Country Reports 2018-2019: Eel stock, fisheries and habitat reported by country

In preparation for the Working Group, participants of each country have prepared a Country Report, in which the most recent information on eel stock and fishery is presented. These Country Reports aim at presenting the best information that does not necessarily coincide with the official status.

Participants from the following countries provided an updated report to the 2019 meeting of the Working Group on Eels:

- Belgium
- Denmark
- Estonia
- Finland
- Germany
- Greece
- Ireland
- Italy
- Latvia
- Lithuania
- Netherlands
- Norway
- Poland
- Portugal
- Spain
- Sweden
- The United Kingdom of Great Britain and Northern Ireland

For practical reasons, this report presents the Country Reports in electronic format only (URL).

Country Reports 2018/2019

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

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Reporting Period: This report was completed in August 2019, and contains data up to 2019.

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 last WG EEL 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.**

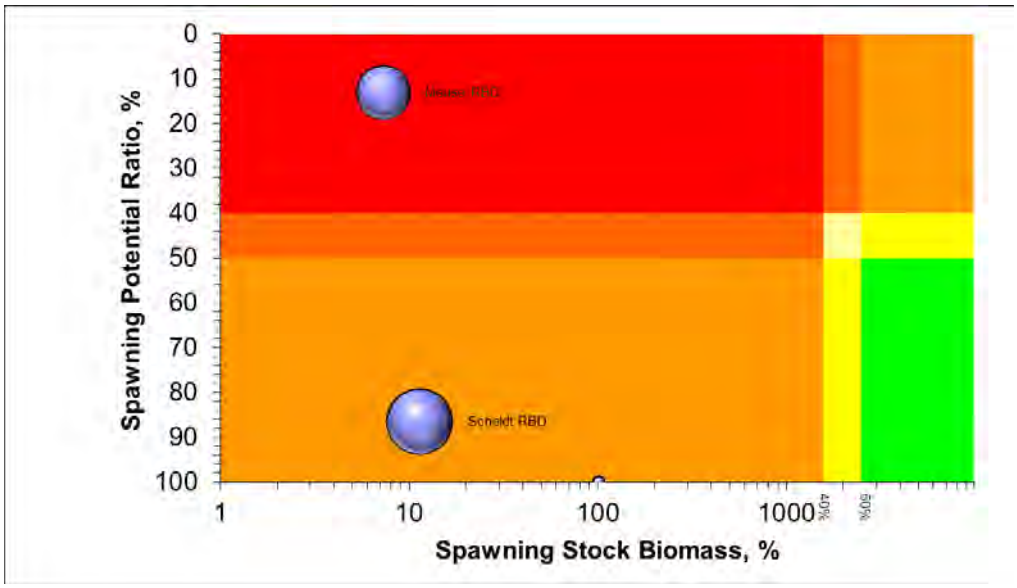


Figure 1. Precautionary Diagram for Belgium.

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 **a new permanent monitoring station to estimate glass eel recruitment in Flanders is available at the Veurne-Ambacht pumping station**.

We include here also data from a new station where glass eel recruitment recently was quantified. The site is located on the Caemerlinckxgeleed migration barrier (Oostende, Flanders). It has the potential to also be included as a future monitoring 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 2019.

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, minimum 252–maximum 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, minimum 252–maximum 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, minimum 252–maximum 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, minimum 252–maximum 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 17815 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 eleven 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. ten 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).

Table 2. Total year catches (kg) between 1964 and 2018. 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.

Decade Year	1960	1970	1980	1990	2000	2010
0		795	252	218.2	17.85	0.318
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

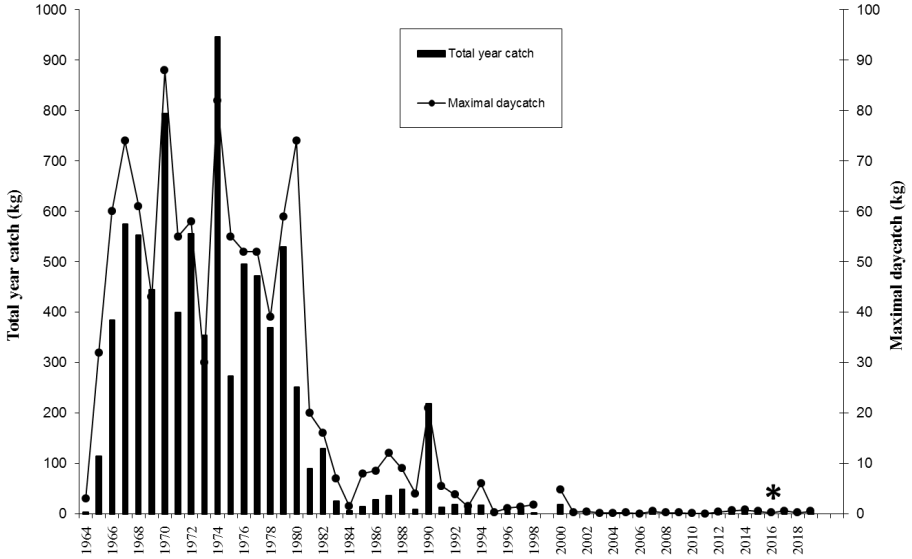


Figure 2A. Annual variation in glass eel catches at river Yser using the dipnet catches in the ship lock at Nieuwpoort (total year catches and maximum day catch per season), data for the period 1964–2018. * The data for 2016 are incomplete and not representative, due to technical problems at the sluices,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

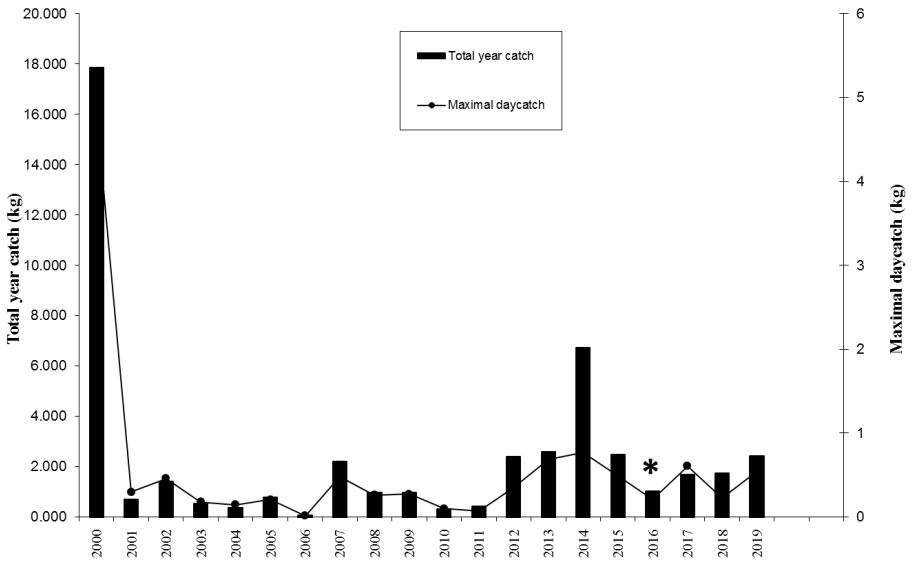


Figure 2B. Annual variation in glass eel catches at river Yser using the dipnet catches in the ship lock at Nieuwpoort (total year catches and maximum day catch per season), data for the period 2000–2018. * The data for 2016 are incomplete and not representative, due to technical problems at the sluices,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

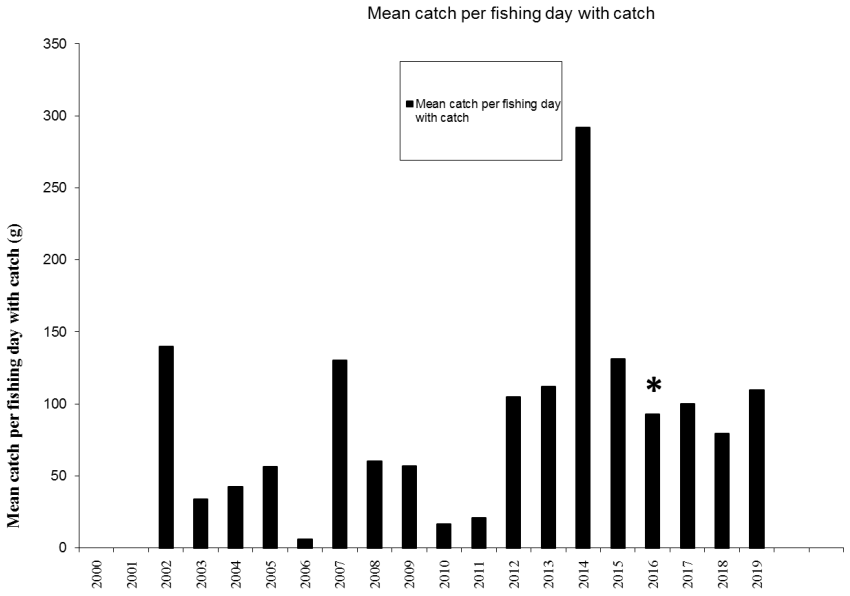


Figure 2C. Annual variation in glass eel catches at river Yser using the dipnet catches in the ship lock at Nieuwpoort) expressed as mean catches per fishing day with catch in g. * The data for 2016 are incomplete and not representative, due to technical problems, and should not be used for statistical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

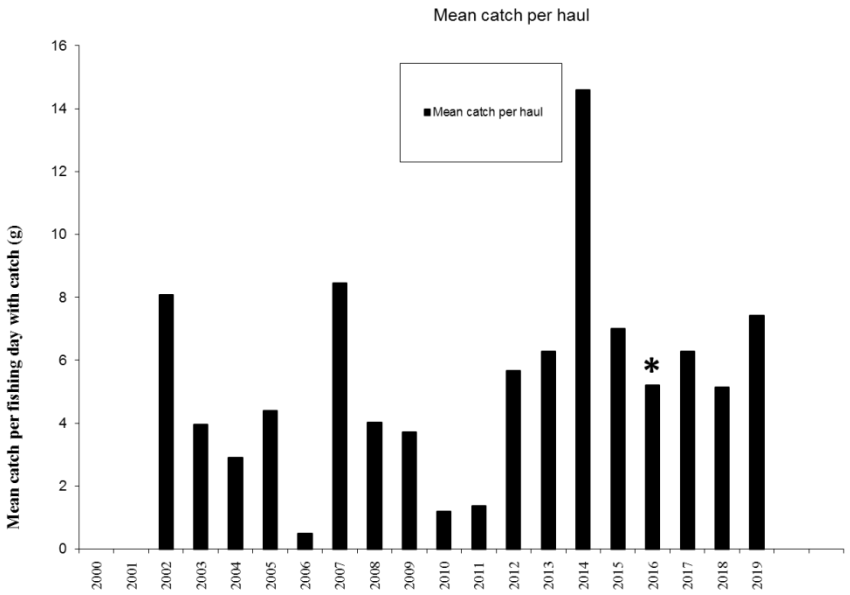


Figure 2D. Annual variation in glass eel catches at river Yser using the dipnet catches in the ship lock at Nieuwpoort), expressed as the mean catches per haul in g. * The data for 2016 are incomplete and not representative, due to technical problems, and should not be used for statistical purposes,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

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.

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

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 & 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 individuals in 2019). Catches are presented in Table 4.

Table 4. Temporal trend in catch per unit of effort for the glass eel monitoring at the at the Veurne-Ambacht pumping station (2016–2019, 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

*** 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.**

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).

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 was 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.

In 2019 up to 16 August, 73 eels were caught, of which 40 were wild individuals (biomass 4070 g, size range 30.5–60.1 cm, median 39.8 cm) and 33 were individuals from the 2018 restocking (biomass 415 g, size range 13.1–29.3 cm, median 18.8 cm). Maximum CPUE was six and 19 individuals per day for stocked eels and wild eels, respectively.

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.

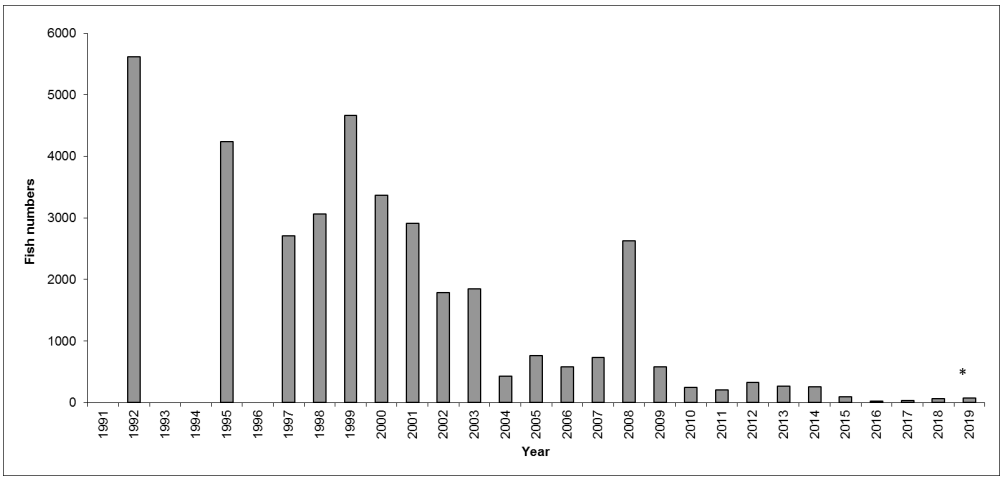


Figure 3. Variation in the number of ascending young yellow eels trapped at the fish trap of the Visé-Lixhe dam between 1992 and 2019. Data from University of Liège (Nzau Matondo *et al*., 2015; Nzau Matondo and Ovidio, 2016). * Data for 2019 (n=73) include wild eels (n=40) and stocked eels (n=33), and 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 2019. 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 2019 (n=73) include wild eels (n=40) and stocked eels (n=33), and may be incomplete. Only the 40 figure was submitted to the international database for further analysis.

Decade Year	1990	2000	2010
0		3365	249
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	73*

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*., 2018), 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 river bank 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 individuals caught), the majority (98%) during night-time. In contrast and counterintuitive to common knowledge, also 570 individuals passed the barrier during tidal fall, again mainly during night-time (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.

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 and 62 143 in 2018. 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 till 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.

A recent 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 waterbodies 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).

Within a few years a new inquiry will be held among anglers in order to determine if this measure has an impact on the total harvest of eel.

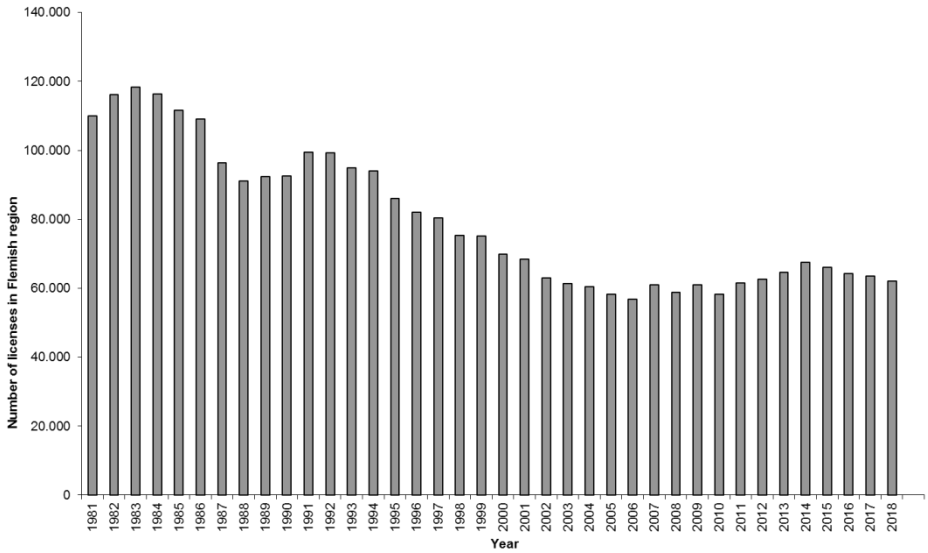


Figure 4. Time-series of the number of licensed anglers in Flanders since 1981 (Data Agency for Nature and Forests).

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 our 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 license 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 and 62 581 in 2018 (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 amounts of illegal fishing equipment 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.

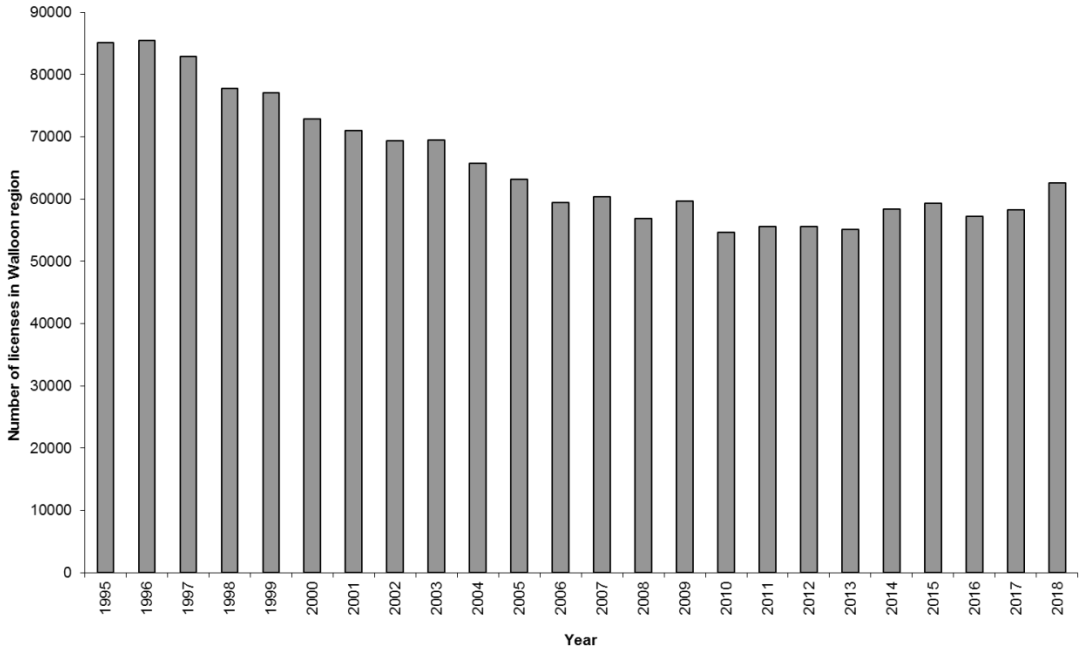


Figure 5. Time-series of the number of licensed anglers in Wallonia since 1995 (Data : Nature and Fish Service of the Nature and Forests Department (DNF - DGARNE - SPW)).

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 waterbodies. 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 company (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 fulfilment 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).

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.

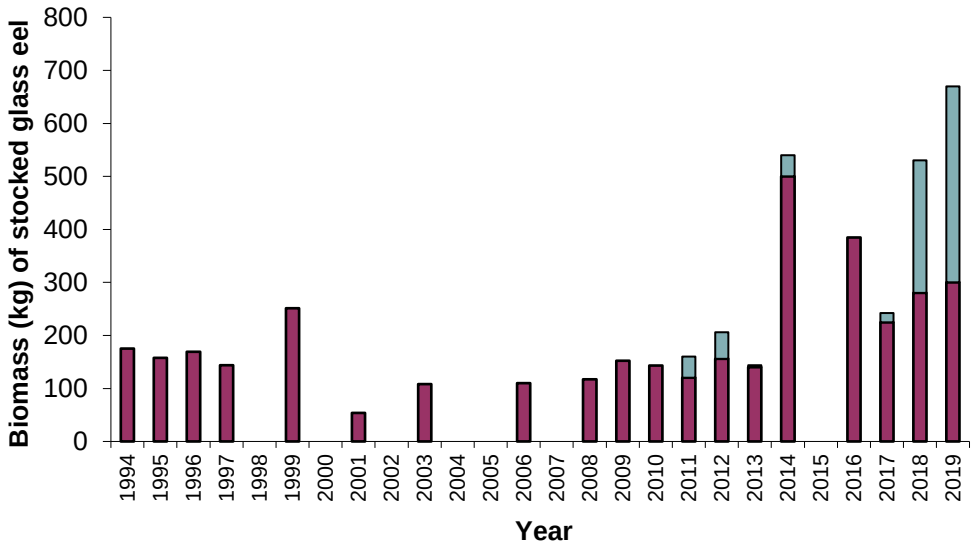


Figure 6 and Table 6. Restocking of glass eel in Belgium (Flanders and Wallonia) since 1994, in kg of glass eel. Flanders is represented in red and Wallonia in blue in the figure. * left Flanders/right Wallonia.

Decade Year	1980	1990	2000	2010
0			0	143
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 (2008–2019).

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)

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 3 small rivers in the context of a research program led by the University of Liège. This research program was financed by European fisheries Fund (EFF, project code 32-1102-002) to test the efficiency of glass eel restocking in waterbodies 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 re-

cruitment 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 six rivers (Hoegne, Wayai, Winamplanche, Berwinne, Gueule and Oxhe). Glass eels were released in 43 sites (Hoëgne: 3.9 kg in six sites; Wayai: 3.6 kg in ten sites; Winamplanche: 0.6 kg in five sites; Berwinne: 4.0 kg in eleven sites; Gueule: 4.3 kg in ten sites and Oxhe: 1 kg at one site). These rivers were both hydromorphologically and physicochemically different. Assessments conducted after restocking at 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 in 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).

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.

Table 8. Origin and amounts of glass eel restocked in Belgium (Flanders and Wallonia) between 2008 and 2018.

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

*** 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.**

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.

3.5 Habitat Quantity and Quality

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

3.6 Other impacts

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

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 makes 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 and 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.

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.

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 program for the water Framework Directive. See 2016 country report report (Belpaire *et al*., 2016b) for a preliminary assessment of electrofishing and fykefishing 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 fykefishing 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 till summer 2019.

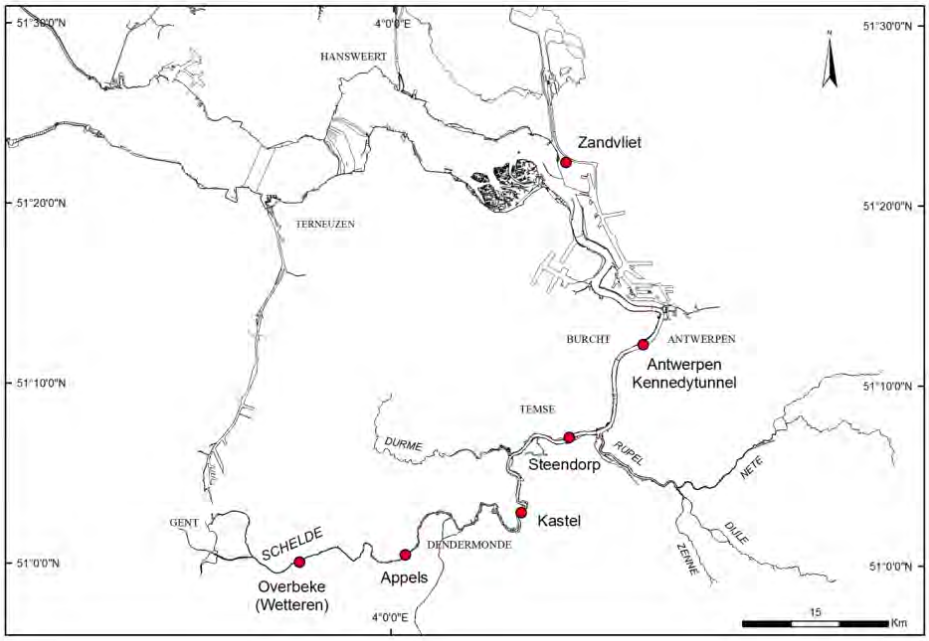


Figure 7. Locations sampled in the Zeeschelde estuary.

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).

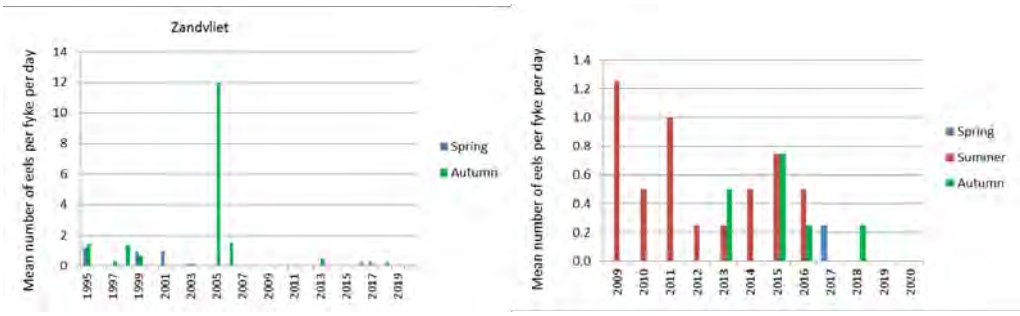


Figure 8. Time trend of fyke catches of eel in Zandvliet. Numbers are expressed as mean number of eels per fyke per day. Left, data are split up in spring catches and fall catches (1995–2019) while right, summer catches are added (2009–2019). Years without monitoring data are excluded from the X-axis.

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.

