexes, in which we released and tracked 86 silver eels. The small scale was a 200 × 150 m area just in front of the most downstream complex of the canal pound, where we analysed the behaviour of 33 eels in relation to the flow field resulting from a computational fluid dynamics (CFD) model. This paper discusses the factors influencing fish behaviour, and the relation between these behaviours on both scales. On the mid-scale, migration efficiency resulted from a combination of intrinsic behaviour and flow in the canal pound. Also on the small scale, intrinsic behaviour influenced the success to pass the navigation lock. Increasing the flow would create more attraction and passage opportunities and hence facilitate migration through shipping canals, but only if this flow guides the fish through safe passage routes.

New paper. Bastien Bourillon, Anthony Acou, Thomas Trancart, Claude Belpaire, Adrian Covaci, Paco Bustamante, Elisabeth Faliex, Elsa Amilhat, Govindan Malarvannan, Laure Virag, Kim Aarestrup, Lieven Bervoets, Catherine Boisneau, Clarisse Boulenger, Paddy Gargan, Gustavo Becerra-Jurado, Javier Lobón-Cerviá, Gregory E. Maes, Michael Ingemann Pedersen, Russell Poole, Niklas Sjöberg, Håkan Wickström, Alan Walker, David Righton, Éric Feunteun, 2020. Assessment of the quality of European silver eels and tentative approach to trace the origin of contaminants – A European overview. Science of the Total Environment, 743, 140675. https://doi.org/10.1016/j.scitotenv.2020.140675.

The European eel is critically endangered. Although the quality of silver eels is essential for their reproduction, little is known about the effects of multiple contaminants on the spawning migration and the European eel management plan does not take this into account. To address this knowledge gap,we sampled 482 silver eels from 12 catchments across Europe and developed methods to assess three aspects of eel quality: muscular lipid content (N=169 eels), infection with *Anguillicola crassus* (N=482), and contamination by persistent organic pollutants (POPs, N = 169) and trace elements (TEs, N = 75).We developed a standardized eel quality risks index (EQR) using these aspects for the subsample of 75 female eels. Among 169 eels, 33% seem to have enough muscular lipids content to reach the Sargasso Sea to reproduce. Among 482 silver eels, 93% were infected by *A. crassus* at least once during their lifetime. All contaminants were above the limit of quantification, except the 1,2 bis (2,4,6-tribromophenoxy)ethane (BTBPE), Ag and V. The contamination by POPs was heterogeneous between catchments while TEs were relatively homogeneous, suggesting a multiscale adaptation of management plans. The EQR revealed that eels from Warwickshire were most impacted by brominated flame-retardants and agricultural contaminants, those from Scheldt were most impacted by agricultural and construction activities, PCBs, coal burning, and land use, while Frémur eels were best characterized by lower lipid contents and high parasitic and BTBPE levels. There was a positive correlation between EQR and a human footprint index highlighting the capacity of silver eels for biomonitoring human activities and the potential impact on the suitability of the aquatic environment for eel population health. EQR therefore represents a step forward in the standardization and mapping of eel quality risks, which will help identify priorities and strategies for restocking freshwater ecosystems.

Ongoing or new projects

Meta-analysis on European silver eel migration

All over Europe, telemetry studies have and are been conducted to reveal migration routes and the migration behaviour of seaward migrating silver eels. The rationale behind these studies can be fundamental insight, but often involve applied research related to habitat restoration and overcoming migration barriers. In this pan-European study, we brought together telemetry data on European silver eels from 19 projects/locations and nine countries (number of projects/locations between brackets per country): Belgium (five), Denmark (one), France (three), Germany (one), Lithuania (one), Norway (one), Portugal (one), The Netherlands (three) and the UK (three). This was done under the framework of the European Tracking Network (ETN, http://www.lifewatch.be/etn/). The ETN aims at delivering multiple benefits for the scientific community: (1) detecting animals on telemetry networks beyond a specific research area (especially when acoustic telemetry is involved), (2) a proper tool to manage and analyse your data and (3) creating a scientific social network of telemetry scientists. Bringing together silver eel telemetry data from freshwater and transitional systems all over Europe allows to conduct a meta-analysis on the migration behaviour. In this meta-analysis, the migration speeds will be linked with spatio-temporal resolutions and biometric measurements (e.g. size and sex) to reveal important insights in how the migration is orchestrated in relation to the spawning period. Furthermore, comparing migration speeds between systems with different anthropogenic stressors can reveal their relative impacts on the migration behaviour and speed. The results of this study not only contribute to the fundamental knowledge of the species, but will aid conservation through translation into management.

Pop-off data storage tags to reveal marine migration routes of European eel (update of 2019 report)

The migration routes of European eel have mainly been deduced and studied in freshwater and estuarine systems, yet, their routes in marine environments remain elusive. Nonetheless, improving our knowledge on that front could reveal important aspects of the life cycle since the largest part of their migration is fulfilled in the marine environment. Tracking silver eels from the Southern North Sea into the Atlantic will expose how eels handle the dynamic hydrology of the English Channel. For instance, if eels apply selective tidal stream transport as they do in estuaries or already start with diel vertical migration. Data is obtained via the tagging of eels with pop-off data storage tags in the Veurne-Ambacht Canal (Nieuwpoort, Belgium) and the Rivers Elbe and Eider (Germany) with an additional two datasets from pop-off satellite archival tags from the River Eider. In Belgium, 102 eels have been tagged in 2018, another 60 in 2019 and this year 70 more will be tagged. In Germany 82 eels were tagged in 2011 and 2012. This study is a collaboration between Ghent University (Belgium), Centre for Environment, Fisheries and Aquaculture Science (UK), Flanders Marine Institute (Belgium), the Research Institute for Nature and Forest (Belgium), Swedish University of Agricultural Sciences (Sweden), Institute of Inland Fisheries Potsdam Sacrow (Germany) and the Thünen Institute of Fisheries Ecology (Germany).

Silver eel migration from the Baltic Sea into the North Sea

DTU Denmark (Professor Kim Aarestrup and Dr Martin Lykke Kristensen) and Ghent University have tagged 70 silver eels with acoustic transmitters and pop-off data storage tags in 2019 to identify the migration routes and behaviour of eels migrating from the Baltic Sea into the North Sea. Not only will the results illustrate how the eels change behaviour when moving from the relative shallow, hydrologically low-dynamic Baltic Sea into the deeper waters along the coast of southern Sweden and Norway, information may be revealed on the capture rate by commercial fishing. Additionally, since eels were single (either acoustic or pop-off data storage tag) or double tagged (acoustic and pop-off data storage tag) a comparative study can be conducted on the effect of external pop-off data storage tag attachment on the progression speed by the eels.

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