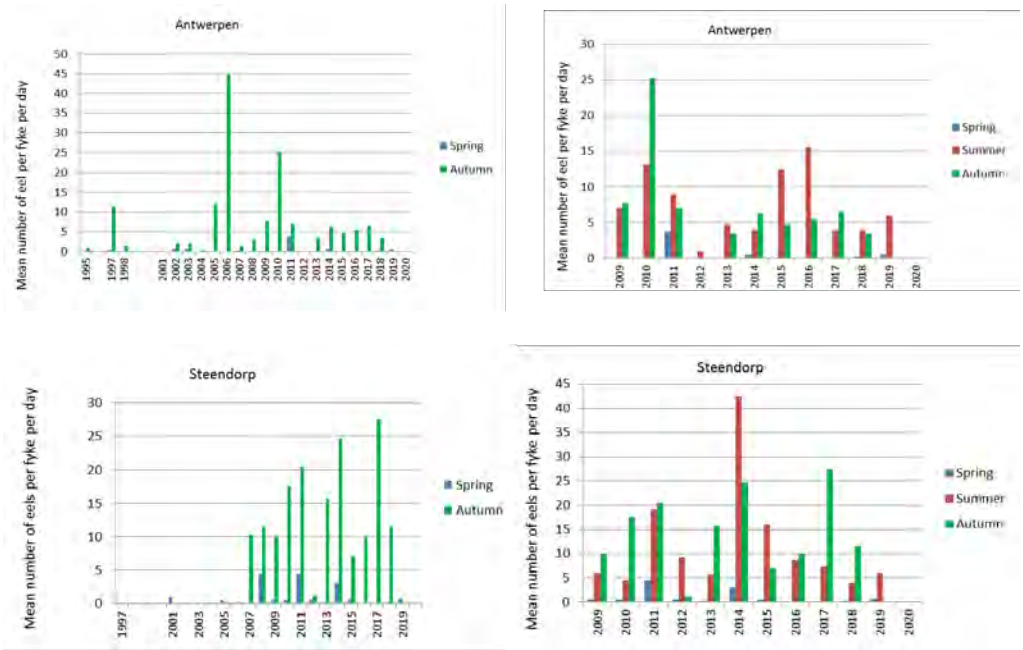


Figure 9. Time trend of fyke catches of eel in Antwerpen and Steendorp. Numbers are expressed as mean number of eels per fyke per day. On the left, data are split up in spring catches and fall catches (1995–2019) while on the right, summer catches are added (2009–2019). Years without monitoring data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

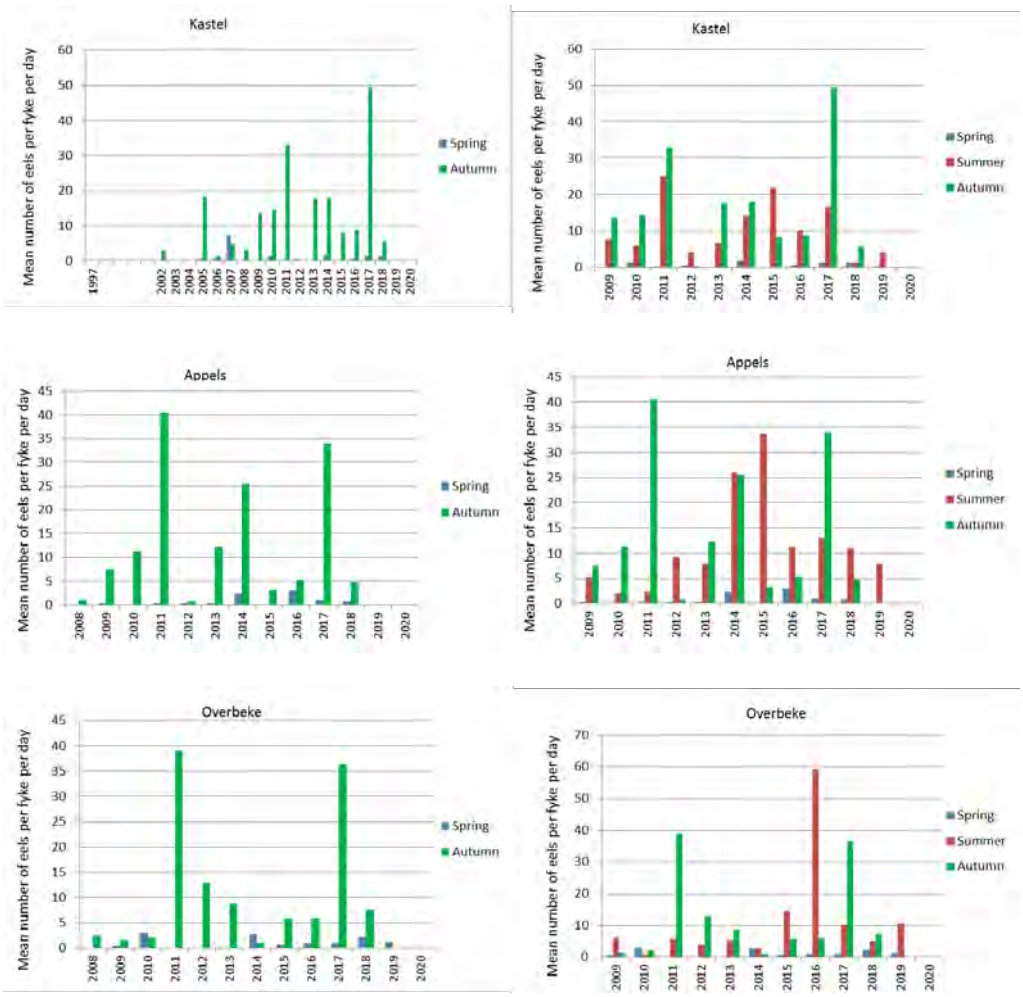
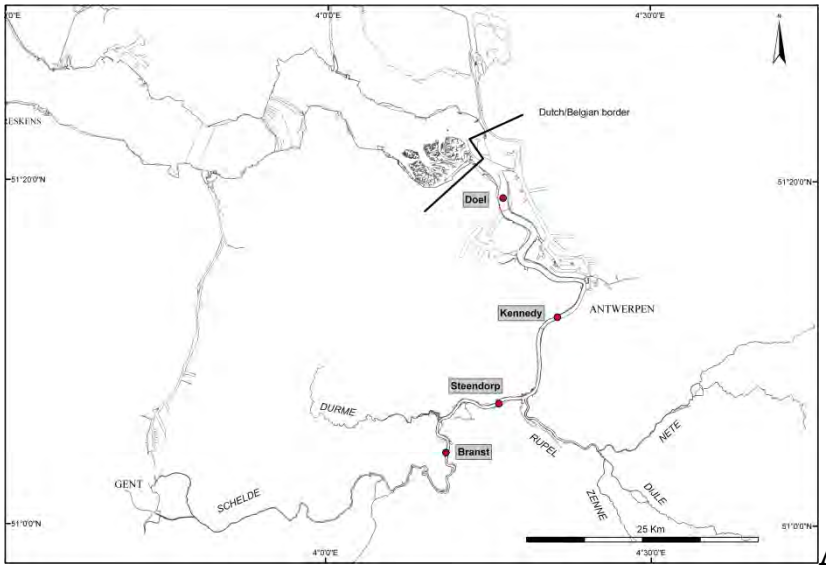


Figure 10. Time trend of fyke catches of eel in Kastel, Appels and Overbeke. Numbers are expressed as mean number of eels per fyke per day. On the left, data are split up in spring catches and fall catches (1997 or 2008–2019) while on the right, summer catches are added (2009–2019). Years without monitoring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



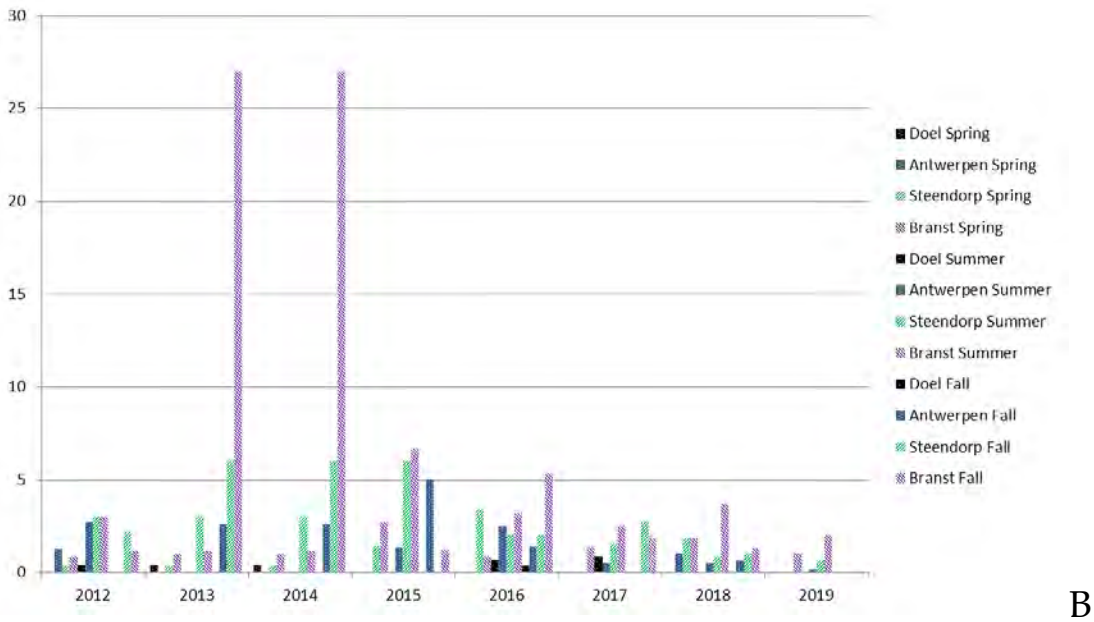


Figure 11. A. Location of the anchor net monitoring sites B. Time trend of catches of eel in a mid-water beam trawl from an anchored boat in Doel, Antwerpen, Steendorp and Branst along the Scheldt River. Numbers are expressed as mean number of eels per hour. Catch data of spring, summer and fall fishing is presented (except for 2019 including only spring and summer data). 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 and dispersal. 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.

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.

Silver eel tagging in the River Scheldt estuary and in the North Sea

Last year we reported on results of tagging and migration studies published by Huisman *et al*. (2016) and by Verhelst *et al*. (2018), see Belgian country report 2018 (Belpaire *et al*., 2018).

Some projects are still ongoing. See under Section 6 "**Ongoing project.** Pop-off data storage tags to reveal marine migration routes of European eel" and **Ongoing project**. Meta-analysis on European silver eel migration.

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 (Belpaire *et al*., 2018).

Some work has been published now (Vergeynst *et al*., 2018; Vergeynst *et al*., 2019). See under Section 6 for the abstracts.

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 Andenne and Lixhe using acoustic telemetry. The aim of the project conducted by EDF-Luminus in collaboration with the University of Liege, the University of Namur and Profish Technology is to analyse the behaviour of the silver eel when facing the different hydropower stations of the Meuse in order to place bypass and protection systems to improve the rate of safe passages.

5.3 Life-history parameters

All eels 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 fykefishing 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. We refer to the 2015 country report (Belpaire *et al*., 2016a) for the latest information.

Contaminants

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).

Besides below we summarize the results of a **monitoring campaign for 2017–2018 for the international reporting for the Water Framework Directive** (Biota Monitoring Flanders (Belgium) (Teunen *et al*., 2019).

Chemical pollutants in the environment, mainly of anthropogenic origin, cause a persistent stress. High concentrations of these pollutants in water bodies can be harmful to aquatic ecosystems and toxic to humans. By creating the European Water Framework Directive (WFD) EU Member States are encouraged to monitor chemical components in surface waters in order to protect the environment from deleterious effects of toxic compounds. Most of these compounds are to be measured in water or sediment. Strong hydrophobic/lipophilic compounds, however, can be difficult to measure in water, due to their low solubility. Accordingly, the European Commission created biota environmental quality standards (biota EQS), for a total of eleven such priority compounds and their derivatives. Depending on the compound, they are to be measured in fish or freshwater bivalves (biota). Bioaccumulation of hexachlorobenzene (HCBz), hexachlorobutadiene (HCBd), mercury (Hg), brominated difenyl ethers (PBDE), hexabromo-cyclododecane (HBCD), perfluoro-octanesulfonic acid (PFOS) and derivatives, dicofol, heptachlor and heptachlorepoxide, and dioxins and dioxin-like compounds were measured in the muscle tissue of European perch (*Perca fluviatilis*) and eel (*Anguilla anguilla*) collected in eleven Flemish waterbodies. In addition, PCBs were measured. To date, no biota EQS exists for PCBs.

In general, pollutant concentrations were higher in the muscle tissue of eel compared to the muscle tissue of perch. Standardization based on fat content, minimalized this effect and even gave a shift towards higher concentrations in perch than in eel, an indication of the lipophilic characteristics of these compounds. Additionally, some important (abiotic) factors (such as age and diet) can play a role as well. For PFOS, the opposite was true: the highest concentrations were measured in perch, possibly caused by a high affinity towards proteins. Stable isotopes analysis confirmed the top predator position of both fish species in the food chain.

We can conclude that the most important trends of the 2015 and 2016 campaigns (Teunen *et al*., 2017; 2018) were confirmed in the present study. In general the biota EQS for mercury, PBDE (Figure 12), PFOS and (cis-)heptachlor epoxide was exceeded in almost all sampling locations. Accumulated concentrations of HCBz, PAHs and dioxins showed an exceedance in fish tissue from some sampling locations. There was no exceedance of the standard for HCBd, HCBD and dicofol on none of the sampled locations. However, PCB concentrations in eel exceeded the European consumption standards in 64% of the sample locations.

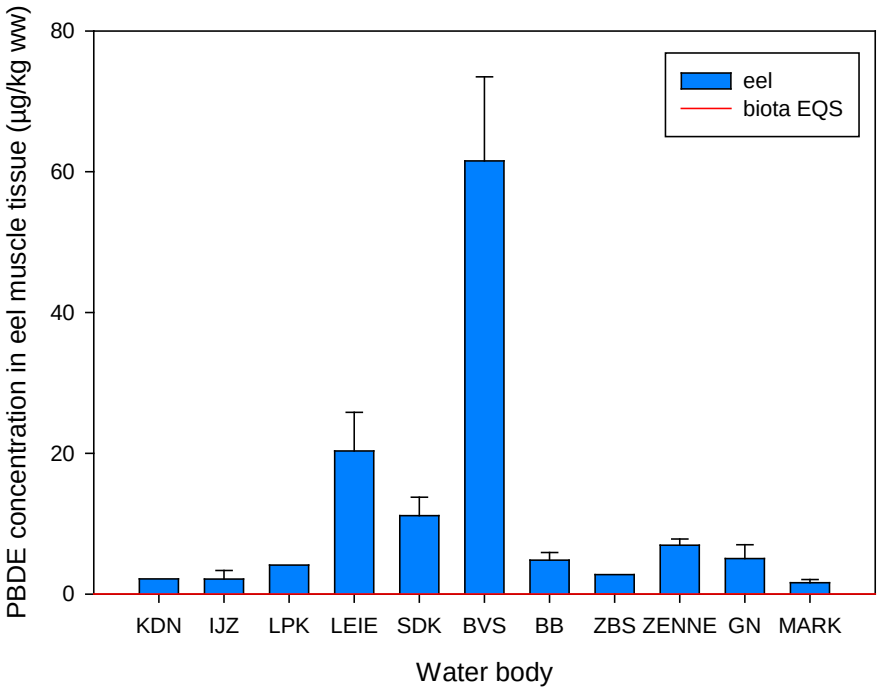


Figure 12. Mean PBDE concentrations in muscle tissue of eel with standard deviation. KDN: Kanaal Duinkerke-Nieuwpoort; IJZ:Kanaal Ieper-IJzer; LPK: Leopoldkanaal; LEIE: Leie; SDK: Schipdonkkanaal; BVS: Bovenschelde; BB: Bellebeek; ZBS: Zeekanaal Brussel-Schelde; ZENNE: Zenne; GN: Grote Nete; MARK: Mark. Biota quality standard for Hg is 0.0085 µg/kg wet weight.

6 New Information

6.1 New papers published

New paper. Vergeynst, J., Pauwels, I., Baeyens, R., Coeck, J., Nopens, I., De Mulder, T., Mouton, A., 2019. The impact of intermediate-head navigation locks on downstream fish passage. River Res Applic. 35 (3), 224–235.

Navigation in inland waterways is increasingly important worldwide and so is inherently the construction and use of navigation locks. However, the impact of navigation locks on downstream migrating fish is rarely documented. In Belgium, the Albert Canal connecting the Meuse River to the Scheldt Estuary may offer migration opportunities for European eel (*Anguilla anguilla*) and Atlantic salmon (*Salmo salar*), two critically endangered species. During their downstream migration phase (respectively silver eels and salmon smolts), both species have to pass five intermediate-head navigation locks before reaching the estuary. Previous research showed that silver eel escapement is largely unsuccessful and that eels are delayed extensively at the navigation lock complexes. To get a better understanding of the mechanisms behind these failures and delays, we tagged and released 62 silver eels and 44 salmon smolts in the vicinity of one navigation lock complex of the canal. This paper reports the mechanisms behind the previously perceived delay, the route choices to pass the complex, and the risks involved. Of the 65% tagged eels and 73% tagged smolts that succeeded to pass the complex, respectively, 20% and 41% needed more than one trial to pass the complex. Moreover, 52% of all trials were via intakes of the lock filling system, at least four smolts (17%) died after intake passing, and about 30% of both intake-passing smolts and eels stopped migrating after passage. Therefore, intermediate-head navigation locks are a potential threat to downstream migrating fish, which requires more research to fully investigate its impact.

New paper. Vergeynst, J. *et al.*, 2018. Fish Behaviour in the Vicinity of a Navigation Lock Complex: the Challenges. Daniel Bung, Blake Tullis, 7th IAHR International Symposium on Hydraulic Structures, Aachen, Germany, 15–18 May. doi: 10.15142/T3S35D (978-0-692-13277-7).

Hydraulic structures such as navigation locks, pumping stations and hydropower plants play an important role in navigation, water management and sustainable energy production. However, these structures may severely impact the aquatic ecosystem and freshwater fish in particular. In Belgium, the Albert Canal connecting the river Meuse to the river Scheldt, is an important migration route for European eel (*Anguilla anguilla*, critically endangered) and Atlantic salmon (*Salmo salar*, vulnerable). Both species have a downstream migrating phase in their lifecycle (respectively silver eels and salmon smolts), during which they are hampered by hydraulic structures. In the coming years, Archimedes screws are to be installed at the navigation lock complexes present in the Flemish part of the canal, which can function both as pumping stations and hydropower generators. A first installation is already present at the navigation lock complex of Kwaadmechelen. Before fish mitigation measures can be implemented, it is important to gain understanding on how the downstream migrating fish are affected by hydrodynamics around the complex. In this paper, we focus on the challenges in investigating fish behaviour, related to the acoustic telemetry used to determine fish positions, as well as on the complexity of a hydrodynamic CFD model for the studied site. Additionally, we present some preliminary results. In the next phase of the research, observed fine-scale behaviour of the fish in front of the navigation lock complex will be compared with predicted flow patterns by means of a CFD model.

New paper. **Nzau Matondo, B.; Seleck E.; Dierckx, A; Benitez, J. P.; Rollin, X.; Ovidio, M., 2019. What happens to glass eels after restocking in upland rivers? A long-term study on their dispersal and behavioural traits. Aquatic Conservation: Marine and Freshwater Ecosystems 29:374–388.**

The European eel *Anguilla anguilla* is a critically endangered fish species as a result of human activities and climate change in river and oceanic ecosystems. Restocking using glass eels in continental freshwater areas is a potential conservation measure for enhancing local eel stocks and for conserving the species in aquatic habitats, where it may otherwise disappear. However, little is known about the fate of these restocked individuals and the early ecological behaviour of the young eels translocated in rivers.

A portable radio-frequency identification (RFID) telemetry system and 12-mm tags were used to track restocked eels for a duration of 4 years. The aim was to understand the early movement, behavioural traits, dispersal, and habitat use of elvers after restocking performed in 2013 with glass eels in a shallow riverine environment.

From the 241 tagged eels (total length, Q_{50} = 152 mm), 85% were detected in 1968 positions during a period of 4 years, beginning in 2014. Clear seasonality in eel activity was observed, with higher mobility in summer when the water temperature was high (above 12°C). Dispersal was slowed by numerous artificial obstacles and the high carrying capacity of habitats. There was a negative relationship between the body size of eels at tagging and their mobility. Five behavioural categories of mobility patterns were identified: ascending, descending, oscillating with an upstream trend, oscillating with a downstream trend, and stationary. The first four categories depleted with time, in favour of stationary individuals that displayed a highly sedentary lifestyle.

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 issue of uncommon restocking practices in upland rivers.

New paper. **Belpaire, C., Hodson, P., Pierron, F., Freese, M., 2019. Impact of chemical pollution on Atlantic eels: Facts, research needs, and implications for management. Current Opinion in Environmental Science & Health 11: 26–36.**

Multiple eel species of the genus Anguillidae are under anthropogenic pressure. This review presents strong evidence that chemical pollution is a driving force behind the catastrophic decline in recruitment and abundance of both the European (*Anguilla anguilla*) and the American eel (*Anguilla rostrata*). In response to this crisis, stock and habitat management policies have blindly focused on increasing the areas available for the recruitment and rearing of yellow eels, and increasing the numbers of silver eels escaping to spawn in the Sargasso Sea. No specific policies or regulations have been adopted to foster recruitment of yellow eels to uncontaminated watersheds, to monitor the quality and condition of silver eels, or to protect silver eels from contaminated environments. Research is needed to identify existing and emerging contaminant problems, to understand their potential impacts on eel reproduction, and to develop indicators of spawner quality and management actions that would increase the likelihood of successful eel reproduction and recruitment.

6.2 Ongoing or new projects

Ongoing project. 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 migration 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 are bringing together telemetry data (i.e. acoustic, radio, PIT and archival telemetry data) on European silver eels 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 your own 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 will allow to conduct a meta-analysis on the migration behaviour. For instance, linking migration speeds with spatio-temporal resolutions and biometric measurements (e.g. size and sex) could 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.

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

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. 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. This study could also further elucidate the impact of anthropogenic stressors on the marine migration phase, such as climate change and consequences of the parasitic swim bladder nematode *Anguillicola crassus*. Even more, the effects of electricity cables on the seafloor between offshore wind mill farms and the mainland on eel migration are underexposed. Since silver eels may rely on electromagnetic fields for orientation, these cables potentially influence migration at sea. Hence, to cover these knowledge gaps, the Flanders Marine Institute, Ghent University and the Research Institute for Nature and Forest tagged 102 silver eels in autumn of 2018 and another 100 will be tagged in autumn 2019.

7 References

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Report on the eel stock, fishery and other impacts in Denmark, 2018–2019

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Reporting Period: This report was completed in August 2019 and contains data up to 2018 and some provisional data for 2019.

1 Summary of national and international stock status indicators

1.1 Escapement, biomass and mortality rates

For 2018 there are no new data.

Year	EMU_code	Assessed Area (ha)	B_0 (kg)	B_{curr} (kg)	B_{best} (kg)	Bcurr/B_0 (%)	∑A	∑F	∑H
2017	Dk_inla	60.000	1.110.000	125.31	168.97	11.3	0.222	0.163	0.059
2018	Dk_inla	ND	ND	ND	ND	ND	ND	ND	ND

Dk_inla. Assessed area (ha) of inland waters. 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).

1.2 Recruitment time-series

1.2.1 Yellow eel recruitment

The recruitment of young eels, to Danish freshwater, is monitored in pass traps at Harte Hydropower Station in river Kolding Å and at Tange Hydropower Station in river Guden Å. Both rivers empty into Kattegat on the east coast of Jutland. On the west coast of Jutland no passive trapping facilities are available. Here the recruitment is monitored in Vester Vedsted brook a small brook by the Wadden Sea. See also Section 9.1 for further information on glass eel monitoring by electrofishing.

In **Vester Vedsted brook** an annual population surveys is made by electrofishing four sections of the brook three times a year (further details in Pedersen, 2002).

At **Harte Hydropower Station** the condition for monitoring recruitment at the eel ladder trap has changed. As part of a river restoration project in River Kolding Å, the water supply to Harte Hydropower station has been reduced by 60% since spring/summer 2008. The effect of lower water supply at the trapping site is a decrease in recruitment to the trapping site reflected in the data. This is the second time a major change to the eel monitoring in River Kolding Å has taken place, since monitoring started in 1967. The first change was in 1991 where a trapping facility was terminated at the Stubdrup Weir. At that time a bypass stream was made at the Stubdrup weir allowing eels to bypass the weir without being trapped. This change is also reflected in the recruitment data (Table 1.2.1).

Due to repair work at Harte Hydropower station the water flow was reduced in 2015 during August and September, and a lower catch of ascending elvers was expected in 2015.

At **Tange Hydropower Station**. The local staff at the station is responsible for the daily maintenance of the el eel ladder trap and registration of data. The fishery in the reservoir lake Tange

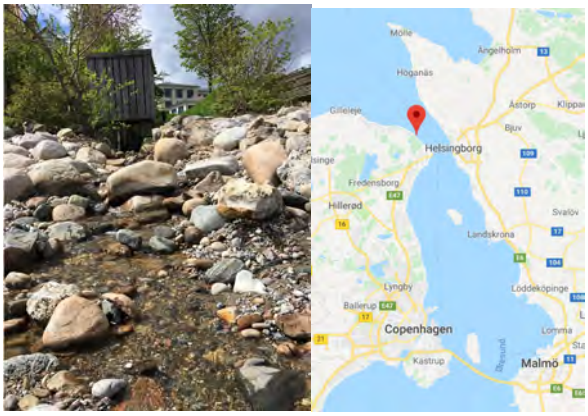
has terminated and the trap has not been in operation since 2015 and no data are available during the last years.

Table 1.2.1. Recruitment data from Tange and Harte Hydropower Stations and Vester Vedsted brook. Mean density during the year and maximum density at any electrofishing occasion.

YEAR	TANGE	HARTE	VESTER VEDSTED BROOK		YEAR	TANGE	HARTE	VESTER VEDSTED BROOK		YEAR	TANGE	HARTE	VESTER VEDSTED BROOK	
			DENSITY EEL/M²					DENSITY EEL/M²					DENSITY EEL/M²	
Year	Kg	Kg	Mean	Max (season)	Year	Kg	Kg	Mean	Max (season)	Year	Kg	Kg	Mean	Max (season)
1967	-	500	-	-	1987	145	105	-	-	2006	123	7	0.3	0.7
1968	-	200	-	-	1988	252	253	-	-	2007	62	7	0.4	0.5
1969	-	175	-	-	1989	354	145	-	-	2008	131	0.9	0.2	0.2
1970	-	235	-	-	1990	367	101	-	-	2009	20	1.3	0.2	0.2
1971	-	59	-	-	1991	434	44	-	-	2010	14	5	0.2	0.4
1973	-	117	-	-	1992	53	40	-	-	2011	84.6	3.6	0.3	0.3
1974	-	212	-	-	1993	93	26	-	-	2012	-	4.1	0.1	0.2
1975	-	325	-	-	1994	312	35	-	-	2013	47	1.4	0.1	0.2
1976	-	91	-	-	1995	83	23	2.6	2.6	2014	36	3.0	0.1	0.1
1977	-	386	-	-	1996	56	6	4.6	6.8	2015	NA	1.3	0.2	0.2
1978	-	334	-	-	1997	390	9	0.7	1	2016	NA	2.4	0.3	0.3
1979	-	291	2.8	6.5	1998	29	18	0.3	0.4	2017	NA	0.9	0.14	0.3
1980	93	522	7	13	1999	346	15	0.4	0.5	2018	NA	0.7	0.47	0.59
1981	187	279	7.8	13	2000	88	18	0.6	0.7	2019	Na	Na	0.5	0.6
1982	257	239	-	-	2001	239	11	0.6	0.8					
1983	146	164	-	-	2002	278	17	0.5	0.6					
1984	84	172	-	-	2003	260	9	0.6	0.7					
1985	315	446	-	-	2004	246	9	0.3	0.4					
1986	676	260	-	-	2005	88	7	0.5	0.5					

Hellebaekken

A new monitoring site since 2011. The site is located in Oresund, Denmark (12.55 E; 56.07 N). An eel trap intercept ascending eels from Oresund. There is a reservoir lake above the trap. It was not possible to make an eel pas connecting the lake with the sea. According to the legislation, it is obligatory to establish a corridor to the lake for migrating eel, so a trap was constructed and the captured eel is carried to the lake and released. The National Forest and Nature Agency is handling the eels and reporting the number of captured eel to DTU Aqua.



Picture of the stream Hellebaekken and the house where the eel trap is located. The map shows the location in Oresund.

Table 1.2.3. Ascending eel trapped in Hellebaekken.

Year	Number
2011	638
2012	162
2013	804
2014	87
2015	1380
2016	1793
2017	782
2018	1094

1.2.2 Glass eel recruitment

Weirs in streams are being removed as a part of National river restoration projects e.g. to meet the requirements of the water frame directive. Monitoring young eel recruitment the traditionally way, using eel pass traps, has become more difficult. New methods and locations are urgently needed in order to monitor the effect of the EU regulation in terms of recruitment of young eel from the ocean.

Since 2008 three small brooks situated on the North Sea coast of Jutland were selected for monitoring. At each brook two stations of ca. 20 m length (close to the shoreline <1000 m) are electrofished at three different times from May to August and the population of eels at each station is calculated using the removal method. The brooks have a water depth <50 cm and width of 1–4 m.

The aim is to have this type of monitoring replacing eel pass traps.

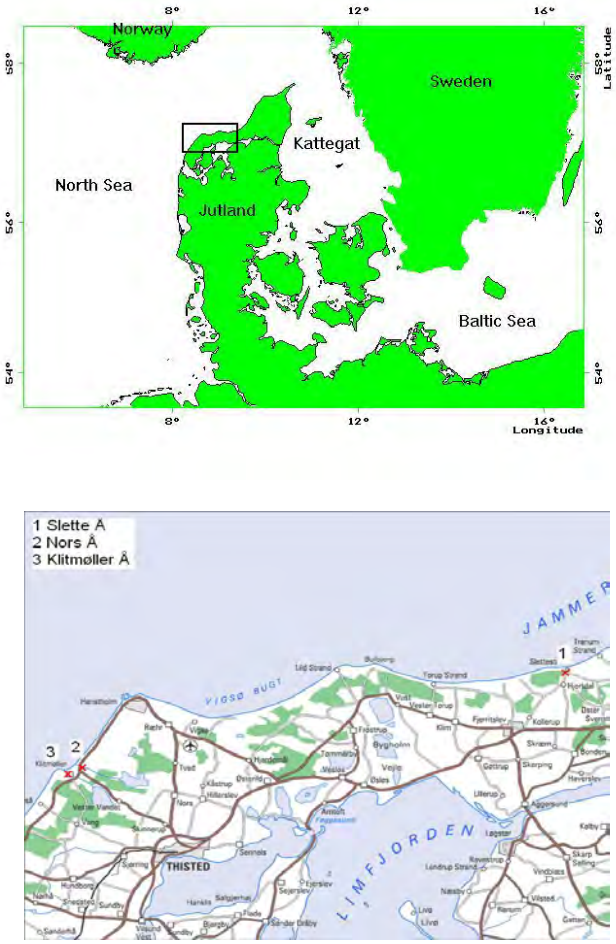
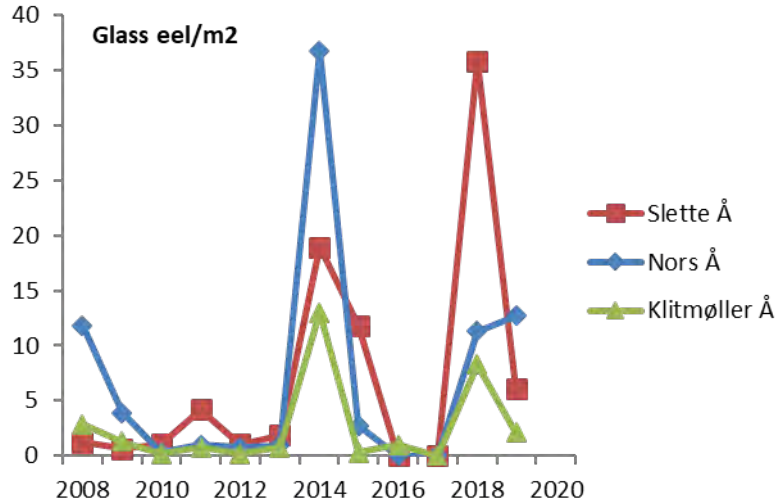


Figure 1.1.2. Map with glass eel monitoring sites (1, 2 and 3) in the North Sea.

Table 1.2.2. Density of newly arrived glass eel pigmented glass eel (eel/m^2) as a mean of three different electrofishing occasions starting medio May to medio August. The maximum density during the season is given.

	Slette Å (1)		Nors Å (2)		Klitmøller Å (3)	
	Mean	Max.season	Mean	Max.season	Mean	Max.season
2008	1.2	1.2	11.8	11.8	2.8	2.8
2009	0.6	1.0	3.9	6.3	1.3	2.2
2010	1.0	1.4	0.3	0.8	0.2	0.2
2011	4.2	5.7	1.0	2.3	0.8	1.2
2012	1.1	1.8	0.8	2.1	0.2	0.2
2013	1.9	2.9	0.9	2.4	0.8	1.8
2014	19.0	29.6	36.8	75.5	13.0	21.4
2015	11.8	27.5	2.8	5.1	0.3	0.3
2016	4.9	6.9	6.9	11.8	1	1.2
2017	1.3	1.9	0.4	0.6	0.9	5.0
2018	35.9	72.9	11.3	17.4	8.3	11.3
2019	6.0	7.4	12.7	27.2	2.1	3.0



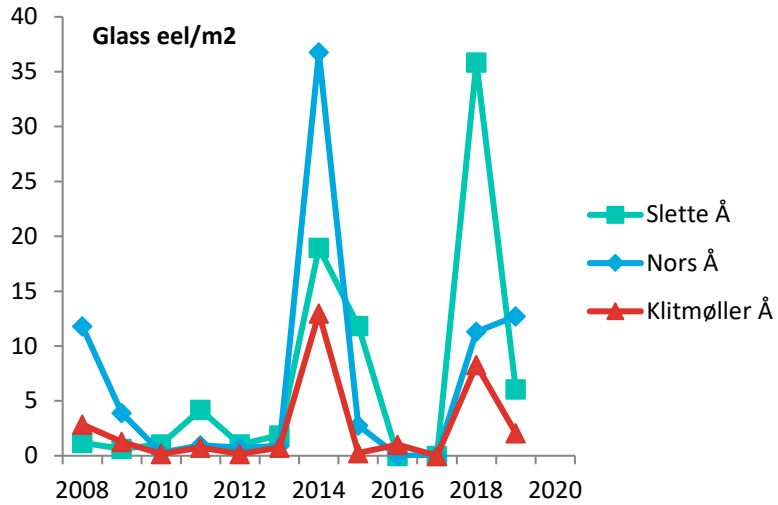


Figure 1.1.3. Monitoring data. Density of newly arrived glass eel pigmented glass eel (eel/m^2) as a mean of three different electrofishing occasions starting mid-May to mid-August.

Slette Å. Monitoring glass eel recruitment by electrofishing. Photo by Jan Skriver.

2 Overview of the stock and its management

2.1 Describe the eel stock and its management

From 1st July 2009 the eel is managed according to the EU regulation, aiming at 40% (relative to the pristine) silver eel escapement in freshwater and 50% effort reduction in the marine waters. The Danish territory is managed as one freshwater EMU excluding two small transboundary river basins named Kruså and Vidå shared with Germany. Intermediate and coastal waters together with community waters constitute the entire marine area.

From 1st July 2009, professional fishing operations are based on licences. The professional fishermen in saline areas are given a licence permitting the use of a limited number of gear in order to meet the 50% effort reduction following the EU eel regulation. Recreational fishermen operating in the marine are permitted to use six fykenets or six hook lines but in a reduced period of the year. Fishing is closed from the 10th of May to 31st of July in order to reduce effort by 50%.

In freshwater a few professional fishermen have a licence permitting the use of a limited number of gears. For landowners and recreational fishermen the open fishing season has been limited to a period of 2.5 months (1 Augustand fishing is closed from 16 October–31 July.

The escapement target of 40% in freshwater has been calculated to be achieved after ca. 85 years if a total ban on freshwater fisheries will commence. Licences are provisionally issued until 31st December every year and have to be renewed. The Ministry of Food, Agriculture and Fisheries may implement further reductions pending the development in the eel stock.

The EU commission has enforced a closing period for commercial and recreational eel fisheries from 1 December 2019 until 1 March 2020.

2.2 Significant changes since last report

There are no changes in eel management since the last country report except the EU enforced closing period. The EU enforced closing period.

3 Impacts on the stock

3.1 Fisheries

3.1.1 Glass eel fisheries

No data; glass eel fishery is forbidden.

3.1.2 Yellow eel fisheries

The commercial time-series on Silver eel landing are shown below see 3.3.1.1 (Freshwater) and 3.3.1.2 (Marine) and recreational see 3.3.2.1.

3.1.3 Silver eel fisheries

The commercial time-series on Yellow eel landing are shown below see 3.3.1.1 (Freshwater) and 3.3.1.2 (Marine).

3.2 Silver eel landings

3.2.1 Commercial

Data on separate landings of yellow and silver eel in fresh and saltwater are given below. Data origin is landing reports by commercial fishermen reported to the ministry. From mid-2009 landings are only reported from those having a licence to fish for eel.

Table 3.3.1.1. Freshwater landings (ton) of yellow and silver eels.

Year	Silver	Yellow	Total	Year	Silver	Yellow	Total	Year	Silver	Yellow	Total
1960	-	-	214	**1980**	-	-	147	**2000**	4	24	28
1961	-	-	235	**1981**	-	-	140	**2001**	2	34	36
1962	-	-	215	**1982**	-	-	163	**2002**	5	27	27
1963	-	-	238	**1983**	-	-	116	**2003**	2	21	24
1964	-	-	223	**1984**	-	-	126	**2004**	4	12	15
1965	-	-	205	**1985**	-	-	111	**2005**	3	10	14
1966	-	-	211	**1986**	-	-	120	**2006**	7	8	14
1967	-	-	243	**1987**	-	-	90	**2007**	5	6	11
1968	-	-	258	**1988**	-	-	119	**2008**	5	4	9
1969	-	-	254	**1989**	-	-	114	**2009**	8	5	13
1970	-	-	249	**1990**	-	-	107	**2010**	10	3	13
1971	-	-	183	**1991**	-	-	99	**2011**	11	4	15
1972	-	-	200	**1992**	-	-	109	**2012**	9	4	13
1973	-	-	201	**1993**	-	-	57	**2013**	10	3	13
1974	-	-	163	**1994**	-	-	60	**2014**	12	3	15
1975	-	-	260	**1995**	-	-	52	**2015**	9	6	15
1976	-	-	178	**1996**	-	-	34	**2016**	10	3	13
1977	-	-	179	**1997**	-	-	39	**2017**	12	5	16
1978	-	-	157	**1998**	-	-	40	**2018**	6.5	5	11.5
1979	-	-	78	**1999**	-	-	30	**2019**	NA	-	-

Table 3.3.1.2. Marine landings (ton) of yellow and silver eels.

Year	Silver	Yellow	Total	Year	Silver	Yellow	Total	Year	Silver	Yellow	Total
1960	2756	1967	4509	**1980**	911	1230	1994	**2000**	382	218	572
1961	2098	1777	3640	**1981**	897	1190	1947	**2001**	446	225	635
1962	2132	1775	3692	**1982**	1003	1375	2215	**2002**	365	217	555
1963	1837	2091	3690	**1983**	884	1119	1887	**2003**	437	188	601
1964	1417	1865	3059	**1984**	830	915	1619	**2004**	343	187	516
1965	1498	1699	2992	**1985**	793	726	1408	**2005**	372	149	506
1966	1829	1861	3479	**1986**	818	734	1432	**2006**	427	154	567
1967	1673	1763	3193	**1987**	538	651	1099	**2007**	411	115	515
1968	2063	2155	3960	**1988**	799	960	1640	**2008**	364	93	448
1969	1552	2072	3370	**1989**	785	797	1468	**2009**	367	87	454
1970	1470	1839	3060	**1990**	834	734	1461	**2010**	304	105	409
1971	1490	1705	3012	**1991**	724	642	1267	**2011**	271	84	355
1972	1662	1567	3029	**1992**	687	655	1233	**2012**	226	78	304
1973	1697	1758	3254	**1993**	523	500	966	**2013**	243	100	343
1974	1378	1436	2651	**1994**	509	631	1080	**2014**	251	80	331
1975	1534	1691	2965	**1995**	408	432	788	**2015**	202	65	267
1976	1477	1399	2698	**1996**	381	336.5	684	**2016**	178	74	251
1977	1141	1182	2144	**1997**	375	383	719	**2017**	170	70	240
1978	1187	1148	2178	**1998**	306	251	517	**2018**	88	82	170
1979	887	939	1748	**1999**	380	307	657	**2019**	Na	-	-

3.2.2 Recreational

Freshwater

Recreational fishermen in freshwater are landowners and do not need a licence to fish. The fishing season is open from 1 August until 15 October and closed from 16 October until 31 July.

Marine

Recreational fishermen in the marine area are allowed to use a maximum of six fykenets. The fishing season is open from 1 August to 9 May and closed from 10 May to 31 July. Landing data are based on interview survey among recreational fishermen (Sparrevohn og Storr-Paulsen, 2010).

The survey (Table 3.3.2.1) is based on interviews from recreational fishermen from both the marine and freshwater. The data should be treated with care and the author believe especially the freshwater catch may be biased (far too high) during 2015 and 2016.

Table 3.3.2.1. Recreational landings in ton (yellow eel), based on interview from people holding a recreational licence (marine) or landowners (freshwater).

Year	Fresh	Marine	Total
2009	NA	100	100
2010	NA	117.5	117.5
2011	4.3	75.2	79.5
2012	0.4	51.9	52.3
2013	0.4	49.5	49,9
2014	2.0	55.0	57.0
2015	23.3	95.0	118.3
2016	10.2	154.1	164.3
2017	8.3	109	117,3
2018	3.5	101.5	105.0

3.3 Restocking

In 2019 a total of 1.810 million 2–5 gram eels were stocked. In freshwater 1.625.000 million eel and in marine waters 0.185 million were stocked (Table 3.5.1 below).

The stocked eels are foreign source imported from France, England and Portugal. Imported glass eels are grown to a weight of 2–5 gram in heated culture before they are stocked.

Table 3.5.1. Restocking of elvers (2–5 g) in marine and freshwaters from 1987–2019. Numbers of eels stocked (in millions).

Year	Marine	Lake	River	Total	Year	Marine	Lake	River	Total
1987	0.07	0.26	1.26	1.58	**2004**	0.52	0.18	0.06	0.75
1988	0.11	0.24	0.4	0.75	**2005**	0.24	0.06	0	0.3
1989	0	0.24	0.17	0.42	**2006**	1.15	0.35	0.1	1.6
1990	2.46	0.49	0.51	3.47	**2007**	0.59	0.21	0.02	0.83
1991	2.3	0.44	0.32	3.06	**2008**	0.52	0.19	0.04	0.75
1992	2.94	0.81	0.11	3.86	**2009**	0.55	0.20	0.05	0.81
1993	2.97	0.76	0.23	3.96	**2010**	0.30	0.57	0.67	1.55
1994	6.12	0.61	0.67	7.4	**2011**	0.20	0.77	0.59	1.56
1995	6.83	0.72	0.9	8.44	**2012**	0.25	0.64	0.64	1.53
1996	3.58	0.58	0.44	4.6	**2013**	0.25	0.66	0.61	1.52
1997	2.02	0.29	0.22	2.53	**2014**	0.26	0.71	0.63	1.60
1998	2.35	0.53	0.1	2.98	**2015**	0.13	0.79	0.61	1.53
1999	3.38	0.56	0.18	4.12	**2016**	0.13	0.69	0.71	1.53
2000	3.02	0.55	0.25	3.83	**2017**	0.13	0.69	0.71	1.52
2001	1.2	0.38	0.12	1.7	**2018**	0.13	0.67	0.31	1.11
2002	1.66	0.47	0.3	2.43	**2019**	0.18	0.88	0.75	1.81
2003	1.54	0.49	0.22	2.24					

3.4 Aquaculture

Aquaculture production of eel in Denmark started in 1984. The production takes place at three indoor, heated aquaculture systems, Table 3.3.1.

Glass eels to Danish aquaculture may be imported from France, Portugal or England. The eel farmers report to the Danish AgriFish Agency what amount of glass eel is imported but not from where it is imported. Data up to 2017 are currently available.

Table. 3.3.1. Annual aquaculture eel production.

Year	Production Units	Production [ton]	Year	Production units	Production [ton]
1984	NA	18	2001	17	2000
1985	30	40	2002	16	1880
1986	30	200	2003	13	2050
1987	30	240	2004	9	1500
1988	32	195	2005	9	1700
1989	40	430	2006	9	1900
1990	47	586	2007	9	1617
1991	43	866	2008	9	1740
1992	41	748	2009	9	1707
1993	35	782	2010	9	1537
1994	30	1034	2011	8	1156
1995	29	1324	2012	8	1093
1996	28	1568	2013	8	824
1997	30	1913	2014	6	842
1998	28	2483	2015	5	1234
1999	27	2718	2016	5	1072
2000	25	2674	2017	3	561
			2018	3	NA

Table 3.2.1. Usage of aquaculture production 2017 (Source: Danish AgriFish Agency).

	Number	Kg
Imported glass eel	10 263 750	4168
Stocking in Dk, size 3,5 g	1 106 000	3871
Stocking exported, size 9 g	1 926 338	17 337
Large eel consumption		531 892
Dead biomass		8100
Total production		561 200

The import and export data **Table 3.2.1** are reported by the eel farmers to the Danish AgriFish Agency. The different categories (import, stocking) are reported in kg and in numbers. The categories stocking export, consumption and dead biomass is reported in numbers. Life mortality from the glass eel stage to the stocked eel stage or the consumption stage is the same level, approximately 5–15 %. It should be noted that the number of glass eel imported to the farm is not necessarily comparable to the number of eel from the farm the same year. The retention time of eel in the farm differs by eel stage, e.g. eel for stocking is 3–12 months and eel for consumption is 18 months or more.

3.5 Entrainment

Hydropower

In 2006 there were 43–61 hydroelectric power units in operation in Denmark. Since then several hydropower units have been closed down (e.g. Vilholdt, Karlsgårdeværket, Harteværket, Holstebro vandkraft, etc). There are no exact data on the number and the capacity of hydroelectric power units at present.

We have measured a loss of 0 and 58% at two particular hydro-power plants. At Tange Hydropower plant there is a significant bypass problem for eels, we have measured a loss of at least 58% (Pedersen *et al*., 2011). At Vestbirk hydropower the fish bypass (1/4 of the water discharge) in combination with 10 mm screens works well and the loss is close to zero. (Pedersen and Jepsen, 2012).

We have no data for other hydro-power plants.

Trout farms (aquaculture)

Research in relation to weirs of trout farms have been conducted in connection with three trout farms in River Kongeåen and River Mattrup Å. The conclusion from these studies was that delay of eel migration due to low discharge was observed in some years and the eels bypass the screens that were supposed to prevent eels and other species to enter the trout farm.

Danish trout farms are often located on the banks of rivers depending on water intake from the rivers. To guide the river water into the trout farm, a weir is built in the river. Less than 250 trout farms use "flow through" river water and approximately ten have systems for recirculation of water. To prevent fish from entering the trout farms a screen with a maximum 6 mm bar distance is obligatory at the point of the water inflow and a maximum 10 mm bar distance at the point of outflow.

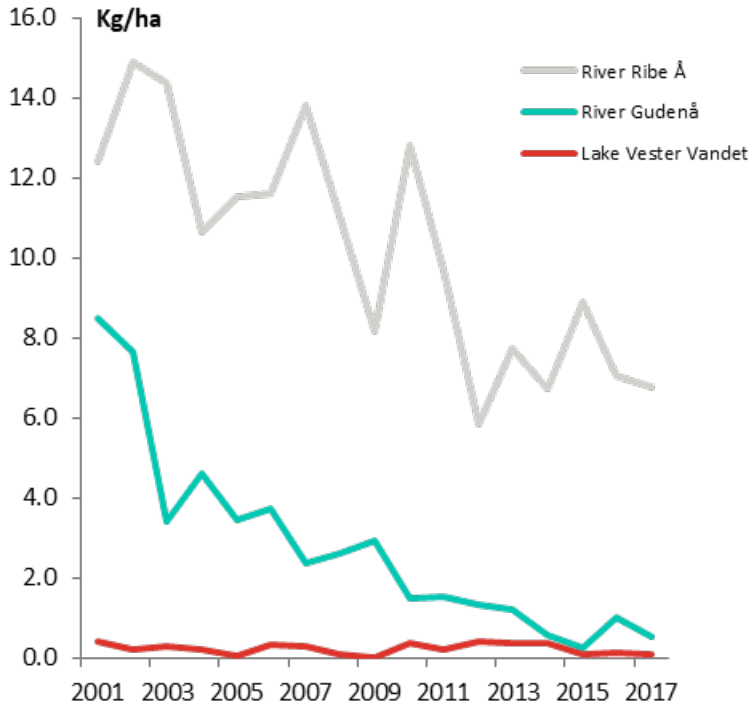
Two studies have been conducted. The first study was at Brejnholt trout farm in River Mattrup Å. Here no mortality was observed but migration delay of silver eels at the weir varied with water discharge. The second study was in River Kongeå, here two trout farms are situated on the bank of the river at Vejen and Jedsted. Both trout farms have 6 mm bar distance at the water intake. At Vejen fish farm several fish entered the fish farm despite the 6 mm bar screen which seems not correctly installed or damaged. At Jedsted no fish entered the fish farm and the screen was working well. If the screen at Vejen fish farm is fixed properly, eels would not be able to enter the fish farm. However, it is quite difficult to see by eye if there is any such problem at other comparable fish farms unless the place where the screen is mounted is dried out.

The conclusion from these studies is that migrating silver eels is likely to have migration delay at weirs, which may depend on the hydrological conditions (water discharge) at some weirs and at other the screens may be incorrect mounted, causing eels to be trapped at the trout farm. No mortality was observed but delay at weirs is likely to cause higher mortality from predators (Pedersen and Jepsen, 2012).

3.6 Habitat Quantity and Quality

The spatial distribution of weirs in relation to hydropower and "flow through trout farms" are geographical limited to Jutland. No updated data since 2006 (see above) on quantity and quality is available.

It was assumed that about 10 ton of eel would die in connection with these weirs throughout the Danish inland waters!



3.7 Other impacts

Nothing to report.

4 National stock assessment

4.1 Description of Method

4.1.1 Data collection

1. Commercial fishermen are obliged to report through logbooks to the ministry of fisheries Landings in weight are separated in yellow and silver eel landings.
2. Recreational fisheries catch are collected through yearly interview surveys.
3. Recruitment data are monitored in freshwater using eel pass traps and electrofishing surveys.
4. Silver eel escapements from all 887 Danish river systems are surveyed using three index river systems. Two river systems with a silver eel trap and one river system with a commercial fisherman (Ribe Å).

Analysis

At River Ribe Å we use tag–recapture to estimate escapement (Petersen estimate, Ricker 1981). The depletion method is used when river population estimates are made by electrofishing.

4.1.2 Reporting

Collected data are published in national reports or international journals, WGEEL CR reports or Eel management progress reports to the EU- commission.

4.2 Trends in Assessment results

Stock indicators

Data from these index systems are used to calculate the total silver eel escapement from the Danish freshwater territory. The count is repeated at least every three years. The National Institute of Aquatic Resources (DTU Aqua) has succeeded in estimating and counting escaping silver eels from River Ribe Å, upper part of River Gudenå and Lake Vester Vandet.

5 Other data collection

5.1 Recruitment time-series

Glass eel surveys are described under Section 1 of this country report.

5.2 Yellow eel abundance surveys

The monitoring in Vester Vedsted may be recognized both as a yellow eel abundance survey as well as recruitment survey. No other surveys are available!

5.3 Silver eel escapement surveys

Described in Section 4 of this country report.

5.4 Parasites and Pathogens

The swimbladder parasite *Anguillicola crassus* is widely distributed throughout both brackish and freshwaters in Denmark. Monitoring of Anguillicola parasites takes place on a yearly basis at three locations since 1987. The number of Anguillicola infected eels (prevalence) is relatively constant during 1987–2017 at all three locations.

Table 11.2. Anguillicola monitoring data 2015.

Location	Salinity ppt	Coordinates	Year	Total	Infected	Prevalence	Intensity
				N	N	%	n
Isefjord	18	55.50N;11.50E	2018	95	24	25.3	1.2
Ringk. Fjord	5–10	55.55N;08.20E	2018	92	68	73.9	6.4
Arresø	0	55.59N;11.57E	2018	106	51	48.1	2.3

5.5 Contaminants

No new data available.

5.6 Predators

Cormorants

Cormorants are possibly the only important predator of eel due to the large number of nesting birds; predation is expected to be largest in the vicinity of the colonies, but birds migrating through Denmark may have significant impact during the fall.

The number of cormorants nesting in Denmark during the last 10–15 years can be regarded as stable, but with some fluctuation. The number of nests is now in an upward trend since 2010–2013. In the year 2000 the highest number of nests 42 481 was counted in colonies throughout Denmark. In 2017 a total of 33 171nests were counted.

In the Danish EMP (2008) it was suggested that in the period 2004–2006 approximately 80 tonne of yellow eel was eaten by cormorants. However recent work from Hirsholmene (57.29′N; 10.37′E) a cormorant colony in Kattegat analysing 350 regurgitated pellets, showed that eel otoliths occurred with a frequency of 0.3% (Poul Hald, 2007). The frequency of occurrence of eel otoliths found in cormorant pellets in 2005 was 0.12% and Sonnesen (2007) suggesting that wild eels are not important as food in Ringkøbing Fjord (55.55′N;08.20′E). However despite this low occurrence, the estimated number of eels eaten in Ringkøbing Fjord by cormorants in 2004 was 38 000, more individuals than was caught in the fishery, and recovery of cw-tags from 20 000 tagged stocked eels showed a 40% predation from cormorants during the first season (Jepsen *et al*., 2010). Thus cormorant predation can be a very significant factor in areas with a high cormorant density. The number of cormorants in Ringkøbing Fjord is not higher than most coastal areas in Denmark.

Recent analyses of data from ongoing studies of silver eel migration, using PIT tagging, showed that even relative large silver eels can be eaten by cormorants as PIT tags were recovered from nearby colonies and roosting sites. The recoveries may provide a basis for quantification of the predation in future studies.

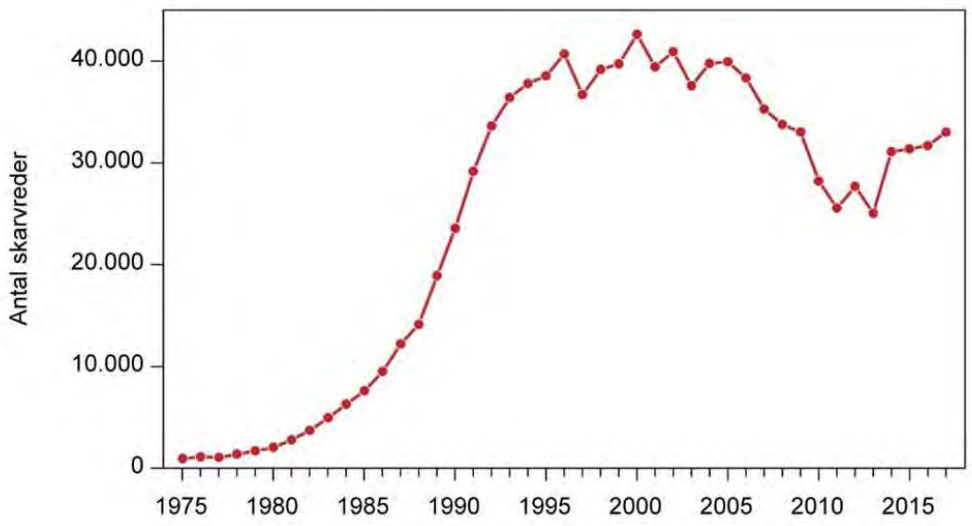


Figure 5.6. Number of cormorant nests in Denmark 1971–2017. Data from NERI. University of Århus.

6 New Information

6.1 New papers

Christoffersen, M., Svendsen, J.C., Kuhn, J.A., Nielsen, A., Martjanova, A., Støttrup, J.G. 2018. Benthic habitat selection in juvenile European eel *Anguilla anguilla*: implications for coastal habitat management and restoration. Journal of Fish Biology, Volume 93, pages 996–999.

The critically endangered European eel *Anguilla anguilla* is dependent on suitable habitat qualities over a vast geographic area. Even though a significant proportion of the population never enters freshwater, the preferred benthic habitat is largely unknown in the marine environment. Examining substratum selection in *A. anguilla* reveals that elvers prefer coarse gravel, suggesting that conservation efforts may benefit from targeting this type of substratum in marine coastal areas.

Pedersen M. I. Jepsen N. Rasmussen G. 2017. Survival and growth compared between wild and farmed eel stocked in freshwater ponds. Fisheries Research, Volume 194, October 2017, pages 112–116.

To evaluate the efficiency of eel stocking, we compared the survival and growth of wild eels (2–5 g) with that of "farmed" eels (3–6 g). Wild eels were caught in a river and farmed eels came from a farm, where wild imported glass eels are cultured. Two experiments of 5–12 month duration were conducted in a series of shallow, open ponds of approximately 200 m^2. Wild and farmed eels were batch tagged, mixed and released in the ponds at an initial density of 0.5 individual /m^2. Survival was rather high (34–88%) with variations between ponds. No significant difference in survival was found between wild and farmed during the first 5 month in both experiments. Growth rates were significantly higher for farmed eels compared to wild eels in both experiments. The results show that farmed eels performed better than wild eels. In regions with low recruitment the eel population may be increased by importing glass eels, stocked directly or stocked as on-grown farmed eel. The optimal size for stocking (between glass- and 3 g eels) may be determined through future studies.

Pedersen M.I. and G. H. Rasmussen. 2018. Fisheries regulation on European eel (*Anguilla anguilla*) for 2018; how big is the effect? Journal of fisheries Research. Volume 2 page 17–18.

The EU Council of Ministers decided in December 2017 to implement a limitation on commercial marine catches on eels exceeding 12 cm in length for 2018. We aimed to evaluate the effect of the fishing limitation using data on actual and potential silver eel escapement (stock indicators). The data suggest that fisheries exploitation of adult eels in the marine areas has relatively little effect on the biomass of silver eel that potentially can escape to the spawning grounds in the Sargasso Sea. The 2018 fishing regulation for the marine commercial fisheries increases migrating of silver eels towards the spawning grounds in the Sargasso Sea, from expected 10 000 t to 10 200 t, equivalent to 2% increase. Other anthropogenic mortality and predation may be far more important than landings of all life stages and account for 49% of the total loss.

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Report on the eel stock, fishery and other impacts, in Estonia

Authors

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Reporting Period: This report was completed in August 2019, and contains data up to 2018

1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

In 2018 the escaping silver eel biomass was estimated by methods described in Chapter 3. However acoustic telemetry was used for ∑H estimation in Narva RBD. This is also described in detail in Chapter 3. In Table 1 the stock indicators for 2016 and 2017 were updated according to our new findings concerning the new value of ∑H. ∑A is calculated as $\sum A = -\ln(B_{curr}/B_{best})$. It has to be kept in mind that fishing mortality is probably higher due to underreporting in commercial landings. Both B_{curr} and B_{best} are calculated in annual restocking conditions while B_0 is the pristine indicator without restocking. 2016 stock indicator calculation based on eel abundance survey that did not cover the whole L. Võrtsjärv and therefore over-estimated $B_{current}$ and B_{best}. The real biomass estimation for B_{curr}/B_0 values could be 6–8% smaller.

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
2016	EE_Narv	1 887 800	90 000	86 563	101 839	96	0.05	**0.1**	0.16
2017	EE_Narv	1 887 800	90 000	64 681	77 001	72	0.06	**0.1**	0.17
2018	EE_Narv	1 887 800	90 000	52 341	64 547	58	0.09	**0.1**	0.21
2016	EE_West	3 650 000	x	x	x	x	x	x	x
2017	EE_West	3 650 000	x	x	x	x	x	x	x
2018	EE_West	3 650 000	x	x	x	x	x	x	x

Key:

EMU_code = Eel Management Unit code (see Table 2 for list of codes); 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.

1.2 Recruitment time-series

No data available.

2 Overview of the national stock and its management

2.1 Describe the eel stock and its management

Management of the eel stock in Estonia is under the control of Estonian government. The Fishery Department of Ministry of the Environment takes care of restocking and local services and Ministry of Rural Affairs gives out fishing licences. Gear and size restrictions apply in eel fisheries. The lowest legal size of the eels caught in the coastal sea is total length (TL) = 35 cm and for inland waterbodies (excluding Lake Võrtsjärv, L. Peipus, and L. Pskov where the limit is 55 cm) the size limit is TL = 50 cm. Since 2008, the number of licences issued for small fykenets in the coastal areas has been reduced by 50%. Since 2011 Lake Võrtsjärv Fisheries Development Agency (FDA) is responsible for restocking of glass/young yellow eel. Since 2008, the number of licences issued for small fykenets in the coastal fisheries has been reduced by 50%.

Commercial eel fisheries in Estonia are roughly divided in two:

1. Freshwater eel fishery (10–20 t/year, 2006–2018) occurs in Narva RBD. All of the eel caught is of restocked background. Occasionally is eel also reported from Lake Ermistu which has a possible connection with the sea in the West-Estonian Basin.
2. Coastal sea eel fishery (0.5–10 t/year, 2006–2018) occurs in the coastal waters of Estonia. Eel is not targeted by the fishery and mostly registered as bycatch in fykenets. Eels both of natural and restocked origin are being fished.

Longlines with 100 hooks per line and harpoons are used in recreational eel fisheries. Eel fisheries in Estonia are described in more detail in paragraph 3.1.

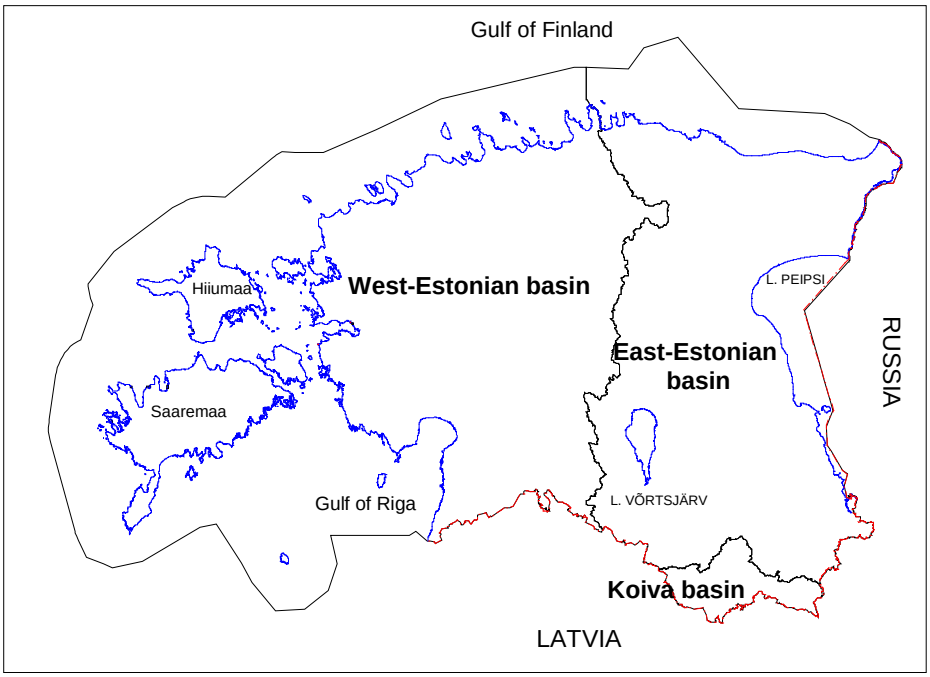

Figure 1. Map of basins. Note that East-Estonian basin and West-Estonian basin correspond to Narva RBD and West-Estonian RBD according to Estonian Eel Management Plan.

According to ordinance of government (RT I 2004, 48, 339) and Water Framework Directive the territory of Estonia is divided into three basins (Figure 1) and nine subbasins. Basins and subbasins are not directly connected to one river, as in European scale Estonian rivers are very small, except River Narva and its watershed area (1/3rd of territory of Estonia and shared with Russia and Latvia). Other more important rivers are River Pärnu, River Kasari and River Gauja, last of which is shared with Latvia (not incl. to the EMP).

Estonia submitted its national Eel Management Plan (EMP) in accordance to the Regulation EC No 1100/2007 establishing measures for the recovery of the stock of European eel on 31st of December 2008 and this plan was approved by the European Commission on 30th of November 2009 (Report of…, 2015).

2.2 Significant changes since last report

Updated values for ∑H and ∑A. See paragraphs 1.1 and 3.4 for details.

3 Impacts on the national stock

3.1 Fisheries

The total capacity of the coastal fishery in 2018 was 1072 commercial fishermen/companies. 82 commercial fishermen/companies of the coastal fishery reported eel (average catch per fisherman/company = 5.9 kg/year) in their catch in 2018. The total capacity of the freshwater fishery in 2017 was 334 commercial fishermen/companies. 73 commercial fishermen/companies of the freshwater fishery reported eel in their catch. In freshwater fishery 93% (16.7 t) of the eel was caught from Lake Võrtsjärv by 45 fishermen/companies (averaging 370.6 kg per company/fisherman). This information is collected by the Estonian Ministry of Rural Affairs. Register is updated every year and available online at http://www.agri.ee/et/eesmargid-tegevused/kalamajandus-ja-kutseline-kalapuuk/puugiload-ja-puugivoimaluste-jaotus and http://www.agri.ee/et/eesmargid-tegevused/kalamajandus-ja-kutseline-kalapuuk/puugi-andmed (both in Estonian). Records are kept over the number and type of gears used. Data from fishermen logbooks are collected once a month and uploaded twice a year. Eel landings in Estonian waters are brought out in Figure 2 and Table 2.

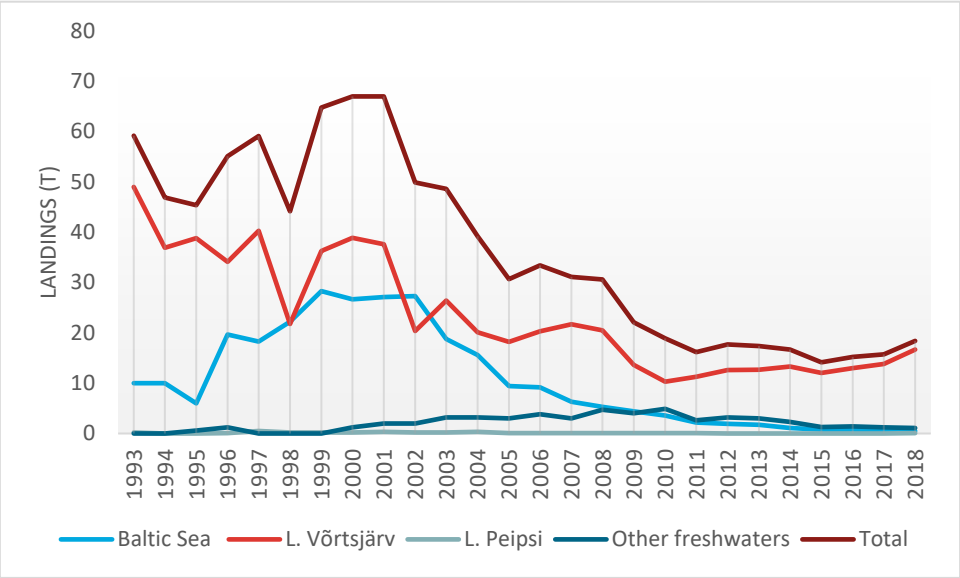

Figure 2. Eel landings (tons) in different waterbodies of Estonia in the period 1993–2018.

Table 2. Eel landings (tons) in different waterbodies of Estonia in the period 1993–2018 and proportion (%) of restocked eels in the reported landings (landings in fresh- vs. coastal waters).

Year	Baltic Sea	L. Võrtsjärv	L. Peipsi	Other freshwaters	Total	Proportion (%) of restocked eels in reported landings
1993	10	49	0.2		59.2	83
1994	10	36.9			46.9	79
1995	6	38.8		0.6	45.4	87
1996	19.7	34.1	0.1	1.2	55.1	64
1997	18.3	40.3	0.5		59.1	69
1998	22.2	21.8	0.2		44.2	50
1999	28.3	36.3	0.2		64.8	56
2000	26.7	38.9	0.2	1.2	67	60
2001	27.1	37.6	0.3	2	67	58
2002	27.3	20.4	0.2	2	49.9	46
2003	18.8	26.4	0.2	3.2	48.6	61
2004	15.6	20.1	0.3	3.2	39.2	60
2005	9.4	18.2	0.1	3	30.7	69
2006	9.2	20.3	0.1	3.8	33.4	73
2007	6.3	21.7	0.1	3	31.1	80
2008	5.3	20.5	0.1	4.7	30.6	83
2009	4.4	13.6	0.1	4	22.1	80
2010	3.6	10.3	0.1	4.9	18.9	81
2011	2.2	11.3	0.1	2.6	16.2	86
2012	1.9	12.6		3.2	17.7	89
2013	1.7	12.7		3	17.4	90
2014	1.1	13.3		2.3	16.7	93
2015	0.8	12.06	0	1.29	14.15	94
2016	0.8	13	0	1.4	15.2	95
2017	0.7	13.8	0	1.2	15.7	96
2018	0.5	16.7	0.1	1.1	18.4	97

In Estonia, both silver- and yellow eels are reported together in commercial fishery so no separate data for silver- or yellow eel in commercial landings are available.

Longlines with 100 hooks per line and harpoons are used in recreational eel fisheries. Both mentioned types of gear require applying for a fishing card, which is issued for a fee by the Estonian Environmental Board. Fishing cards require reporting of catch. However eel can also be caught by bottom lines which require paid recreational fishing rights but reporting of catch is voluntary. Time-series for reported recreational eel catch in the period 2005–2018 is brought out in Figure 3. Recreational eel catches by gear type for period 2008–2018 are visualized on Figure 4. It can be seen that recreational eel catches in coastal waters are almost non-existent compared to their freshwater counterparts. This is possibly due to low number of eels inhabiting the coastal areas combined with less recreational fishermen actually fishing for eels.

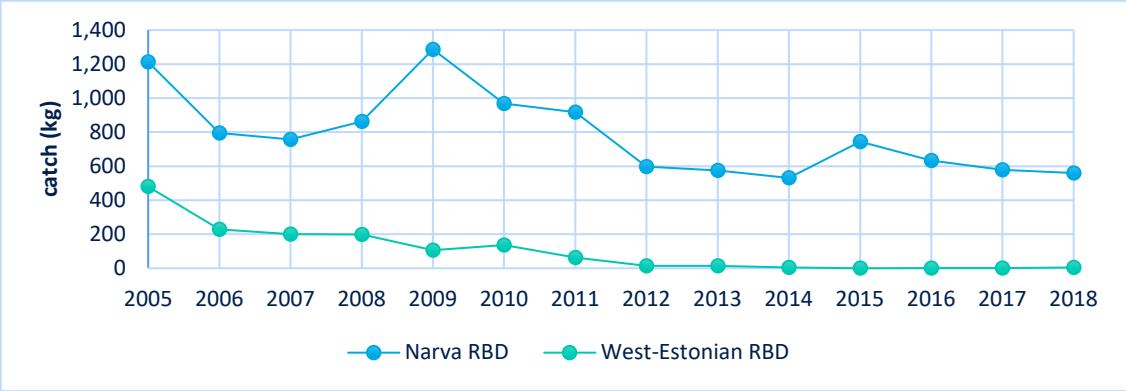

Figure 3. Recreational catch during period 2005–2018 in the Estonian Eel Management Units.

Figure 4. Reported recreational eel catches in the period 2008–2018 by different gear („FW" denotes freshwater while „C" coastal waters). Note that data by gear are incomplete compared to the total recreational catch (Figure 3).

3.1.1 Glass eel fisheries

No data available.

3.1.2 Yellow eel fisheries

No data available.

3.1.3 Silver eel fisheries

No data available.

3.2 Restocking

In Estonia, eels are restocked only into the waterbodies of Narva RBD. These waterbodies are L. Võrtsjärv, L. Saadjärv, L. Kaiavere, L. Kuremaa and L. Vagula. Restocking of eels has been a tradition since 1956 and from 1970s, restocking has taken place annually (Table 3). Depending on availability of finances and restocking material either glass eels or ongrown eels have been restocked. In 2018, 1.4 million glass eels (474.7 kg) were restocked to waterbodies of Narva RBD. The tender for restocking material was won by Sarl Foucher-Maury from France and the glass eels were brought to Estonia in a live fish truck.

Table 3. Restocking of glass eel and ongrown eel in Estonia (in 10^6).

	1950		1960		1970		1980	
	glass		glass		glass		glass	
year	eels	elver	eels	elver	eels	elver	eels	elver
0			0.6		1		1.3	
1							2.7	
2			0.9		0.1		3	
3							2.5	
4			0.2		1.8		1.8	
5			0.7				2.4	
6	0.2				2.6			
7					2.1		2.5	
8			1.4		2.7			0.18
9								
	1990		2000		2010			
	glass		glass		glass			
year	eels	elver	eels	elver	eels	elver		
0			1.1			0.21		
1	2			0.44	0.68	0.2		
2	2.5			0.36	0.91	0.12		
3				0.54	0.89	0.13		
4	1.9			0.44	3	0.19		
5		0.15		0.37	1.87			
6	1.4			0.38	0.9	0.22		
7	0.9			0.33		0.31		
8	0.5			0.19	1.4			
9	2.3			0.42				

In L. Võrtsjärv, the largest amounts of glass eels were restocked in the late 1970s and early 1980s which resulted in the peak of recorded landings in 1988 (103.8 t, Figure 5). From year 2000 until 2010 only ongrown eels were restocked, stabilising landings for the forthcoming years. However from 2011 onward both ongrown and glass eels were introduced to L. Võrtsjärv (with 2014 being

the peak year of amounts of eel restocked). This led to probable rise in commercial landings in the near future.

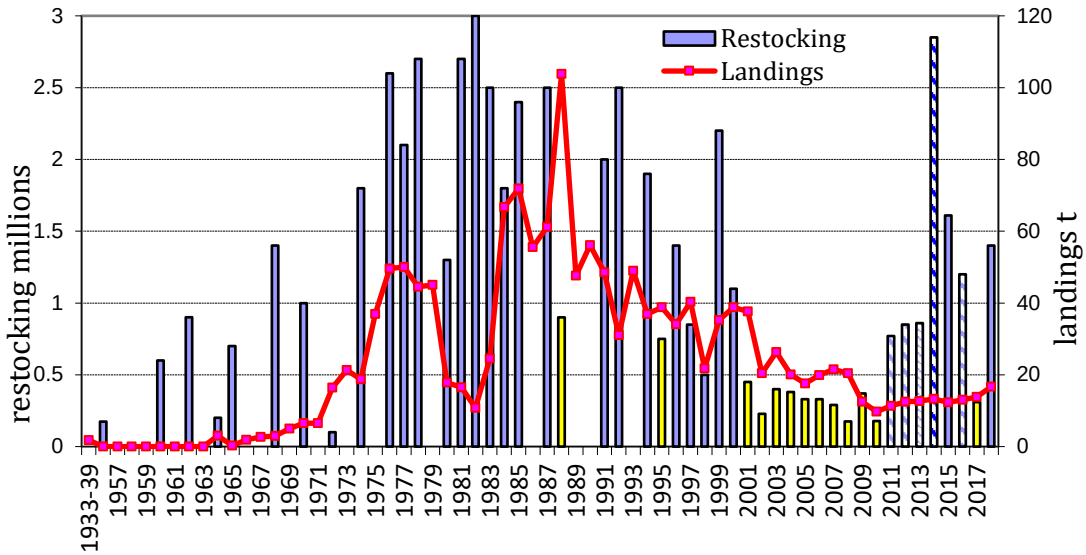

Figure 5. Time-series of amounts of eel restocked and commercial landings in Lake Võrtsjärv during period 1930s–2018. Purple bars denote years when only glass eels were restocked, yellow bars denote restocked ongrown eels and striped bars denote years when both glass- and ongrown eels were restocked.

3.3 Aquaculture

No data available.

3.4 Entrainment

In 2018–2019 an European Maritime Fisheries Fund project "The migration of silver eel on river Narva and estimation of penetrability through Narva Hydroelectric Station turbines" has been (project will finish in December, 2019) carried out on Narva Resrvoir and River Narva (Figure 6). In October 2018, a total of 45 alive silver eels (tagged with Vemco V9 coded transmitter tags, https://www.vemco.com/; mean TL = 700 mm) were released into the reservoir to measure the mortality caused by Narva Hydroelectric Station turbines.

Figure 6. Location of Narva Reservoir and the release spot of tagged eels. Red arrows show the migration route through River Narva. Light blue stripe marks the location of Narva Hydroelectric Station dam.

The turbines are large with 3 m diameter and rotate slowly at 60 RPM. For control, nine dead tagged specimens were released directly under the dam to see whether there is movement differences compared to the alive eels. Vemco VR2w receivers were submerged to both Narva Reservoir and also River Narva downstream from the HES (Figure 7). Also manual receivers were used to track the movement of tagged fish from the shore. All dead specimens remained close to the release spot giving good comparison to the ones that passed the turbines alive. By the time of writing this report (August 2019) 41 silver eels had passed through the turbines with 36 of them making it to the Baltic Sea alive. Five specimens were presumed to have died while passing through the turbines as they remained close to the control group under the dam. Four specimens remained still in the reservoir.

Figure 7. Location of Vemco VR2w receivers on Narva Reservoir and River Narva

On the assumption of aforementioned tagging study, we have concluded that the Narva HES turbines cause a mortality of **0.12** for passing silver eels. This value can slightly change as there is still a chance of the remaining four eels in the reservoir moving through the Narva HES turbines before the project ends.

3.5 Habitat Quantity and Quality

Narva RBD is shared with Russian Federation and the escapement of silver eel depends not only on measures put into practice in Estonia. The present EMP covers Estonian part of the basin and measures assure 40% of silver eel escapement applying only in territory under the jurisdiction of Estonia. The Narva RBD includes the fourth biggest lake in Europe, Lake Peipsi (Peipus) (355 500 ha), Lake Võrtsjärv (27 000 ha) and hundreds of small lakes and rivers. Most of the lakes in Narva RBD are relatively shallow and eutrophic, suitable habitats for eel. Feeding conditions are good and growth rate is rather rapid (6.9 cm/year in L.Võrtsjärv, Silm *et al*., 2017). Lake Peipsi is located on the border of the Republic of Estonia and the Russian Federation and consists of

three parts: the largest and deepest northern part L. Peipsi s.s. (area 261 100 ha, mean and maximum depth 8.3 and 12.9 m resp.), the middle part L. Lämmijärv (23 600 ha, 2.5 and 15.3 m) and the southern part L. Pihkva (70 800 ha 3.8 and 5.3 m). Altogether 157 000 ha belongs to Estonia. The catchments area 47 800 km^2 including the lake, covers territorial parts of Estonia ($^1/_3$) and Russia ($^2/_3$) (Pihu and Haberman, 2001). There are about 240 inlets into L. Peipsi. The largest rivers are the Velikaya (in Russia) and the Emajõgi connecting L. Peipsi with L. Võrtsjärv. The only outflow, the Narva River runs its waters (12 km^3 per year) into Gulf of Finland (Järvalt, 2008).

The second large lake in this basin is Võrtsjärv, very shallow and turbid lake with a surface area of about 27 000 ha and mean and maximum depths of 2.8 m and 6.0 m, respectively. Its drainage basin (310 400 ha, including 10 300 ha in Latvia) is situated in the Central Estonia. Small lakes where eel fishery take place in the basin, are L. Saadjärv (707 ha), L. Kuremaa (497 ha) and L. Kaiavere (250 ha) in Vooremaa district and L. Vagula (519 ha) in South Estonia (Järvalt, 2008).

3.6 Other impacts

No data available.

4 National stock assessment

4.1 Description of Method

4.1.1 Data collection

Data are collected by regular fykenets and an enclosure fykenet system in Narva RBD.

Data are collected annually during the fishing season (May–September). 100–200 specimens are collected from commercial fishermen to measure length and weight. Up to three regular fykenets (mouth opening 1–3 m, mesh size in the codend >18 mm) set in different locations in L. Võrtsjärv are used for collecting scientific samples.

Enclosure fykenet system was used on the small lakes of Narva RBD in 2018. The methodology was modified after Ubl and Dorow (2015). A random fishing area was selected taking the depth (as the leader nets of the system are 1.8 m high, the sampling spot should not be very deep) into account. The system was set for one week per sampling spot. Samples were collected twice a week. All eels caught were measured and weighted. Sex and silvering stage was determined. Also the occurrence of parasites and the type of food ingested was recorded. From a select sample, otoliths were extracted for age reading and possible micro-chemical analyses. Samples were taken from May until the middle of October 2018.

Collected otoliths were etched and stained with 1% HCl acid and neutral red solution according to the Swedish method (ICES, 2009).

West – Estonian RBD: University of Tartu was responsible for the scientific monitoring of eel. Small fykenets were used for annual monitoring. Six monitoring areas in the coastal waters have been surveyed since 1998. The gear is 55 cm high with a semi-circular opening and a leader or wing that is 5 m long. Fykes are made of 17-mm mesh in the arm and 10-mm in the codend. Mostly yellow eel were caught using this gear. Catch per unit of effort (CPUE) data were presented as an average number of eels caught per fyke/day by study years and monitoring areas (Bernotas *et al*., 2016)

Length and weight along with the CPUE of small fykenets. Otoliths are collected for age reading and micro-chemical analyses.

4.1.2 Analysis

Enclosure fykenet system (Ubl and Dorow, 2015) was used to determine approximate number of eels per hectare in L. Võrtsjärv in 2016–2017. Escaping silver eel biomass was calculated using these variables:

N – number of eels in lake according to enclosure fykenet catches

Ni – number of i-age group eels in the lake

F – commercial fishing mortality for given year

Fi – commercial fishing mortality of i-age group eels for given year

Pi – proportion of i-age group eels in commercial landings (%)

NRi – corrected number on i-age group eels in commercial landings according to enclosure fykenet data

Ji – number of i-age group eels in the lake after subtracting commercial fishing mortality for given year

Vi – escapement of i-age group eels for given year

k – correlation coefficent

M – natural mortality

$$F_i = \frac{F \times P_i}{100}$$

$$N_i = \frac{N \times P_i}{100}, if\ i = 9 - 14\ years$$

$$N_i = N_{i+1}\frac{Fi}{0{,}9}, if\ i = 6 - 8\ years$$

$$NR_i = N_i \times k, where\ k = \frac{N}{\sum_{i=6}^{14} N_i}$$

$$Ji = NR_i - F_i - M \times NR_i$$

$$V_i = J_{i-1} - J_i, if\ i = 10 - 14\ years$$

Analysis of mortality caused by hydropower facilities is described in paragraph 3.4.

4.1.3 Reporting

Results are reported annually to the Ministry of Environment and ICES.

4.1.4 Data quality issues and how they are being addressed

As of now, yellow and silver eel are reported together in commercial landings, which makes silver eel escapement calculations based on the commercial landings data difficult. Also under-reporting exists in commercial landings.

4.2 Trends in Assessment results

The stock indicators of Narva RBD have been reported since 2016. According to our findings the escaping silver eel biomass ($B_{current}$) has decreased over the period of 2016–2018 while fishing mortality has had a slight increase (Figure 8). One of the reasons behind the decrease in $B_{current}$ is that younger age groups are starting to appear in the official landings (see Chapter 5.3). According to methodology described in paragraph 4.1.2 the biomass of commercially targeted eel (TL>55 cm) in L. Võrtsjärv was ~466 000 specimens which is 18% less than in 2016. At the end of the first decade in 2000s, the restocking amounts also decreased (Table 3), playing an important role in the decrease of the biomass indicators. Fishing mortality during the period 2016–2018 has risen from 0.05 to 0.09 however the number of commercial fishing gear has stayed the same.

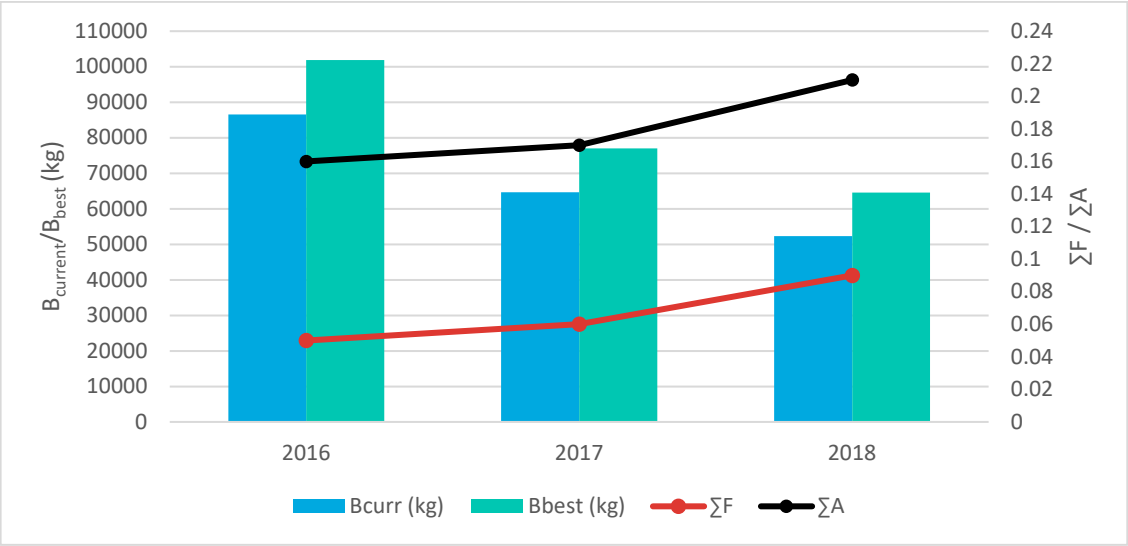

Figure 8. Changes in the amount of silver eel biomass that currently escapes to the sea to spawn (in the assessment year; $B_{current}$), the amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the current stock (B_{best}), ∑F = mortality due to fishing, summed over the age groups in the stock (rate), ∑A = all anthropogenic mortality summed over the age groups in the stock (rate) in Narva RBD during period 2016–2018.

5 Other data collection for eel

5.1 Yellow eel abundance surveys

See ICES, 2018.

5.2 Silver eel escapement surveys

See Chapter 4.1.2.

5.3 Life-history parameters

In 2018 an Environmental Investment Centre project "Estimation of eel abundance on the small lakes of Lake Peipsi basin" was carried out on L. Saadjärv, L. Kuremaa, L. Kaiavere and L. Vagula (the latter is excluded in this paragraph due to insufficient data). One of the goals of the study was to measure growth rates of restocked eels in these waterbodies and compare the results to L. Võrtsjärv. Restocking densities per hectare in the small lakes are much higher than in L. Võrtsjärv and this reflects also in the growth rates (Figure 9).

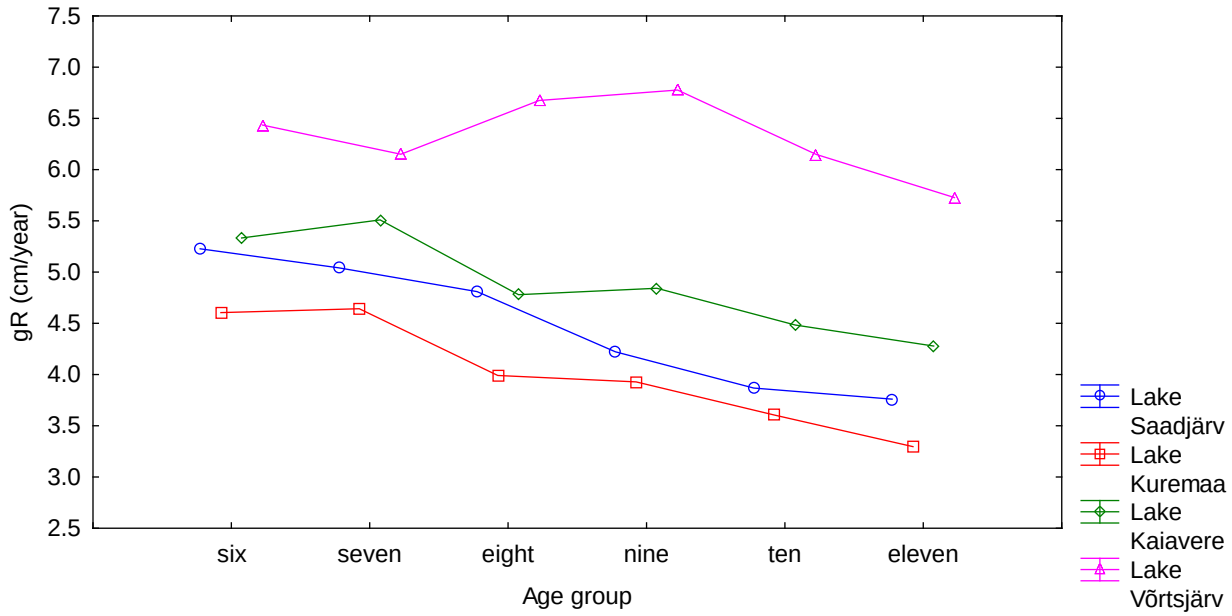

Figure 9. Growth rates of studied eels from L. Saadjärv (N=78), L. Kuremaa (N=60), L. Kaiavere (N=108) and L. Võrtsjärv (N=144).

Studied eels from small lakes showed a substantially different diet than their L. Võrtsjärv counterparts. In L. Võrtsjärv the most common food object for eels was the larvae of *chironomidae* with fishroe being second and different small fishes third. In the small lakes fish roe was prevalent in eels diet, while larvae of *chironomidae* was discovered only from samples collected in L. Saadjärv and L. Kaiavere. Higher competition for food resources in the small lakes can also play a role in the slower growth compared to L. Võrtsjärv.

50 eels were caught from L. Võrtsjärv using regular survey fykenets in 2018 and 113 specimens were also analysed from same type commercial fykes. The mean length and weight of caught

specimens was TL=59.7 cm and TW=391.4 g respectively. Compared to 2017, mean length of caught specimens had decreased by 2% and mean weight by 24%. Most of the eels caught (68%) were FII stage yellow eels belonging to age groups 7 and 8. During the period 2002–2010 only ongrown eels were restocked to L. Võrtsjärv. Starting from 2011 glass eels have also been introduced annually (excluding year 2017, see ICES, 2018) and these fish start to appear in the commercial catches (Figure 10).

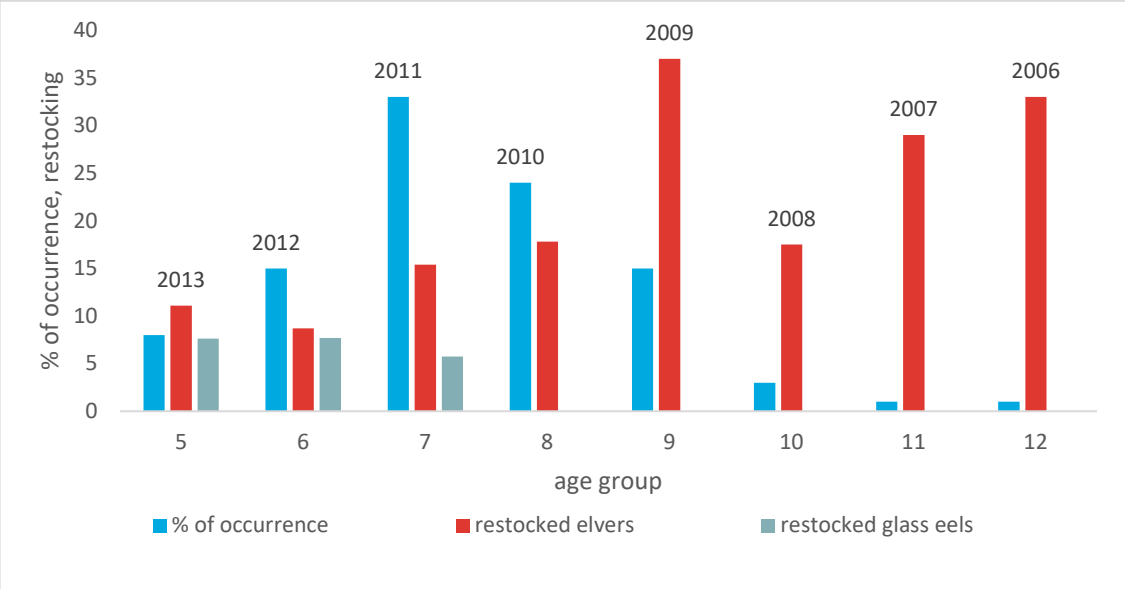

Figure 10. Age structure of eels (N=100) caught by survey and same type commercial fykenets from L. Võrtsjärv in 2018. Blue columns show the percentage of occurence of certain age group in the catch. Red and grey columns present the number of glass eels (*10^5) and ongrown eels (*10^4) restocked along with the year of restocking. Each age group derives directly from certain year batch of restocked eels.

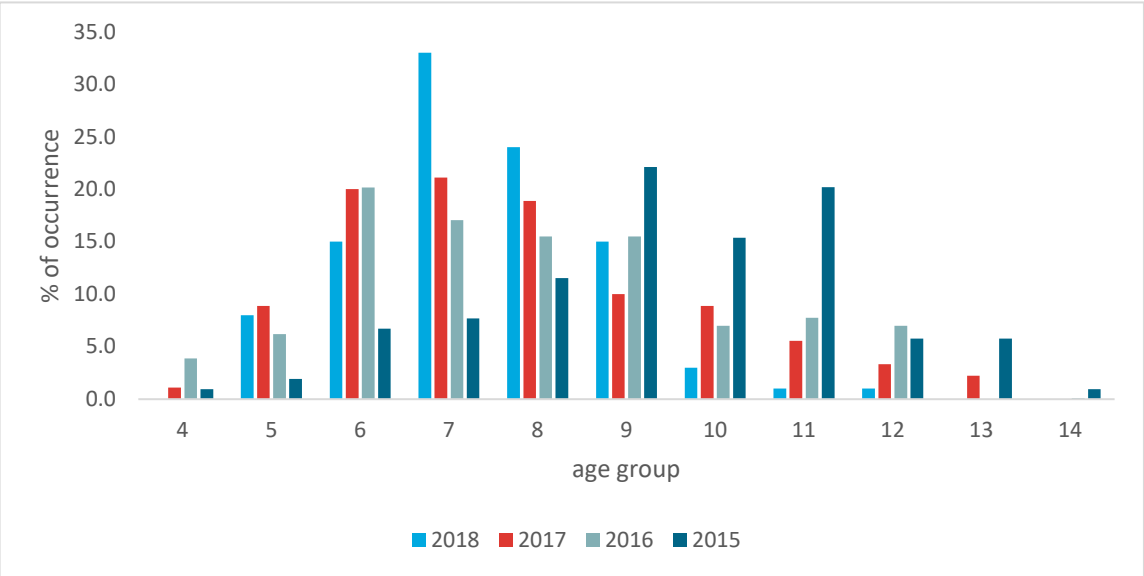

Figure 11. Occurrence of different age groups in the fykenets in L. Võrtsjärv over the period 2015–2018.

As comparison between the last four years composition of different age groups in fykenet catches demonstrates (Figure 11), appearance of younger eel age groups is rising in the fishery. In 2015 the dominating age group in the fykenet catch was age group 9 (restocked in 2006 as elvers) while in 2018 the most prevalent age group was 7 (restocked in 2011 as both glass eels and elvers).

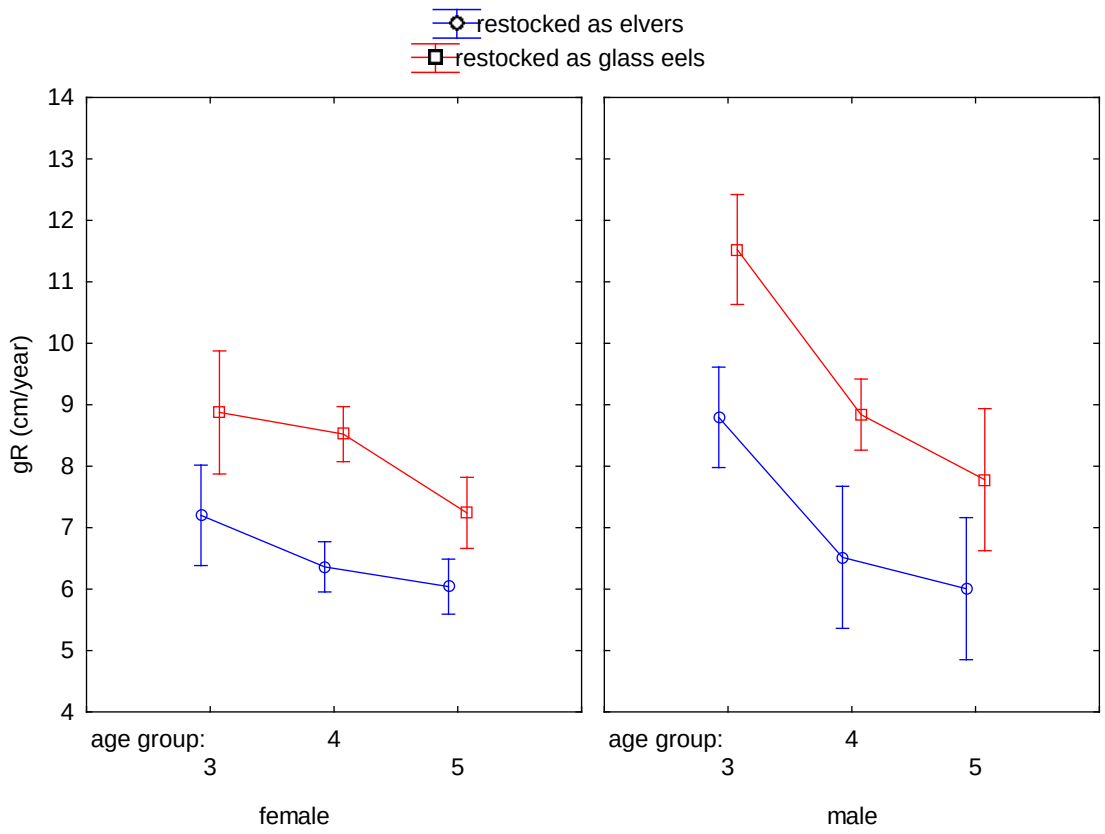

Figure 12. Growth rates for female and male eels (restocked as either elvers or glass eels) by age group in L. Võrtsjärv (Roslender, 2019).

In L. Võrtsjärv growth rate analysis for age group 3–5 male and female eels indicated that both sexes grow faster when restocked as glass eels as opposed to being restocked as elvers (Figure 12). The difference in female growth rate during the early years after restocking explains appearance of younger age classes in the fykenet catch as they reach the legal size limit earlier. It is however interesting that male eels tend to grow faster from their female counterparts in L. Võrtsjärv. Explanation for this was hard to find but most likely growth parameters in early life history (unsexed eels with rapid growth become males, Holmgren *et al.*, 1997) coupled with rich food sources play the biggest role.

5.4 Diseases, Parasites and Pathogens or Contaminants

In 2018, samples for swimbladder parasite *Anguillicoloides Crassus* spp were collected from L. Võrtsjärv and small lakes of Narva RBD (in conjunction with the project described in paragraph 5.3). Our results showed that the highest percentage of *A. Crassus* among the studied samples was found in L. Saadjärv and L. Vagula (65% of studied eels were infected in both lakes, Figure 13). In other studied waterbodies the prevalence of the nematode was somewhat lower (48–50%). However intensity of infection (parasites per fish; Bush *et al.*, 1997) was highest in L. Vagula and L. Võrtsjärv (N_{mean}=6; Figure 13).

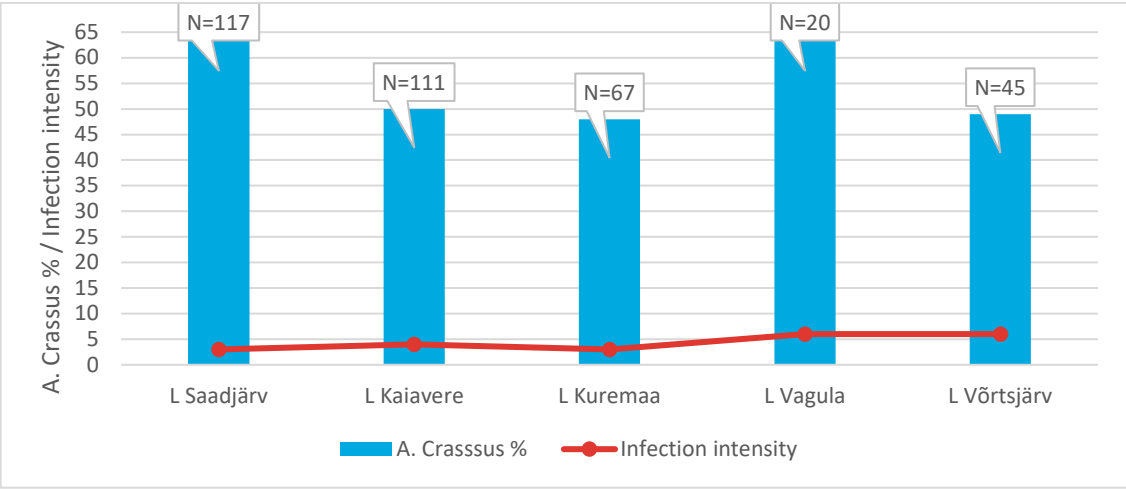

Figure 13. *Anguillicoloides Crassus* spp prevalence (%) and mean infection intensity (parasites per fish) in studied Estonian waterbodies in 2018. Data label N mark the number of eels sampled.

In L. Võrtsjärv the infestation hadn't changed in 2018 compared to 2017 (ICES, 2018). As stated in ICES, 2018, it can be concluded the infection intensity may affect the swimming speed of eels (Sperngel and Lüchtenberg, 1991) and also the possibility of reaching spawning grounds in the Sargasso Sea.

6 New Information

In 2019 a Cross Border Cooperation Programme (https://estoniarussia.eu/) project ESTRUSEEL was implemented. The main objective of the project is to assess the distribution and origin of the eels residing in the shared waterbodies of Estonia and Russia (most notably Lake Peipsi and Narva Reservoir). Data will be collected in the period 2019–2021 and the project concludes in early 2022.

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Report on the eel stock, fishery and other impacts, in Finland

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Reporting Period: This report was completed in August 2019, and contains data up 2018 and some provisional data for 2019

1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

No available data.

1.2 Recruitment time-series

No available data.

2 Overview of the national stock and its management

2.1 Describe the eel stock and its management

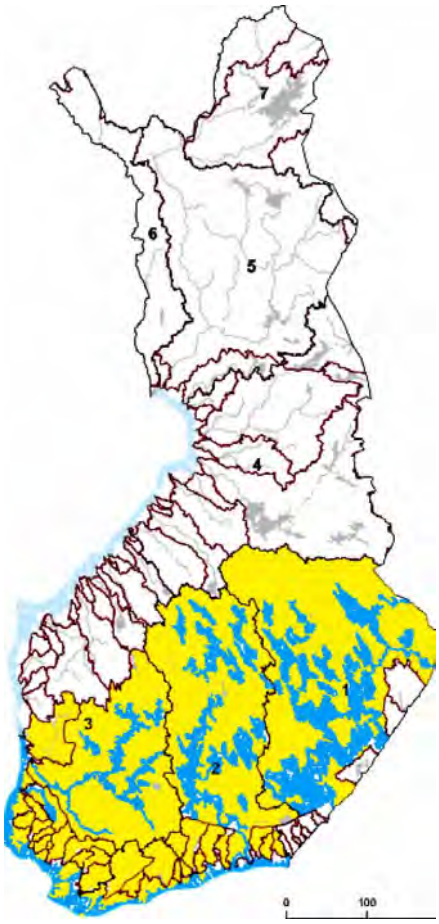
There are not available data to provide stock indicators of silver eel escapement biomass and mortality rates. In Finland eels are on their northeastern limits of natural geographical distribution. Natural eel populations have probably always been very sparse, and the overall importance of the species has been low. In freshwaters only in few areas in southern parts of the country eel have been a target in the recreational fisheries. According to old fishermen the catch and the importance of eel to local fisheries were still high in 1940–1960 in some parts of the Gulf of Finland, mainly in the estuary of the river Kymijoki and east of the city of Kotka. Also in Finnish Archipelago, eel was a common species at that time. Almost all rivers running to the Baltic are closed by hydroelectric power plants. Natural eel immigration is possible only in few freshwater systems near the coast and in the coastal areas of the Baltic. Eel populations and eel fisheries in Finnish inland waters depend almost completely on introductions and re-stockings. First introductions were conducted in 1893 but until now the most numerous introductions were made in the sixties and 1970s. During the years 1979–1988 it was not allowed to import eels because eel was detected to be a possible carrier of some viral fish diseases. For this reason it was decided in 1989 to carry on re-stockings only with glass eels reared in a careful quarantine. Since then glass eels originating from River Severn in the UK have been imported through a Swedish quarantine and re-stocked in almost one hundred lakes in Southern Finland and in the Baltic along the Southern coast of Finland.

Finnish EMP covers the whole Finnish national territory as one eel river basin. It is bounded to the ICES Ecoregion Baltic Sea.

Terms used in the EMP to define natural habitats for the eel were:

- outlet of the river basin is in Finland's national territory;
- there has been natural immigration of elvers before the damming of the rivers;
- there have been considerable stockings lately;
- there has been regular eel fishery.

On the grounds of the terms two categories with few subcategories were defined:



a) Area of free migration includes all coastal waters of the Baltic and the inner archipelago to the depth of ten meters and the few small undammed river basins running to the Baltic. The area was subdivided into two categories:
   1. Reserve area (the Bothnian Bay area) where eels exist but for climatically and geographical reasons have always been very rare. Light blue area in the map. Total area is 1783 km².
   2. Main management area for the eel (the Gulf of Finland and the small undammed river basins running to it). Deep blue coastal area in the map Total area is 4677 km² for the coastal area and 382 km² for the small river basins. According to EMP stockings in this area compensates in the long run the loss of silver eels in freshwaters.

b) Area where immigration of elvers is totally prevented because of the dams and the hydroelectric turbines in the dams have a severe negative effect on the escapement of silver eels. This area includes three major freshwater river basins; Vuoksi (number 1 in the map), Kymijoki (number 2) and Kokemäenjoki (number 3), and also some small water basins running to the Baltic. Yellow area in the map, main lakes in the area are coloured in deep blue. Total area is 20 509 km². No management actions take place in this area.

The management actions are directed towards the free migration area complex (a1, see above). Meanwhile, the management measures are not directed towards the dammed waters area complex (b, see above). The theoretical (40% objective) natural eel production of dammed waters area was thought to be compensated by directing the substitutive additional measures towards the free migration area.

In the short term, the restocking measures in the EMP were greatly increased. It was calculated that the total amount of glass eels needed for stocking purposes in first few years was about 530 000 specimens annually and 1 070 000 specimens annually thereafter. In the long term, the purpose of restocking measures was to rebuild a sustainable eel stock in the free migration area complex. After this the restocking measures may gradually be cut down. The catch of eel fisheries was also to be monitored. Should the catch level rise too high in order to achieve the objective, proper restraint measures in fisheries should be applied accordingly.

The Finnish EMP was adopted in January 2010. No extra finance was given to fulfil the stocking plan. In eight years since then just about 1,1 million eels have been stocked in total. And of those 40–60% have been paid by private water owners to benefit the local fisheries in the sea or in the freshwaters.

2.2 Significant changes since last report

Since October 2018, catching of eels is prohibited in four months (October–January) in sea and freshwaters both in commercial and recreational fishery. For every illegally caught eel, there has been an administrative penalty fee of 3510 € since 1.5.2019.

3 Impacts on the national stock

3.1 Fisheries

Finnish eel catches are very low and there are no fisheries targeting eel. Annual catch estimates are available for professional and biennial for recreational fisheries. Earlier studies suggest, that most eels in Finland originates from restocking programmes. It is possible to get limited number of eel samples from the fykenet fisheries bycatch.

3.1.1 Glass eel fisheries

There is no glass eel fishery in Finland as glass eel doesn't exist there.

3.1.2 Yellow eel fisheries

There are no specific data on yellow eel fisheries. Since 2008, the total professional marine eel landings (yellow and silver together) have varied between 609–2300 kg/year based on annual logbook data. In freshwater commercial fisheries, a new logbook based registry was implemented form 2016 onwards. As result the landings of commercial fisheries was reported and the catch was 36 kg in 2016 and 23 kg in 2017. Results for 2018 will be available October 2019. In recreational fisheries the landings in freshwater have varied between 3000–11 000 kg/year and in the sea between 2000–13 000 kg/year. In recreational fisheries landings are based on data collected by questionnaires every second year. Data are collected with a postal survey. The sample is taken from the population information system maintained by the Population Register Centre. Data are collected from household-dwellings, the statistical unit of the survey. The big variation in the eel landings is mainly explained by the small sample size of only 6000–7000 households.

Table 1. Commercial landings (kg) of eels (yellow and silver together) in freshwaters and sea from 2008 to 2018. Commercial freshwater landings includes "Trap and transport" fish from freshwater to the sea in one location in 2014–2018, EMU = Fl Finl.

Year	Commercial Fresh	Commercial Sea	Fl Finl alltogether
2005			
2006	0		
2007			
2008	0	1000	1000
2009		1800	1800
2010	0	2300	2300
2011		1549	1549
2012	0	1539	1539
2013		1307	1307
2014	287	1021	1308
2015	503	609	1112
2016	475	1277	1726
2017	328	1045	1350
2018	542	1064	1606

Table 2. Recreational landings (kg) of eels (yellow and silver together) in freshwaters and sea from 2008 to 2018. EMU = Fl Finl.

Year	Recreational Fresh	Recreational Sea	Fl Finl altogether
2005			
2008			
2007			
2008	4000	13000	17000
2009			
2010	9000	1000	10000
2011			
2012	3000	2000	5000
2013			
2014	11000	9000	20000
2015			
2016	1000	7000	8000
2017			
2018	in October 2019	in October 2019	

No available data on effort.

3.1.3 Silver eel fisheries

There are no specific data on silver eel fisheries. See 3.1.2.

3.2 Restocking

No wild glass eels migrate to Finnish coast. Earlier studies have shown, that all naturally migrating eels have reached yellow eel stage when arriving to Finnish waters. Instead, glass eels captured elsewhere are restocked to Finnish waters. All restocked glass eels are labelled with strontium chloride since 2009.

In last 28 years glass eels have been imported and stocked into Finnish freshwaters and coastal waters through a Swedish quarantine (Scandinavian Silver Eel). Origin of those glass eels have been mainly England (River Severn estuary). After the Finnish EMP approval in 2010, 1,5 million individuals (mean weight 1 g) have been stocked. Roughly a little bit more than half of the eels have been stocked into coastal waters where they can freely leave for spawning migration. About 20% of those stocked into freshwaters are stocked in lakes which are directly connected to the sea or there is only one small dam between them and free migration.

Table 3.

Year	Freshwaters (no migration connection to the sea, or above hydroelectric dams)	Costal (free to migrate)	Fl Finl alltogether
2005	20 500	43 500	64 000
2006	37 400	17 600	55 000
2007	68 500	38 500	107 000
2008	195 700	10 300	206 000
2009	113 300	4700	118 000
2010	75 000	78 000	153 000
2011	134 000	172 000	306 000
2012	109 000	68 000	177 000
2013	100 000	97 000	197 000
2014	85 000	62 000	147 000
2015	61 000	41 000	102 000
2016	40 000	39 000	79 000
2017	61 500	59 000	120 500
2018	22 500	59 000	81 500
2019	28 000	106 500	134 500

3.3 Aquaculture

At the moment there is no eel aquaculture in Finland. In 2013 40 000 glass eels (ongrown ~1 g) were imported to aquaculture through the Swedish quarantine. According to the fish farmer (Polar Fish) in 2014 and 2015 the import was 50 000 glass eels annually. In 2016 and 2017 no glass eels were imported there anymore.

Production was about 500 kg in 2014 and also in 2015. This is not official information but based on the discussions with the one and only eel farmer in the country. Farming was experimental and conducted in a recirculation system. There were still some eels in the farm in 2016–2017 but the farm was going out of the business due to slow growth of the fish and economic reasons.

3.4 Entrainment

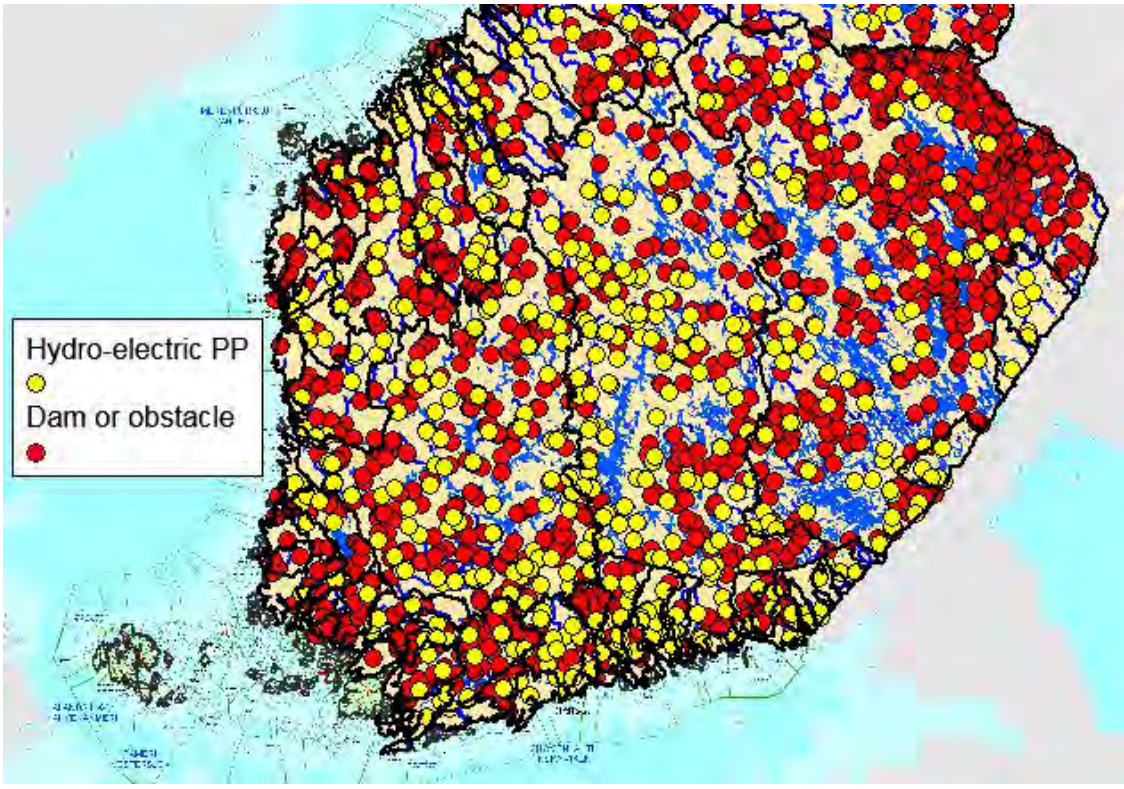


Figure 1. Hydro-electric power plants and other dams in Finland.

In southern Finland all big rivers are totally blocked for upriver migration. There are several hydroelectric power plants with turbines. Also downstream migration for eels is almost impossible and mortality is high but unknown.

In the coastal area some small watercourses from Virojoki to Vaasa migration is still possible both ways.

3.5 Habitat, Quantity and Quality

In the Vuoksi watercourse (brown in the map) eels have hardly existed because of the rapids in Imatra have been too rough even for eels to climb up. Nowadays there are electric power plants in the rapids. Otherwise the habitats are suitable growing areas for eels.

Lower reaches of the Kymijoki watercourse (blue in the map), Kokemäenjoki watercourse (red in the map) and the small coastal watercourses in the south and in the west (green in the map) have been the main distribution area of eel in Finland. All those watercourses are excellent growing areas for eels. But in Kymijoki and Kokemäenjoki watercourses there have been several hydroelectric dams since 1920–1930 and upstream migration has been impossible since that. All eels there originates from stockings. Downstream migration is possible but high mortality in turbines have been observed in both watercourses.

Of the 108 500 hectares in the small coastal watercourses from Vaasa in the west to Virojoki in the east only 37 800 hectares are still accessible for eels. From those areas it is also possible for eels to migrate downstream freely. In the same coastal region there are still over 4 million hectares of suitable growing areas for eel in the Baltic (from shoreline to the depth of 10 meters) where free migration is possible.

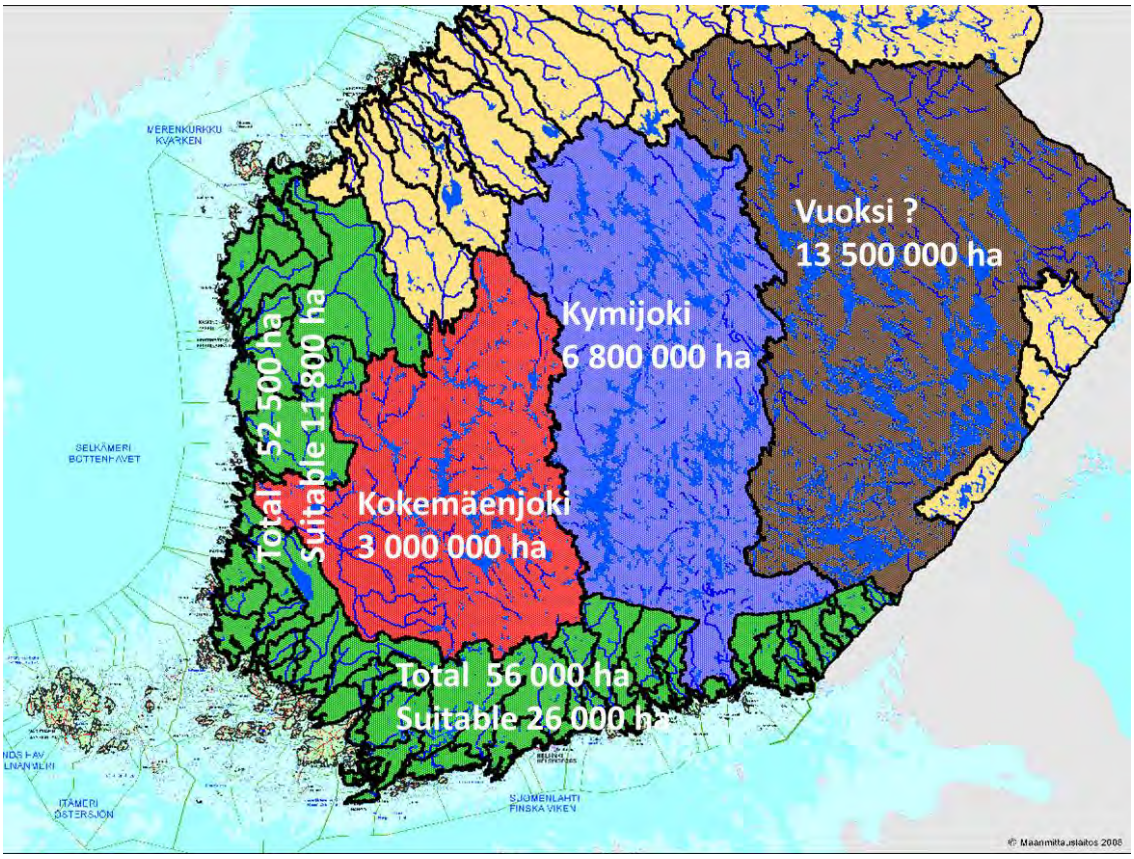


Figure 2. The three main watercourses and the small coastal watercourses in southern Finland and their water areas in hectares. Only in the coastal watercourses there is some 30 000 hectares of suitable habitats left for natural immigration on eels. In all other areas the populations originates from stockings.

3.6 Other impacts

No data.

4 National stock assessment

4.1 Description of Method

4.1.1 Data collection

An index for the abundance of yellow eels and silver eels along the Finnish coast is obtained from fisheries statistics. Both yellow and silver eels are caught as bycatch in professional and recreational fisheries. Eel has been also included in the EU Data Collection Programme in Finland since 2017. Since that samples are collected along the Finnish coast to estimate the share of yellow/silver eels and restocked/wild eels (on the basis of strontium chloride label, only for individuals from year-class 2009 and later). Samples are collected in two locations in inland waters as well: Vesijärvi (Kymijoki watershed) and Kulovesi (Kokemäenjoki watershed), where all eels are supposed to be of restocked origin due to migration barriers.

Samples have been collected in freshwaters with the help of local recreational fishermen and in the sea by professional fishermen. Fish have been collected mainly alive from the fishermen but occasionally also as frozen. In few cases the fishermen have measured (weight and length) the fish and delivered the head and the guts together with the length/weight data to Luke where otoliths have been removed and swimbladder examined for Anguillicola.

For every fish following information has been collected:

- Catching date and killing date
- Catching site
- Fishing gear
- Length
- Weight
- Sex
- Colour (sides and belly)
- Vertical and horizontal diameter of the eye
- Weight of the gonad (only occasionally)
- Anguillicola (no/yes, how many, size).

So far when age analysis has been done grinding and polishing method has been used, Swedish style as described in ICES, WKAREA Report 2009 in Bordeaux. Lately, also cutting slices with otolith saw and etching using EDTA and staining using neural red has been used.

An index for the silver eels migrating from Finland is obtained from two sites. There is an eel trap in the river Vääksynjoki and an echosounder (DIDSON) in Kokemäenjoki under the lowest hydropower dam. Vääksynjoki is running from Lake Vesijärvi in the upper reaches of the Kymijoki watercourse, 150 km from the sea. The eels caught in this trap are tagged and released into the sea at Kymijoki estuary (below hydropower dams). All eels are originally restocked in the lake Vesijärvi. During 2014–2018 1383 eels have been caught and transported to the sea. This year until the end of June an additional 414 eels have been caught. In total 2,7 tonne of eels have been transported over the hydroelectric power plants.

Table 4. Eel catches in the river Vääksynjoki during 2014–2018.

	n	mean length, cm	(min-max)	mean weight, g	(min-max)
2014	189	95	(79-115)	1520	(744-2637)
2015	337	93	(71-119)	1492	(743-3060)
2016	298	93	(65-113)	1506	(450-2610)
2017	193	94	(85-113)	1581	(634-3394)
2018	366	93	(73-116)	1482	(730-2752)

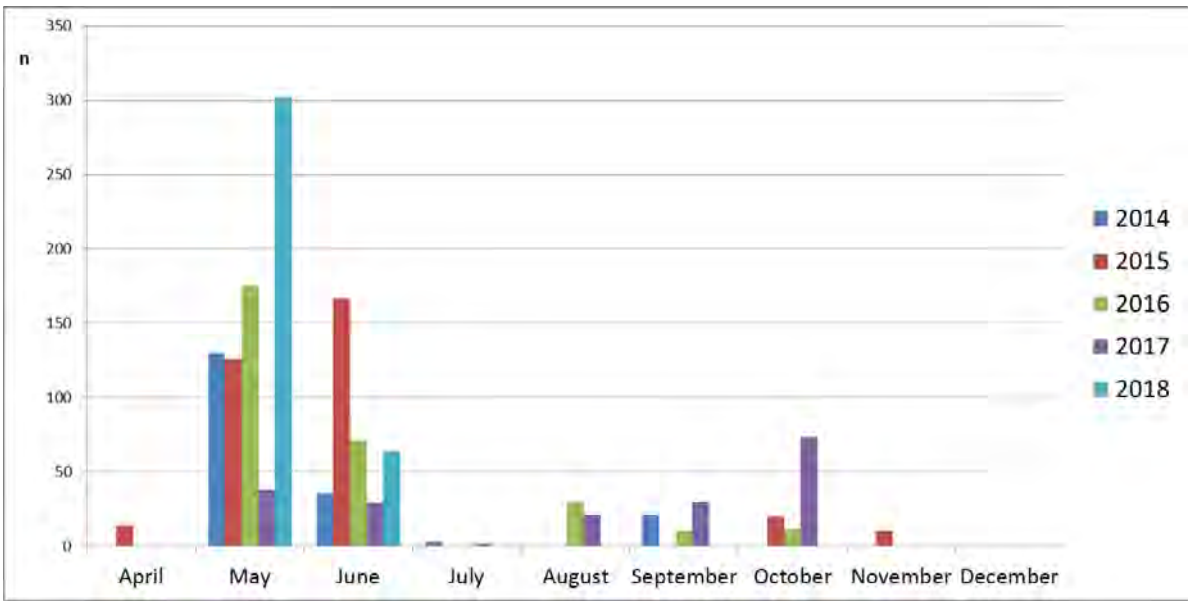


Figure 3. Seasonal variation in the silver eel catches in the trap in the river Vääksynjoki.

DIDSON has been used in autumns in 2011 and 2012 and in spring in 2013 to monitor downstream migration of silver eels in Nokia in the upper reaches of the Kokemäenjoki watercourse above the uppermost dam. In autumn 2013 monitoring was done in Pämpinkoski downstream the same watercourse below the five electrical power plants. Observations are presented in the table below.

DATE	OBSERVED IND.	MEAN LENGTH, CM	RANGE, CM
Nokia			
12.9–11.10.2011	221	90,5	63–123
27.9–8.11.2012	314	85,6	51–111
17.4–13.5.2013	98	89,1	61–115
Pämpinkoski			
11.9–23.10.2013	122	81,8	47–112

In 2018 autumn monitoring was done few kilometres downstream Pämpinkoski only few kilometers from the sea. The river is there rather wide (80 m) and only part of it (20–40 m) is covered by the DIDSON. The activity of the eels was at its peak in the second half of October, 113 eels were observed, half going downstream and half upstream. It is unclear how many true migrating silver eels there were, and which were of the local population of yellow eels. Water level and stream velocity fluctuates there greatly daily due to the electric power plants upstream and might also mix up the orientation of the migrating eels.

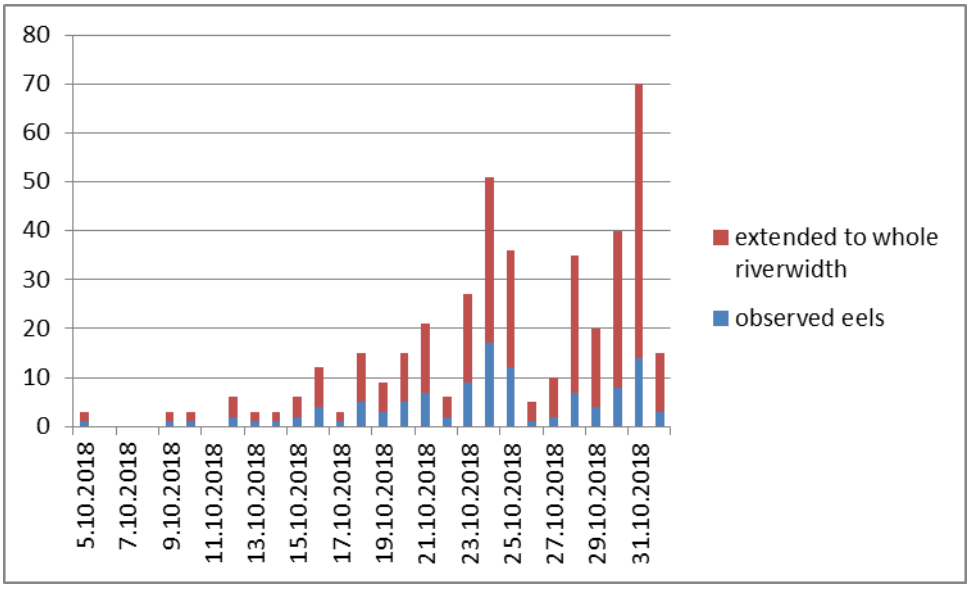


Figure 4. Eel activity in the lower reaches of the River Kokemäenjoki in autumn 2018. Both upstream and downstream migrating eels included.

This year is the first time monitoring is possible through the whole ice free period. It began in May and lasts until November. DIDSON is installed in Pämpinkoski where the eels previously were mostly migrating downstream and were it is possible to cover almost 60–80% of the river width.

4.1.2 Analysis

None.

4.1.3 Reporting

None.

4.1.4 Data quality issues and how they are being addressed

No data.

4.2 Trends in Assessment results

No available data.

5 Other data collection for eel

5.1 Yellow eel abundance surveys

See 4.1.1

5.2 Silver eel escapement surveys

See 4.1.1

5.3 Life-history parameters

During 1974–1994 over 2000 eels were collected in thirty lakes and in some lake outlets in southern Finland. Length, weight, eye diameter, colour of the sides and belly, sex and weight of the gonads (not always) were determined and after 1986 also swimbladders were examined for Anguillicola. Age and growth were also determined. The aim of the study was to evaluate the biological outcome of eel stockings made in 1960s and 1970s and to estimate the yield to fishery and the proportions of eels escaping the lakes. The results were published mainly in 1980s (Pursiainen and Toivonen, 1984; Pursiainen and Tulonen, 1986; Tulonen, 1988; Tulonen, 1990; Tulonen and Pursiainen, 1992).

There were no routine biological sampling programmes or eel research projects during 1994–2005. Some occasional samples were taken in few lakes for the authors' personal interest. Also in some small water systems silver eel escapement has been monitored since 1974 (one place), 1980 (two places) and 1989 (two places) with eel boxes in the outlets. Eels in the lakes have been restocked there in 1967, 1978 and 1989 respectively.

In 2006 a four-year study on the biological and economical outcome of eel stockings made since 1989 and on the state of natural eel stocks was established in FGFRI. The main goal was to compile the facts and other biological data about eels in Finland to the Eel Management Plan. In the study some sampling was also done in ten lakes in southern Finland and in eight areas in the Baltic along the coasts of Gulf of Finland and Bothnian Bay and in the rivers running into them. Due to sparse populations the sample sizes are only in few cases big enough (>100 individuals) to make any scientific evaluations. Since 2010 there has been sampling in the most interesting locations.

In recent years, there has been eel marking programs going on to shed some light into migratory behaviour of restocked eels.

5.4 Diseases, Parasites and Pathogens or Contaminants

One sample of "natural" elvers has been collected in 2002 in southwest Finland and on the coast of the Bothnian Bay. One third of the elvers were infected with Anguillicola. This was the first time Anguillicola ever found in Finland (Tulonen, 2002). Since then Anguillicola has spread almost to every eel population in the sea and after 2007 also to some freshwater populations where it is still spreading.

The concentrations of radionuclides 134Cs and 137Cs and PCB in eels were investigated in 1995 (Tulonen and Saxen, 1996; Tulonen and Vuorinen, 1996).

6 New Information

None.

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Report on the eel stock, fishery and other impacts, in Germany 2019

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1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

In Table 1, the most recent data on assessed areas and stock indicators for the relevant German RBD's are given.

Table 1. Stock indicators of silver eel escapement, biomass and mortality rates, and assessed habitat area. EMUs averaged from 2014–2016 (Fladung and Brämick, 2018).

Year	EMU_code	Assessed Area (ha)	B_0 (t)	B_{curr} (t)	B_{best} (t)	Bcurr/B_0 (%)	∑F	∑H	∑A
2014–2016	DE_Eide[4]	468 783	1708	638	659	37.34	0.01	0.01	0.03
2014–2016	DE_Elbe[2]	201 019	1553	101	38	6.48	1.15	0.27	1.42
2014–2016	DE_Ems[2]	44 088	820	176	87	21.41	0.11	0.01	0.12
2014–2016	DE_Maas[1]	892	9	0	0	0.67	0.73	0.11	0.84
2014–2016	DE_Oder[2]	80 366	373	91	82	24.48	0.20	0.00	0.21
2014–2016	DE_Rhei[1]	61 065	532	223	8	41.98	0.26	0.64	0.89
2014–2016	DE_Schl[3]	333 379	4205	2038	2029	48.47	0.03	0.00	0.03
2014–2016	DE_Warn[3]	368 309	1367	1441	1486	105.36	0.07	0.00	0.07
2014–2016	DE_Wese[2]	55 472	730	130	47	17.81	0.34	0.20	0.54

Key:

EMU_code = Eel Management Unit code (see Table 2 for list of codes)

B0 = the amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the stock (kg)

Bcurr = the amount of silver eel biomass that currently escapes to the sea to spawn (in the assessment year) (kg)

Bbest = 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.

[1] **Inland waters**

[2] **Inland and transitional waters**

[3] **Inland and coastal waters**

[4] **Inland, transitional and coastal waters**

1.2 Recruitment time-series

At present, three German recruitment time-series are included in the international assessment (Frische Grube ('WiFG'), Wallensteingraben ('WisW'), Dove Elde eel ladder ('DoEl')).

Since the early 2000s, immigration and upstream migration of young eels have been monitored on some locations in Mecklenburg-Pomerania (Ubl and Dorow, 2010; Frankowski, 2015), as summarized in earlier WGEEL reports and the ICES data call. Since these time-series did not assess elvers and glass eels separately, a new time-series was set up in 2015 directly in the Warnow River, where elvers and glass eels are reported separately.

As part of an EFF funded project the North Rhine Westphalian State Agency for Nature, Environment and Consumer Protection (LANUV) tested a methodology for determining natural recruitment at several locations in river systems Rhine, Ems, and Meuse. Only few eels were caught. Reliable quantitative data are to be expected only in case of a significant increase in the natural recruitment. The findings are used and the method is applied in an ongoing stocking project (2016–2019), financed by the EMFF. The project ends in 2019 and the results will therefore be available in 2020.

In Schleswig-Holstein there are currently three monitoring stations for ascending eel, all of them within the Eel management unit (EMU) Eider. The monitoring is trend based as the catching system (trapping ladder) is not able to catch quantitatively due to the lack of an appropriate location concerning technical feasibility. The monitoring station in Verlath ('Verl') is the one which has been running the longest, since 2010. Two other stations are located in the waterbodies Broklandsau ('Brok') (since 2012) and Soholmer Au ('Lang') (since 2015).

Further monitoring activities have been started in the recent years in the EMUs Ems ('EMS-H', 'Ems-B') (Salva, 2013; Salva *et al*., 2014–2017; Simon *et al*., 2016; 2017a) and Rhine (pers. comm. Karin Camara). However, these new activities are so far not considered "time-series". Another Ems series summarized historical data on commercial glass eel landings between 1946 and 2001 (data not shown in Table 2). Methodical details and effort of this series are not well known and values are not comparable to other Ems series.

Table 2. Numbers of ascending eels caught at German monitoring stations. Effort data are not presented here. Source: ICES Data Call 2019.

Series	WiFG	WisW	DoEl	WaSG	WaSE	Farp	DoFp	Verl	Brok	Lang	HoS	HHK	Ems-H	Ems-B
EMU	DE_Warn	DE_Warn	DE_Elbe	DE_Warn	DE_Warn	DE_Warn	DE_Elbe	DE_Eide	DE_Eide	DE_Eide	DE_Eide	DE_Eide	DE_Ems	DE_Ems
Life Stage	GY	GY	Y	G	Y	GY	Y	GY	GY	GY	GY	GY	G	GY
2003	na	na	1,981	na	na	na	2,365	na	na	na	na	na	na	na
2004	na	173	676	na	na	na	3,145	na	na	na	na	na	na	na
2005	na	153	721	na	na	na	2,861	na	na	na	na	na	na	na
2006	17	123	1,035	na	na	na	3,124	na	na	na	na	na	na	na
2007	19	296	890	na	na	101	2,440	na	na	na	na	na	na	na
2008	81	509	542	na	na	67	1,395	na	na	na	na	na	na	na
2009	4	238	na	na	na	25	na	na	na	na	na	na	na	na
2010	0	614	62	na	na	29	2,659	28,772	na	na	1	155	na	na
2011	0	113	2,024	na	na	84	3,236	10,888	na	na	na	171	na	na
2012	2	35	1,523	na	na	14	4,386	9,952	440	na	na	34	na	na
2013	0	39	350*	na	na	8	630*	7,409	338	na	na	13	na	14,802
2014	10	8	49	na	na	200	344	9,425	770	na	na	na	1,760	43,371
2015	17	55	278	6	58	72	1,209	10,879	1,467	307	na	na	524	1,488
2016	2	1,299	259	468	43	194	742	12,810	2,090	244	na	na	1,569	4,816
2017	8	490	18	118	138	292	1,464	20,461	2,460	274	na	na	1,430	3,930
2018	44	293	60	110	56	191	2,805	13,274	1,820	260	na	na	2,089	4,313

Key: Recruitment series: WiFG: Frische Grube; WisW: Wallensteingraben; DoEl: Dove Elde eel ladder; WaSG: Warnow Scientific Glass eel monitoring; WaSE: Warnow Scientific Elver monitoring; Farp: Farpener Bach; DoFp: Doemitz fishpass; Verl: Verlath Pumping Station; Brok: Broklandsau Pumping Station; Lang: Langenhorn Pumping Station; HoS: Holmer Siel; HHK: Inlet construction North Hauke Haien Koog; Ems-H: Ems (Herbrum) Glass eel monitoring; Ems-B: Ems (Bollingerfaehr) Elver monitoring.

Life stage: G=glass eel, Y=yellow eel.

***sampling was disturbed for six weeks due to a flood event.**

2 Overview of the national stock and its management

2.1 Describe the eel stock and its management

This report provides the most recent information about eel stocks, eel fishery and eel surveys in Germany. During the implementation process of the Eel Management Plans (EMPs), the authorities in the States ("Bundesländer") in Germany established a dedicated (permanent) working group. However, the group mainly focuses on the requirements of the EMP progress reports (i.e. reports in three-year intervals), but not on an annual calculation of the stock parameters in the "in-between-periods".

In 2018, the third progress report of the German EMPs and the recent development of the eel stocks was submitted to the European Commission (Fladung and Brämick, 2018). It covers the period 2014 to 2016 and many data in the here presented Country Report also refer to this period. The most recent version of the German Eel Model (GEM IIIb) has been used in all nine Eel management units (EMUs) to calculate the eel population parameters.

If new data for years later than 2016 had become available, they were included in the report. For practical reasons, the relevant authorities and institutions in the States mainly focus on the requirements of the reports to the EU Commission and not on providing detailed data on an annual basis. This is mainly caused by limited resources and capacities of the regional fisheries authorities, which are confronted with an increasing effort for European and national regulations. Therefore, there is no permanent new calculation of escapement, production and other population parameters for each year.

2.1.1 EMUs, EMPs

In December 2008, Germany has submitted EMPs for all River Basin Districts (RBDs, see Water Framework Directive) (Figure 1) that constitute a natural habitat for the European eel, as required by the EU Council Regulation 1100/2007, which will further be referred to as Eel Management Units (EMUs). The plans had been prepared for nine EMUs (Eider, Elbe, Ems, Meuse, Oder, Rhine, Schlei/Trave, Warnow/Peene and Weser). No plan was prepared for the river Danube, since according to a decision of the European Commission the Danube does not constitute a natural distribution area for eel in the sense of the Council Regulation 1100/2007.

The relevant German river systems belong to the ICES Ecoregions North Sea (Rhine, Elbe, Weser, Ems, Eider) and Baltic Sea (Oder, Warnow/Peene, Schlei/Trave).

Figure 1. River Basin Districts (RBD) in the Federal Republic of Germany: Eider, Schlei/Trave, Elbe, Warnow/Peene, Oder, Weser, Ems, Rhine, Meuse and Danube.

2.1.2 Management authorities

In Germany, inland fishery is under the legal competence and responsibility of the (federal) states ("Bundesländer"). Therefore, nine single EMPs have been prepared, which, however, all have a common structure. These EMPs were submitted to the European Commission together with a German "frame" providing a short summary of the results of the estimates for escapement (including a balance for whole Germany) and of common aspects, which should not be repeated in each single plan. Yet, the measures for the stock management were decided for each RBD and consequently differ (slightly) between the EMUs.

2.1.3 Regulations

The new rules regarding eel in the EMPs have become part of fisheries laws or fisheries regulations in the respective States.

2.1.4 Management actions

The main measures proposed in the EMPs are:

- increase minimum size limits to 45 cm or 50 cm (differs between federal states);
- maintain and, if possible, increase re-stocking of eels (not all EMUs);
- closed seasons (periods differ differs between federal states);
- attempts to reduce mortality by hydropower use (e.g. at turbines, water intakes; etc.);
- actions to reduce mortality by cormorants.

The following tables show the present state of the implementation of the planned measures. Meanwhile most of the measures have been implemented, but in some cases the targets were only achieved partially. This was caused by various reasons and is particularly the case for stocking, where the planned numbers could not be achieved in all EMUs and years.

Table 3. Implementation of management measures in the EMU Eider.

EMU code	Action Type	Action	Life Stage	Planned	Outcome
DE_Eide	Com Fish	Increase minimum size limit	Yellow	EMP	Implemented
		Close stationary eel traps	Mixed	Other	Partially implemented
		Restrictions for long line fisheries	Mixed	Other	Implemented
	Rec Fish	Increase minimum size limit	Yellow	EMP	Implemented
	Hydropower and Pumps	Trap and Transport	Silver	EMP	Currently not implemented due to logistic challenges
		Upgrade hydropower installations to protect fish and improve connectivity	Mixed	EMP	Partially implemented
	Restocking	no	---	---	---
	Other	Predator control	Mixed	EMP	Implemented
		Participation in European cormorant management	Mixed	EMP	Partially implemented
		Improve longitudinal connectivity	Mixed	Other	Partially implemented
		Scientific studies and monitoring and data collection	Mixed	EMP/Other	Implemented
		Legal framework	Mixed	EMP	Implemented
		Improve means of fishery control	Mixed	Other	Implemented

Table 4. Implementation of management measures in the EMU Elbe.

EMU code	Action Type	Action	Life Stage	Planned	Outcome
DE_Elbe	Com Fish	Increase minimum size limit	Mixed	EMP	Partially implemented
		Close stationary eel traps	Silver	EMP	Partially implemented
		Reduction of fisheries intensity in coastal waters	Mixed	EMP	Partially implemented
		Introduction of regional fishing limitations	Mixed	Other	Implemented
		Restrictions for long line fisheries (only in Schleswig-Holstein)	Mixed	Other	Implemented
	Rec Fish	Increase minimum size limit	Mixed	EMP	Partially implemented
		Introduction of bag size limit for eel anglers	(Yellow)/Mixed	Other	Implemented
		Closing fishery at night for anglers	(Yellow)/Mixed	Other	Implemented
	Hydropower and Pumps	Recovery of patency at important dams/weirs	Silver	EMP	Partially implemented
		Trap and Transport	Silver	Other	Implemented
	Restocking	Stabilize/increase amount stocked	Glass-, ongrown eels	EMP	Partially implemented
	Other	Improve longitudinal connectivity	Mixed	EMP/Other	(Partially) implemented
		Scientific studies and monitoring and data collection	Mixed	EMP	Implemented
		Legal framework	Mixed	EMP	Partially implemented

Table 5. Implementation of management measures in the EMU Ems.

EMU code	Action Type	Action	Life Stage	Planned	Outcome
DE_Ems	Com Fish	Increase minimum size limit	Yellow	EMP	Partially implemented
		Reduction of fisheries intensity in coastal waters	Mixed	EMP	Not implemented (of minor importance since no coastal eel fisheries are currently active)
	Rec Fish	Increase minimum size limit	Yellow	EMP	Partially implemented
	Hydropower and Pumps	Hydropower mortality is of subordinate importance in the RBD Ems. There is no urgent need for measures.			
	Restocking	Stabilize/increase amount stocked	Glass	EMP	Implemented
		Supply financial support for stocking	Glass	Other	Implemented
	Other	Scientific studies and monitoring and data collection	Mixed	EMP	Implemented
		Legal framework	Mixed	EMP	Partially implemented

Table 6. Implementation of management measures in the EMU Maas.

EMU code	Action Type	Action	Life Stage	Planned	Outcome
DE_Maas	Com Fish	Increase minimum size limit	Yellow	EMP	Implemented
	Rec Fish	Increase minimum size limit	Yellow	EMP	Implemented
	Hydropower and Pumps	No permission for new hydropower facilities	Silver/Mixed	EMP	No action needed.
	Restocking	Stabilize/increase amount stocked	Glass/On-grown	EMP	Implemented
		Supply financial support for stocking	Glass	Other	Implemented
	Other	Improve longitudinal connectivity	Mixed	Other	Partially implemented
		Scientific studies and monitoring and data collection	Mixed	Other	Implemented
		Include eel in existing species protection programmes	Mixed	Other	Implemented
		Legal framework	Mixed	EMP	Implemented

Table 7. Implementation of management measures in the EMU Oder.

EMU code	Action Type	Action	Life Stage	Planned	Outcome
DE_Oder	Com Fish	Increase minimum size limit	Yellow	EMP	Implemented
		Close stationary eel traps (but no concrete targets)	Silver	EMP	Not implemented
	Rec Fish	Increase minimum size limit	Yellow	EMP	Implemented
		Introduction of bag size limit	Mixed	Other	Implemented
	Hydropower and Pumps	Hydropower mortality is circumstantial in the German part of the RBD Oder. There is no need for special measures.			
	Restocking	Stabilize/increase amount stocked	Glass/On-grown	EMP	Implemented
	Other	Improve longitudinal connectivity	Mixed	Other	Implemented
		Scientific studies, monitoring and data collection	Mixed	EMP	Implemented
		Legal framework	Mixed	EMP	Implemented

Table 8. Implementation of management measures in the EMU Rhine.

EMU code	Action Type	Action	Life Stage	Planned	Outcome
DE_Rhei	Com Fish	Increase minimum size limit	Yellow	EMP	Implemented
		Introduce closed season	Mixed	EMP	Implemented
		Establish prolonged closed season	Mixed	Other	Implemented
	Rec Fish	Increase minimum size limit	Yellow	EMP	Implemented
		Introduce closed season	Mixed	EMP	Implemented
		Establish a prolonged closed season	Mixed	Other	Implemented
	Hydropower and Pumps	Trap and Transport	Silver	EMP/Other	Implemented
	Restocking	Stabilize/increase amount stocked	Glass	EMP	Implemented
		Supply financial support for restocking	Glass	Other	Implemented
	Other	Improve longitudinal connectivity	Mixed	Other	Implemented
		Predator control	Mixed	EMP	Partially implemented
		Scientific studies, monitoring and data collection	Mixed	Other	(Partially) Implemented
		Legal framework	Mixed	EMP	Partially implemented
		Include eel in existing species protection programmes	Mixed	Other	Implemented

Table 9. Implementation of management measures in the EMU Schlei/Trave.

EMU code	Action Type	Action	Life Stage	Planned	Outcome
DE_Schl	Com Fish	Increase minimum size limit	Yellow/Silver	EMP	Implemented
		Reduction of fisheries intensity in coastal waters	Mixed	EMP	Implemented
		Close stationary eel traps	Mixed	Other	Partially implemented
		Restrictions for long line fisheries	Mixed	Other	Implemented
	Rec Fish	Increase minimum size limit	Yellow/Silver	EMP	Implemented
	Hydropower and Pumps	Trap and Transport	Silver	EMP	Currently not implemented due to logistic challenges
		Upgrade hydropower installations to protect fish and increase connectivity	Mixed	EMP	Partially implemented
	Restocking	Stabilize/increase amount stocked	Glass	EMP	Mostly implemented
	Other	Improve longitudinal connectivity	Mixed	Other	Partially implemented
		Predator control	Mixed	EMP	Implemented
		Participation in European cormorant management	Mixed	EMP	Partially implemented
		Scientific studies and monitoring and data collection	Mixed	EMP/Other	Partially implemented
		Legal framework	Mixed	EMP	Implemented
		Improve means of fishery control	Mixed	Other	Implemented

Table 10. Implementation of management measures in the EMU Warnow/Peene.

EMU code	Action Type	Action	Life Stage	Planned	Outcome
DE_Warn	Com Fish	Increase minimum size limit	Mixed	EMP	Implemented
		Reduction of fisheries intensity in coastal waters	Mixed	EMP	Implemented
		Close stationary eel traps	Mixed	Other	Partially implemented
		Introduce a closed season	Mixed	EMP	Implemented
	Rec Fish	Increase minimum size limit	Yellow	EMP	Implemented
		Introduce a closed season	Mixed	EMP	Implemented
	Hydropower and Pumps				
	Restocking	Stabilize/increase amount stocked	Glass/On-grown	EMP	Partially implemented
	Other	Improve longitudinal connectivity	Mixed	Other	Partially implemented
		Predator control	Mixed	EMP	Partially implemented
		Scientific studies and monitoring and data collection	Mixed	EMP/other	Implemented
		Legal framework	Mixed	EMP	Implemented

Table 11. Implementation of management measures in the EMU Weser.

EMU code	Action Type	Action	Life Stage	Planned	Outcome
DE_Wese	Com Fish	Increase minimum size limit	Yellow	EMP	Partially implemented
		Reduction of fisheries intensity in coastal waters	Mixed	EMP	Not implemented (of minor importance since no coastal eel fisheries are currently active)
		Establish or prolong closed season for eel fishery (only applied in a part of the EMU)	Mixed	Other	Implemented
	Rec Fish	Increase minimum size limit	Yellow	EMP	Partially implemented
	Hydropower and Pumps	Introduce trap and transport programme and/or turbine management	Silver	Other	Implemented
	Restocking	Stabilize/increase amount stocked	Glass	EMP	Implemented
		Supply financial support for stocking	Glass	Other	Implemented
	Other	Scientific studies and monitoring and data collection	Mixed	Other	Implemented
		Legal framework	Mixed	EMP	Partially implemented

2.2 Significant changes since last report

There were no significant changes since the last country report.

3 Impacts on the national stock

3.1 Fisheries

Commercial fisheries in Germany usually are mixed fisheries, which catch different species and also both stages, yellow and silver eel (though some gears primarily target one of these stages). Landings of yellow and silver eels have not been reported separately in the past. Though separate reports have recently been implemented in some states, these numbers were not available (except for Warnow/Peene, Schlei/Trave, and Eider). Therefore, in the following all data are given combined for yellow and silver eels. The data were taken from the EMPs (for 2007, commercial fishery) and from the 2018 EMP progress report (Fladung and Brämick, 2018) (anglers). It is assumed that the data has not changed considerably since 2007 for commercial fisheries; yet, it should also be noted that more recent data are available for fishing effort (see further below), which are more relevant to assess the intensity of the fishery. Furthermore, in Mecklenburg-Pomerania, fishing pressure on the European eel was notably reduced, especially in coastal areas with 255 full-time and 125 part-time fishers in 2016 (Dorow and Lill, 2014; Dorow *et al*., 2017). It is expected that this downward trend will continue in the future, particularly since it is uncertain who will succeed retired fishers.

<u>EMU Eider</u>

- 69 full-time (68 coastal, one inland water), 146 part-time, 300 hobby fishermen (1200 fykenets allowed)
- about 20 000 anglers (in 2013, Fladung and Brämick, 2018)

<u>EMU Elbe</u>

- 413 full- and part-time fishermen / fishing enterprises, (11 102 fykenets, 31 stownets, 24 electrofishing gears, 38 stationary eel traps in 2007)
- 412.370 anglers (in 2016, Fladung and Brämick 2018)

<u>EMU Ems</u>

- four full-time and five part-time fishermen (using fykenets and stownets)
- 50 811 anglers (in 2016, Fladung and Brämick, 2018)

<u>EMU Maas</u>

- 5830 anglers (in 2016, Fladung and Brämick, 2018)

<u>EMU Oder</u>

- 89 full- and part-time fishermen / fishing enterprises (using 2116 fykenets, seven stownets, 23 electrofishing gears, five stationary eel traps in 2007)
- 36 667 anglers (in 2016, Fladung and Brämick, 2018)

<u>EMU Rhein</u>

- approximately 288 (full-) and part-time fishermen (fykenets and a few stownets)
- 158 569 anglers (in 2016, Fladung and Brämick, 2018)

<u>EMU Schlei/Trave</u>

- coastal fishery: 142 cutters (124 full-time, 18 part-time), 107 boats (full-time) and 379 boats (part-time fishermen); in total 628 fishing vessels of different size; 808 hobby fishermen (allowed to use 3232 fykenets)
- inland fishery: 16 fishing enterprises
- about 23 711 anglers (in 2016, Fladung and Brämick, 2018)

EMU Warnow/Peene

- coastal fishery in 2016: 255 full-time fishers, 125 part-time fishers, less than 150 hobby-fishers
- inland fishery in 2017: 39 fishing enterprises with ca. 120 vessels
- 76 873 anglers (in 2016, Fladung and Brämick, 2018)

EMU Weser

- 17 full-time fishermen, 99 part-time fishermen (using stownets, fykenets, traps)
- 114 879 anglers (in 2016, Fladung and Brämick, 2018)

3.1.1 Glass eel fisheries

There is no glass eel fishery in Germany.

3.1.2 Yellow/Silver eel fisheries

3.1.2.1 Commercial

Landings data are recorded by fishers and reported to regional authorities. Data on landings of yellow and silver are not yet completely available for all EMUs for years later than 2016.

Table 12. Commercial yellow and silver eel landings (kg) in German EMUs since 2005.

Year	DE_Eide F	DE_Eide C	DE_Elbe	DE_Ems	DE_Maas	DE_Oder	DE_Rhein	DE_Schl F	DE_Schl C	DE_Warn F	DE_Warn F / Y	DE_Warn F / S	DE_Warn C	DE_Wese
2005	3,272	2,948	18,4165	8,906	30	16,769	51,991	22,048	20,194	22,175	na	na	88,256	34,008
2006	2,807	2,804	19,9174	9,257	30	16,979	48,256	20,199	21,061	24,931	na	na	92,541	34,158
2007	2,182	2,144	18,6352	9,015	30	17,111	47,596	21,858	11,269	22,399	na	na	71,604	32,075
2008	2,272	2,049	18,9946	5,864	30	14,553	39,463	21,858	13,237	18,310	na	na	76,374	24,412
2009	2,151	1,041	20,4347	6,286	30	13,722	22,311	11,602	6,464	18,705	na	na	63,789	23,755
2010	1,917	1,381	18,9871	7,148	30	12,742	15,769	16,060	14,376	20,715	na	na	66,980	19,351
2011	1,946	1,214	13,0043	5,902	na	8,606	14,686	14,246	12,222		14,721	7,349	41,596	26,353
2012	1,089	967	11,3795	4,819	na	10,226	21,337	9,519	10,086		8,120	7,406	34,880	22,775
2013	1,142	796	12,5714	5,099	na	10,279	20,139	11,731	12,691		11,159	5,571	37,955	22,482
2014	1,213	899	10,0900	4,456	na	10,645	16,937	10,017	13,413		7,683	7,838	38,465	19,330
2015	1,424	581	10,3589	3,856	na	11,403	18,105	6,603	15,158		8,310	6,067	34,236	14,747
2016	910	543	8,5807	3,527	na	8,528	22,844	5,482	15,399		9,103	6,222	31,112	15,452
2017	1,171[1]	621[2]						10,818[3]	13,525[4]					

Key:

Y: Yellow eels, S: Silver eels, F: Freshwater, C: Coastal waters, T: Transitional waters

[1]In DE_Eide catches were assessed separately for F and T and for life stages (Y and S) in 2017. This value includes catches of Y in F (7 kg), Y in T (990 kg), S in F (6 kg), and S in T (168 kg).

[2]In DE_Eide catches were assessed separately for life stages (Y and S) in 2017. This value includes catches of Y in C (457 kg) and S in C (164 kg).

[3]In DE_Schl catches were assessed separately for life stages (Y and S) in 2017. This value includes catches of Y in F (6220 kg) and S in F (4598 kg).

[4]In DE_Schl catches were assessed separately for life stages (Y and S) in 2017. This value includes catches of Y in C (11875 kg) and S in C (1650 kg).

3.1.2.2 Recreational

Data on landings of yellow and silver eel are not yet available for years later than 2016.

In 2016, the total number of valid fishing licences in the EMUs relevant for eel was 900 679. This is approximately 3% higher compared to 2008 (the first year of the implementation of the EMPs). Yet, it is not known, how many anglers actually fish for eel.

Fladung *et al*. (2012a) found that only about 58% of all anglers in the river Havel system fished for eel, and of these, only about one third was successful. There was a considerable variability in angling activity and angling success between the anglers. In relation to the total number of valid fishing licences, the annual yield was 0.6 eels or 288 g eel per angler in this system. Similar results had been found for the State Mecklenburg-Pomerania in an earlier study (Dorow and Arlinghaus, 2008; 2009).

Data on releases of undersized eels are not available in Germany and accordingly not considered in the calculation of losses due to recreational fisheries. However, two studies investigated the post-release mortality of eels (Weltersbach *et al*., 2016; 2018) and found that fishing gear significantly affected the catch of undersized eels with mortalities between 8.4 and 64.4%, thus highlighting the need to consider these effects in future management approaches.

Table 13. Recreational yellow and silver eel landings (kg) in German EMUs since 2005.

Year	DE_Eide F	DE_Eide C	DE_Elbe	DE_Ems	DE_Maas	DE_Oder	DE_Rhein	DE_Schl F	DE_Schl C	DE_Warn F	DE_Warn C	DE_Wese
2005	5,704	525	113,328	25,315	407	11,314	87,007	12,205	4,302	22,386	8,460	66,192
2006	5,133	525	113,883	22,322	370	11,235	92,700	12,205	4,087	22,322	8,436	66,091
2007	4,620	525	112,805	15,896	404	10,656	91,558	12,205	3,882	22,904	8,656	61,575
2008	4,158	525	112,886	12,001	95	10,887	63,763	9,000	3,688	22,805	8,619	44,880
2009	3,742	525	116,049	13,116	82	11,178	60,096	8,000	3,504	23,408	8,847	37,514
2010	3,368	525	104,471	13,062	95	9,647	48,728	7,000	3,504	22,947	8,673	30,530
2011	3,031	525	105,971	10,563	84	10,088	45,416	6,000	3,504	23,544	10,590	31,584
2012	2,728	525	106,766	11,242	81	10,103	41,358	6,000	3,504	23,131	10,486	30,388
2013	2,455	525	105,111	11,898	80	10,102	42,929	6,000	3,504	22,353	10,053	35,971
2014	2,210	525	109,578	11,518	60	10,483	42,040	6,000	3,504	22,599	10,164	35,807
2015	2,210	525	109,413	9,438	60	10,541	41,243	6,000	3,504	23,150	10,412	39,128
2016	2,210	525	111,090	9,960	58	10,560	40,835	6,000	3,504	23,106	10,392	39,538

Key: Y: Yellow eels, S: Silver eels, F: Freshwater, C: Coastal water.

3.1.2.3 Fishing effort

In the frame of the implementation of the EMPs, data on fishing effort became available due to documentation requirements in the Regulation 1100/2007. Data were taken from the third EMP progress report to the EU Commission (Fladung and Brämick, 2018) and refer to 2016.

Fisheries in Germany usually are mixed fisheries, which catch different species and also both stages of eel, yellow and silver eel (even though some gears are more specialized for one of the stages). Therefore, fishing effort cannot be presented separately for yellow and silver eels. Hence, Table 14 gives the data on total fishing effort on both stages.

The main fishing gears for eel in Germany are fykenets (different types), among which the "small fykes" are the most important group. It is important to note that for this gear, a reduction of 38% in effort was documented between 2008 and 2016, thus continuing the downward trend that was already reported earlier (e.g. Dorow and Lill, 2014; Fladung and Brämick, 2015). All other gears also showed a reduction in effort, which is notable for stownets with 37% (which mostly target silver eels). Though effort for 'hook bouys' and stationary traps was greatly reduced, they only account for a very small fraction of the total effort.

Table 14. Fishing effort with the most relevant eel fishing gears of commercial and semi-commercial fisheries in German waters in 2016 and change (%) in relation to the 2008-data. Data are presented as gear * days used.

EMU	Small fykes	Large fykes	Longlines (eel line 100 at hooks)	Aalpuppen ("Hook buoy")	Stownets	Stationary eel traps	Electro fishing
Eider	7,985	6,268	0		127	0	0
Elbe*	230,486	287,902	171	4,180	1,618	255	49
Ems	2,552	5,609	0		3,995	0	0
Maas	0	0	0		0	0	0
Oder	195,460	26,534	3,354	5,626	240	2	55
Rhein	126,199	5,990	45		217	0	349
Schlei/Trave	418,150	7,450	415		0	20	0
Warnow/Peene	2,724,110	51,365	114,574	2,591	0	264	14
Weser	130,803	2,834	0	0	710	0	0
Total	**3,835,745**	**393,952**	**118,559**	**12,397**	**6,907**	**541**	**467**
**Change from 2008 to 2016 (%)*, ** **	**-38**	**-8**	**-36**	**-69**	**-37**	**-77**	**-24**

***Without Hamburg, because no data were reported, **Without the State of Brandenburg, because no data from this State were available for 2008.**

3.1.2.4 Economic importance

Data on the real economic importance of eel for the German fisheries are rare. However, a study by Fladung and Ebeling (2016) revealed that eel is still very important for the inland fishery in the State Brandenburg (which is one of the most important States for the German inland fishery sector). On average, eel contributed 27% to the revenues of the fishing companies, which is related to the comparably high prices for eel, which can be three to four times the prices for other freshwater fish.

In a study focussing on the economic importance of the eel fishery in inland waters in the State Mecklenburg-Vorpommern, similar results on the economic importance of eel have been found using a written survey (Dorow and Frankowski, 2019). For example, depending on the individual commercial fishery the eel accounts between 40–70% of the harvest revenues.

A recent study on the economic impact of eel management measures on stakeholders (Hanel *et al*., 2019) in four countries (France, Germany, Greece and Spain) clearly shows the lack of economic data for eel fisheries in European inland waters. This lack of data hinders the assessment of the economic importance of eel for fisheries and an economic impact assessment of management measures.

3.1.2.5 Underreporting and illegal catches

No data available.

3.2 Restocking

Available data on eel stocking are provided in the ICES data call on eel 2019. The information for 2018 and 2019 is not yet complete. Hence, the complete and summarized data for 1985–2017 are given here. It is likely that the order of magnitude was the same in 2018 and 2019. Generally, restocking intensity is influenced by glass eel price, funding and the contribution of commercial and recreational fishers.

Table 15. Total weight (kg) of glass eels restocked in German EMUs since 2005.

Year	DE_Eide F*	DE_Elbe F*	DE_Ems F*	DE_Maas F**	DE_Oder F*	DE_Rhein F**	DE_Schl F	DE_Schl C	DE_Warn F	DE_Warn C	DE_Wese F*
2005		254	131			1,454					67
2006			74			1,689					52
2007			53			1,943			2		16
2008			34			859			8		10
2009		34	25			1,062			8		48
2010		1153	39	21		1,028			3		37
2011		548	36	30		3,070	30	50	3		47
2012		885	8	51	3	2,217			3		34
2013		1416		56	26	2,318	2	22	3		49
2014		2025		80	94	1,167	26	572	3	120	393
2015		1036		37	59	1,313	30	117	8	120	91
2016		581	14		81	844	136	157	20	114	246
2017							122	301			
2018							157	157			

F: freshwater, C: coastal, * including transitional waters, ** including all eels of age group 0.

Table 16. Total number of glass eels restocked in German EMUs since 2005.

Year	DE_Eide F*	DE_Elbe F*	DE_Ems F*	DE_Maas F**	DE_Oder F*	DE_Rhein F**	DE_Schl F	DE_Schl C	DE_Warn F	DE_Warn C	DE_Wese F*
2005		636,667	436,667			572,014					221,667
2006			245,970			664,320					171,667
2007			176,760			764,320			6,719		54,524
2008			114,533			337,863			26,713		30,800
2009		10,2819	84,800			417,736			25,116		156,533
2010		4,328,454	129,071	14,534		404,290			10,098		122,446
2011		1,638,050	112,917	16,000		1,207,661	100,000	166,667	9,168		152,515
2012		2,989,570	266,67	20,000	9,000	872,048			7,655		108,485
2013		3,824,120		24,500	76,765	911,804	6,667	73,333	11,569		151,159
2014		6,024,572		45,100	235,764	459,234	86,667	1,906,667	62,370	400,000	1,238,954
2015		3,564,919		74,000	146,750	516,503	1,315,15	531,818	434,778	400,000	302,667
2016		1,707,043	46,667		203,000	331,966	572,567	694,466	66,830	378,000	791,167
2017							391,859	872,608			
2018							490,133	523,333			

F: freshwater, C: coastal, * including transitional waters, ** including all eels of age group 0.

Table 17. Total weight (kg) of yellow eels restocked in German EMUs since 2005.

Year	DE_Eide F*	DE_Elbe F*	DE_Ems F*	DE_Maas F**	DE_Oder F*	DE_Rhein F**	DE_Schl F	DE_Schl C	DE_Warn F	DE_Wese F*
2005		34,433	8,082		4,120	23,524	10,462		3,139	17,421
2006		44,473	5,036		1,934	22,229	2,858		3,935	17,279
2007		38,581	5,786		1,547	20,460	2,710		4,876	15,787
2008	23	38,191	2,552		4,809	17,477	4,347		2,252	11,006
2009		39,291	1,896	95	3,866	17,659	4,545		3,789	10,505
2010		37,728	2,702	99	3,246	18,132	5,363	324	807	9,777
2011		37,530	2,911	58	4,512	17,777	2,809	434	3,116	7,027
2012	5	25,991	2,841	15	2,204	20,059	2,540	650	2,834	9,281
2013		24,176	2,963	15	1,207	19,973	2,800	3,180	2,056	10,581
2014	20	27,826	3,583	15	1,509	21,746	2,001	400	3,902	8,484
2015		14,572	4,433	83	1,330	20,808	2,424	1,632	3,047	10,464
2016		14,179	3,726	362	1,368	23,025	1,666	1,682	3,168	7,900
2017	9						2,708	3,289		
2018							1,430	1,851		

F: freshwater, C: coastal, * including transitional waters, ** including all eels > age group 0.

Table 18. Total number of yellow eels restocked in German EMUs since 2005.

Year	DE_Eide F*	DE_Elbe F*	DE_Ems F*	DE_Maas F**	DE_Oder F*	DE_Rhein F**	DE_Schl F	DE_Schl C	DE_Warn F	DE_Wese F*
2005		1,974,829	839,854		131,277	1,493,826	438,986		151,300	1,415,553
2006		5,350,460	566,301		86,096	1,417,999	123,075		329,333	1,409,972
2007		5,344,928	648,341		70,597	1,310,382	127,455		441,221	1,312,199
2008	2,875	6,124,378	228,590		168,241	1,068,885	220,871		371,986	810,180
2009		6,197,118	207,319		148,608	1,093,815	253,206		314,295	696,984
2010		5,95,8491	270,050		162,585	1,115,992	406,855	32,350	494,805	673,282
2011		4,501,324	370,932		150,844	1,124,118	168,497	43,400	311,832	752,248
2012	714	2,764,066	550,397		93,304	1,288,461	206,243	65,000	260,385	1,132,237
2013		2,861,636	452,879		141,897	1,269,989	245,464	318,000	393,527	1,299,436
2014	2,404	3,490,863	1,188,919		150,647	1,391,479	245,077	53,333	432,630	1,522,093
2015		2,776,118	1,183,994		220,320	1,327,016	290,233	224,214	264,222	2,343,802
2016		1,781,408	794,632		118,687	1,470,664	287,008	240,286	343,170	1,811,776
2017	1,354						431,117	479,630		
2018							193,230	332,657		

F: freshwater, C: coastal, * including transitional waters, ** including all eels > age group 0.

3.3 Aquaculture

3.3.1 Aquaculture Seed supply

Data on seed supply to aquaculture are provided annually by the Federal Statistical Office. However, information about the sources of the glass eels was not provided. In general, the legal situation regarding the availability of the data (sources) appears to be a bit unclear (data protection, etc.). Glass eels, which are brought to aquaculture, are partly used for re-stocking as ongrown eels later (see chapter on aquaculture production). Data for 2016 were not available, presumably due to legal data protection issues.

Table 19. Overview on aquaculture seed supply in Germany.

Year	Recipient country	Donor country	Donor EMU	Life stage	Quantity (kg)
2015	Germany	ND	ND	G	3,340
2016	Germany	ND	ND	G	ND
2017	Germany	ND	ND	G	3,347
2018	Germany	ND	ND	G	2,757

3.3.2 Aquaculture production

Data on aquaculture production are provided annually by the Federal Statistical Office and data on the use of aquaculture production are provided in the yearly report on freshwater fisheries (Brämick, 2017). Data on use/life stage are separated as ongrown eels (used for stocking) and yellow/silver eels at marketable size (mostly human consumption). No data on use/life stage were available for 2017.

Data on use/life stage were not reported separately before 2015 (though available in the report on freshwater fisheries) because there was a drastic decline (magnitude of ~10) in the quantity of ongrown eels from 2014 and earlier to 2015, with an equivalent increase in the production of yellow/silver eels for human consumption. Since reporting in 2015 was consistent with the following year and the number of ongrown eels prior to 2015 was unrealistically high, only total aquaculture production is given for earlier years (for original data see 2017 report). Though definite causes are unknown, the decline could be attributed to the inclusion of exported/otherwise used ongrown eels in the category OG prior to 2015 and was possibly further reinforced by a shift towards glass eels as stocking material.

Table 20. Overview on aquaculture production and use/life stage of eels (YS = yellow/silver eel at marketable size, mostly human consumption, OG = ongrown, used for stocking) in Germany.

Year	Donor country	Life stage	Quantity (kg)
2007	Germany	YS, OG	774,000
2008	Germany	YS, OG	749,400
2009	Germany	YS, OG	667,000
2010	Germany	YS, OG	681,000
2011	Germany	YS, OG	692,000
2012	Germany	YS, OG	744,000
2013	Germany	YS, OG	758,000
2014	Germany	YS, OG	926,000
2015	Germany	OG	29,000
2015	Germany	YS	1,147,000
2016	Germany	OG	38,000
2016	Germany	YS	1,061,000
2017	Germany	YS, OG	1,202,162
2018	Germany	OG	37,500
2018	Germany	YS	1,055,500

3.4 Entrainment

Impacts of hydropower turbines, cooling water intakes, etc. are considered in the German Eel Model. The model assumes that turbines damage only silver eels, although there are also some

effects on yellow eels during movements within the rivers. Estimation of the turbine mortalities are based on original data or average mortality of ~30% less a percentage for the protection device.

According to the position of the obstacles and the known or estimated mortality rates at each location, the RBDs can be divided into several sub-areas, for each of which the cumulative turbine mortality down to the estuary can be calculated. By using a step size of ten percent, the whole system can be divided into ten subareas of similar turbine mortality. This way of modelling makes it easy to study the effect of improvement of the migration capacity of hydropower stations because the influenced area will be added to another subarea.

Based on this stratified structure, the overall impact of technical obstructions on the eel stocks is calculated on an EMU basis. However, this modelling approach assumes equal distribution of eels in the EMUs, while it is likely that the abundance is higher in downstream regions. Therefore, hydropower mortality might be overestimated. Comprehensive information on the spatial distribution of these impacts are not available.

3.5 Habitat Quantity and Quality

So far, aspects of habitat quality are only considered indirectly by including the effects of technical obstructions at barriers (see above) and predation by cormorants in the GEM. Furthermore, habitat-specific growth rates are used in most areas, which can be considered an effect of habitat quality.

However, effects of contaminants, diseases or parasites so far cannot be quantified and are, hence, not considered.

3.6 Other impacts

The impact of predation by cormorants on the eel stock is controversially debated in Germany. In the GEM cormorant predation has been included in the term "natural mortality". Table 21 provides estimates for predation of eels by cormorants for the German RBDs between 2005 and 2016. The order of magnitude has clearly increased again since 2011. Estimates are based on numbers of cormorants in the relevant regions and proportion of eels in the diet of cormorants. The most recent EMP progress report (Fladung and Brämick, 2018) further highlights that predation by cormorants is most relevant in age groups 2–4, causing ~15–26% of the overall yearly mortality in this age groups (average of all EMUs between 2014–2016).

Table 21. Estimates of predation on eels by cormorants for German EMUs (t).

EMU	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
DE_Eide	9	8	8	7	7	6	6	6	5	6	4	4
DE_Elbe	142	129	115	121	121	123	112	134	148	158	155	151
DE_Ems	3	3	3	2	2	1	1	1	1	1	1	1
DE_Mass	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	1	1	1	1
DE_Oder	43	36	36	40	43	41	31	46	38	40	36	24
DE_Rhein	15	14	14	12	11	11	11	12	11	14	15	17
DE_Schl	37	35	31	25	25	25	24	21	21	21	27	30
DE_Warn	11	8	8	8	7	6	5	6	5	7	8	9
DE_Wese	5	6	5	5	4	3	4	3	3	4	4	5
DE total	264	240	221	221	219	216	194	229	233	252	251	241

4 National stock assessment

4.1 Description of Method

There is no continuous calculation of the stock indicators on an annual basis. For the calculation of the stock indicators for the third EMP progress report (Fladung and Brämick, 2018), the GEM III was used. It includes the option to calculate the cohort development separately for males (no habitat specific growth rates in all EMUs) and females and also the possibility to calculate the so far missing mortality rates. The model has already been used for management considerations (Brämick *et al*., 2015) in the river Havel system, the largest tributary to the river Elbe. A description of the previous version (GEM II) had been given by Oeberst and Fladung (2012).

The model incorporates the weight and sex of eel as well as the mean water temperature to estimate the natural mortality. Natural mortality was estimated based on Bevaqua *et al*. (2011). In addition, three density levels of the eel stock are considered to determine natural mortality. The areas given in the EMPs and in the reports include all habitats, which would be potential eel habitats under undisturbed conditions; only some habitats e.g. in the trout region, far away from the coast may have been excluded, because these areas are no typical eel habitats. Areas above impassable barriers are also included in the calculation of escapement. In agreement with the eel regulation, coastal waters have been included in some cases but not in others. When they were not included, fisheries should be decreased by 50% outside the areas covered by the EMP.

All estimates refer to the whole EMU without assuming differences within the system except for hydropower mortality. It is obvious that there will be differences between different habitat types, but sufficient data are not available to conduct more differentiated approaches. As a consequence, the values represent a mean value for the whole EMU. Though based on knowingly false assumptions, this is regarded the best possible approach under pragmatic aspects. Meanwhile the model predictions have been compared to empiric data by tagging experiments. These experiments largely supported model estimates, at least in the order of magnitude in the Elbe and Schwentine river systems (Fladung *et al*., 2012b; Prigge *et al*., 2013). Besides the growth functions, some of the input data are still not available for each EMU (e.g. length at maturation), in which case values from the EMU Elbe were used. However, efforts continue to collect system specific data in the frame of the DCF.

Restocking applies in all German RBDs except for the River Eider. In the calculation of B_0 and B_{best}, re-stocking is not included. $B_{current}$ includes the effect of re-stocking in all RBDs, where re-stocking applies. The values of $\sum A$ represent real mortalities and are not lowered by re-stocking.

4.1.1 Data collection

The main input parameters of the model are: fisheries yield (commercial (from national landing statistics) and recreational), stocking and estimates for natural immigration based on the ICES recruitment time-series, predation by cormorants, mortality by hydropower (turbines, etc.), growth functions and length-mass relationships. For details see Oeberst and Fladung (2012).

The biological sampling, e.g. to determine growth, etc. is mainly done in the frame of the DCF, which is explained in more detail in the relevant chapter (see below). Additionally, various DCF independent data collection programmes exist in several states aiming to provide input data for the GEM III.

4.1.2 Analysis

A description of the basic model has been given by Oeberst and Fladung (2012). A first example of how the model can be used for management consideration has been given by Brämick *et al*. (2015).

4.1.3 Reporting

The results are presented in the EMP progress reports according to the EU Eel Regulation (1100/2007) and in the annual WGEEL Country Reports. The implementation reports are publicly available (in German):

https://www.portal-fischerei.de/bund/bestandsmanagement/aalbewirtschaftungsplaene/umsetzungsbericht/?no_cache=1andsword_list%5B%5D=Aal

Data which are obtained in the frame of the DCF are regularly reported to the EU.

4.1.4 Data quality issues and how they are being addressed

The quality of the available data is not easy to assess. There is no long history of eel stock assessment in Germany and hence the results are based on landing statistics, estimates and model calculations. The reliability of the landing statistics has not been evaluated so far. The model used to calculate the different population parameters of eel in German waters (Oeberst and Fladung, 2012), has been further developed (GEM III) and has also been tested in the frame of the POSE project. The model results have been compared to data obtained by tagging studies and are considered acceptable (Fladung *et al*., 2012b; Prigge *et al*., 2013). Yet, the studies also indicated that the quality of the results strongly depends on the quality of the input data. Hence, the data basis for the modelling of the stock will have to be improved continuously in the future. The reliability of the results will also be enhanced by increasingly using river specific data obtained in the frame of the DCF sampling.

These issues have been further addressed with the implementation of EU MAP in 2016, aiming at a data collection that provides more comprehensive and robust input data for the model.

4.2 Trends in Assessment results

In absolute terms, mortalities due to fisheries (i.e. landings) and hydropower (i.e. eels lost to turbines and cooling water intakes) was reduced in all German EMUs from 2005–2007 to 2014–2016 (Tables 22 and 23). In some EMUs, however, (modelled) fishing and other anthropogenic mortality rates actually increased in the observed time period (Table 24). This contradiction is partly attributed to the fact that the modelled decrease in the abundance of eels in the fished population (i.e. above minimum landing size) or exposed to hydropower mortality (i.e. silver eels) was higher than the observed decrease in catches. Yet, the overall fishing effort also decreased (Table 14), which suggests a decrease in both, absolute and relative mortalities. It is, however, hardly possible to standardize fishing effort considering the large differences between the gears used. Thus, the overall decrease in fishing effort does not necessarily entail a decrease in fishing mortality rates since gears might vary with respect to fishing efficiency. Furthermore, the decrease in effort was not consistent for all gears and/or EMUs (yet, some areas did show a notable decrease in fishing intensity, e.g. the southern Baltic coastal areas, see above). Accordingly, the presented results remain somewhat inconclusive and it is unclear to which degree they are related to uncertainties in the model and/or respective input data.

It should be further noted, that although other anthropogenic mortalities are presumed to be almost exclusively caused by hydropower, ΣH (Table 1) is not considered a good indicator for the development of mortality at hydropower plants and pumping stations. A detailed explanation is given by Fladung and Brämick (2018). Briefly, anthropogenic mortalities were calculated for every year separately (and not for a given cohort) and are thus linked to yearly recruitment. Accordingly, the effect of measures will only be fully represented in these figures, once the stock is fully comprised of cohorts that are affected by these measures and the results refer to the whole stock. To get a more realistic picture, hydropower losses were calculated separately based on the fraction of silver eels only, which revealed that hydropower mortality rate remained constant over the observed time period (Fladung and Brämick, 2018).

Table 22. Eel landings from commercial and recreational fishing (in tons) in Germany by EMU, expressed as silver eel equivalents. Change is calculated as the average from 2005–2007 to the average of 2014–2016.

EMU	2005	2006	2007	2014	2015	2016	Change (%)
Eider	14	13	11	5	5	4	-61
Elbe	334	355	341	237	239	224	-32
Ems	46	42	33	18	15	16	-59
Maas	0,5	0,4	0,5	0,1	0,1	0,1	-84
Oder	31	31	31	23	23	20	-29
Rhine	155	155	153	62	63	69	-58
Schlei/Trave	89	86	69	43	42	43	-48
Warnow/Peene	141	147	125	86	82	80	-40
Weser	139	139	130	68	70	74	-48
Total	949	969	893	542	539	531	-43

Table 23. Losses of eels due to hydropower and cooling water intakes (in tons) in Germany by EMU, expressed as silver eel equivalents. Change is calculated as the average from 2005–2007 to the average of 2014–2016.

EMU	2005	2006	2007	2014	2015	2016	Change (%)
Eider	33	29	26	12	11	10	-63
Elbe	170	122	89	23	30	39	-76
Ems	6	6	5	3	2	2	-61
Maas	<1	<1	<1	≈0	≈0	≈0	-93
Oder	3	3	2	<1	<1	<1	-93
Rhine	398	408	405	211	199	189	-51
Schlei/Trave	5	5	5	1	1	1	-71
Warnow/Peene	1	1	1	<1	<1	<1	-64
Weser	86	80	75	36	27	23	-64
Total	701	654	608	287	270	265	-58

Table 24. Development of anthropogenic mortality rates after the implementation of eel management plans.

EMU	∑F			∑H			∑A		
	2005–2007	2014–2016	Change (%)	2005–2007	2014–2016	Change (%)	2005–2007	2014–2016	Change (%)
Eider	0.02	0.01	-1	0.01	0.01	-3	0.03	0.03	-2
Elbe	0.60	1.15	93	0.27	0.27	0	0.87	1.42	64
Ems	0.13	0.11	-12	0.01	0.01	0	0.14	0.12	-11
Maas	0.69	0.73	6	0.11	0.11	0	0.80	0.84	5
Oder	0.18	0.20	9	0.02	0.00	-88	0.20	0.21	1
Rhine	0.30	0.26	-15	0.75	0.64	-15	1.05	0.89	-15
Schlei/Trave	0.06	0.03	-40	0.00	0.00	-64*	0.06	0.03	-41
Warnow/Peene	0.06	0.07	31	0.00	0.00	-51*	0.06	0.07	30
Weser	0.30	0.34	14	0.19	0.20	6	0.49	0.54	11
Total	0.13	0.14	8	0.06	0.04	-34	0.19	0.18	-5

*** relative changes not relevant because ∑H is almost 0.**

Apart from the considerable influence of stocking on recruitment and differences in the fishing intensity, the sometimes vast differences in anthropogenic mortalities between EMUs can be explained by the inclusion of coastal habitats with comparably low mortalities in some EMUs (Schlei/Trave, Warnow/Peene and Eider).

Considering the fraction of silver eels only, hydropower mortality rate remained constant in six out of nine EMUs and was reduced due to the implementation of trap and transport (Rhine, -11%) and reduced stocking (Oder, -88%) while a slight increase in the Weser (+6%) is attributed to newly built hydropower facilities (For details see Fladung and Brämick, 2018). Due to the implementation of the WFD (EC 2000/60) it is to be expected that mortalities will be reduced in the future. So far, however, measures focused mostly on enabling upstream migration, which explains the largely unchanged hydropower mortality for silver eels in most EMUs.

5 Other data collection for eel

5.1 Yellow eel abundance surveys

In 2014, 2016 and 2017, an abundance survey for eel in the Schleswig-Holstein part of the Baltic Sea was carried out, using a standardized catching method that catches eel >36 cm quantitatively using an enclosure approach of Ubl and Dorow (2015).

The enclosure monitoring approach is running in the coastal waters of Mecklenburg-Vorpommern since 2008. In 2015 and 2016 an experimental evaluation of the fishing efficiency of the enclosure-fykenet system was conducted addressing the efficiency of the external boundary net (Dorow *et al*., 2019) and the proportion of enclosed eels harvested within the standard of 48 hours (Dorow *et al*., submitted). Based on the evaluation studies a correction factor was derived allowing the estimation of unbiased yellow eel densities based on the enclosure monitoring harvest results.

Since 2004 a logbook study with commercial coastal fishing enterprises is conducted in the state Mecklenburg-Vorpommern (Dorow and Lill, 2014). The generated data allow the calculation of eel specific CPUE data considering different size classes and gear types. Focussing on the smallest size class (yellow eels less than 150 g), increasing CPUE values were observed within the last two years which were on average higher compared to the overall mean of complete time-series 2004–2018 (Dorow, unpublished data).

5.2 Silver eel escapement surveys

Since 2004 approximately 150 marked silver eels were released per year in the tributaries of the German part of the river Rhine. Purpose was studying: 1) the migratory behaviour of silver eel from the Rhine system to the North Sea, and 2) the success in actually reaching the sea. The study is performed by North Rhine Westphalian State Agency for Nature, Environment and Consumer Protection (LANUV, Germany) in cooperation with RWS Water, Verkeer en Leefomgeving (the Netherlands), and will be continued in order to gain information about the effects of the opening of the Haringvliet sluices (Rhine-Meuse Delta) in 2018.

In the years 2013 and 2014, a total of 65 marked silver eel were released in the tributaries Havel and Dahme of the German part of the river Elbe. Purpose was studying the migratory behaviour (routes, time periods, speed). The study was performed by the Institute for Inland Fisheries Potsdam-Sacrow (IFB, Germany) and finished in 2016.

A scientific stownet system is used to monitor the silver eel escapement in the River Warnow (EMU Warnow/Peene). Since 2009 the stownet is used in a standardized way (Reckordt *et al*., 2014). After a decrease in catch rates untill 2015 an increase of the silver eel escapement was observed since 2016 (Frankowski, unpublished data). Data on escapement rate, behaviour and mortality have been assessed by means of acoustic telemetry in the Warnow River. In the context of a permanent silver eel descent in the freshwater part of the Warnow River, a permanent escapement was likewise occurring into the Baltic Sea (Frankowski *et al*., 2019).

Since 2004 a logbook study with commercial coastal fishing enterprises is conducted in the state Mecklenburg-Vorpommern (Dorow and Lill, 2014). The generated data allow the calculation of eel specific CPUE data considering different size classes and gear types. Focussing on the smallest size class (yellow eels less than 150 g), increasing CPUE values were observed within the last

two years which were on average higher compared to the overall mean of complete time-series 2004–2018 (Dorow, unpublished data).

5.3 Life-history parameters

Sampling of European eels in freshwater is mandatory under the DCF started in spring 2009. Biological parameters (i.e. length, weight, age, sex and maturity) were collected in all RBDs except Meuse (no commercial fisheries) and Danube (no natural habitat of *A. anguilla*). With the implementation of the multiannual program for the collection, management and use of fisheries data (EU MAP, EU 2016/1251) in 2016, the data collection was renewed. Since large parts of the required data can only be provided through modelling, sampling is now focused on providing system specific data on local eel subpopulations in order to improve input data for the GEM and validate the results. The respective data requirements (mostly data related to silver eel escapement) were elicited on a national level in close co-operation with national authorities and in accordance with end-user needs (e.g. ICES Data call, EMP progress reports, management authorities). Furthermore, sampling is conducted in a way that minimizes the amount of sacrificed fished to a required minimum, thus age readings are only conducted if directly required by relevant endusers. Details on the data collection for the period from 2017–2019 are specified in the National Workplan for Germany. Some additional parameters were and will be analysed, such as *Anguillicola crassus* infestation and concentration of some contaminants. However, these additional investigations are not mandatory under the DCF. At present, no data on the fishery itself are sampled within the DCF. This was decided, because a lot of these data have to be obtained in the frame of the Eel Management Plans and the formal and administrative requirements of the EU Council Regulation 1100/2007.

Since 2015 a project with the aim of comparing the performance (survival, growth) of stocked glass eels and stocked farm eels has been carried out in parts of the Schleswig-Holstein Baltic Sea, which was finished in 2019 (report available under https://www.schleswig-holstein.de/DE/Fachinhalte/F/fischerei/Downloads/abschlussberichtAalprojekt.pdf?__blob=publicationFileandv=2 (in German)).

Aiming to evaluate the efficiency of glass eel stocking in coastal waters of the southern Baltic a scientific stocking experiment was started in the coastal waters in 2014 (Dorow and Schaarschmidt, 2014). First recaptures of stocked eels marked with Alizarin red indicate high growth rates compared to nearby inland waters during the first period of the continental life phase in brackish coastal waters (Simon *et al*., 2017b). Furthermore, growth differences between natural immigrants and stocked eels were detected where three year aged stocked eels showed higher total lengths compared to three year aged natural immigrants (Wichmann *et al*., 2018).

5.4 Diseases, Parasites and Pathogens or Contaminants

Several studies on eel parasites and pathogens have been conducted during the recent years. Here a short description of the results of studies in this field from the recent years is given to allow an overview about the general situation in German waters.

Leuner (2013) studied the infestation with *A. crassus* in eels in Lake Starnberger See. In 2013, the swimbladders of 90 eels were investigated in September and October and a prevalence of 87% was found (for comparison: 1998: 91%, 2006: 61%, 2012: 81%). Most recent results (Leuner, 2015) indicate that the prevalence of *A. crassus* declined to 61%. Infection intensity was highest in 1998 (12 nematodes per swimbladder) and varied between five and nine parasites per swimbladder in the following years. In 2013, the value was six parasites per swimbladder. The proportion of swimbladders showing callosity was 18% in 1998 and increased to 100% in the following years.

In 2012 (55%) and 2013 (56%) lower proportions of callosity were documented, possibly because younger eels had been studied. Most recent results (Leuner, 2015) indicate that the prevalence of *A. crassus* declined to 61%.

Kullmann (2014) studied the infestation with *A. crassus* in eels from the river Elbe estuary, the Kiel Canal and the Elbe-Lübeck-Canal. Prevalence was highest in the Kiel Canal (64.91%), followed by eels from the river Elbe estuary (54.83%) and the Elbe-Lübeck-Canal (43.66%). Mean infection intensity (nematodes per swimbladder) was significantly higher in the Kiel Canal (5.94) than in river Elbe estuary (3.07) and the Elbe-Lübeck-Canal (1.04).

Information on infestation of eels with *A. crassus* is also given by Marohn *et al*. (2014) for the Schwentine system. Prevalence of *A. crassus* infection was 79.9% and 21.4% of all analysed eels had infection intensities above ten nematodes per host and were considered to be severely infected. Most specimens showed visible but moderate swimbladder damages (Hartmann class 2 and 3; 89.2% (Hartmann, 1994)), whereas 4.3% were classified as severely damaged (Hartmann class 4; Hartmann, 1994). Only 6.5% were unaffected (Hartmann class 1). 73.3% of all nematode-free swimbladders showed signs of earlier infections.

The infestation of eels with the swimbladder parasite *Anguillicola crassus* in north German inland and coastal waters was studied by Wysujack *et al*. (2014). Between 1996 and 2011, the swimbladders of 17 219 eels from eight freshwater and coastal water areas were analysed. Prevalence, abundance of parasites, infection intensity and severity of the damage to the swimbladder were recorded by visual inspection. In the freshwaters the prevalence was in the range of 65–83%, whereas significantly lower values were found in the brackish waters. The differences were less clear for infection intensity but significantly lower values were found in the outermost location in the Baltic Sea. Mean damage to the swimbladders was highest in eels from the Rivers Weser and Elbe and lowest in the Baltic coastal waters. Prevalence and damage degree were stable in all waters except for two rivers, where a decreasing trend in infection intensity was found. Information on the *A. crassus* infection in two lakes in the state Mecklenburg-Vorpommern including the infection rate of wrongly stocked American eels (Frankowski *et al*. 2013) are provided by Thieser *et al*. (2013).

There are currently studies going on within an EMFF (European Marine Fisheries Fund) project monitoring restocking (2016-2019) in North Rhine Westphalia (Germany) focusing on parasitic, viral (AngHV 1 (HVA), EVEX (Eel Virus European X), Eel-Picornavirus (EPV-1)) and bacterial diseases in the rivers Rhine, Ems and Lippe.

Anguillid herpesvirus 1 (AngHV 1) infection was investigated in eels from the Northern German Schlei Fjord. 68% of the eels were found to be virus positive while larger specimens were more often infected (Kullmann *et al*. 2017).

To examine the impact of an *A. crassus* infection on the silver eel migration, Simon *et al*. (2018) compared the *in situ* diving behaviour of a migrating silver eel infested with *Anguillicola crassus* to three uninfested specimens. Results suggest that diving behaviour is not affected during the first stretch of the spawning migration, while further excluding the possibility that eels stay in a hydrostatic equilibrium, thus indicating a more complex role of the swim bladder for vertical migrations than previously thought.

Regarding contaminants, several studies on contaminants in eel have been conducted in Germany. It is not possible to provide all details here. Instead the references are given:

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6 New Information

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Report on the eel stock, fishery and other impacts, in Greece 2018

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1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

The calculation of the indicators was based on the data provided by the General Directorate for Fisheries of the Ministry of Rural Development and Food, as in 2018 due to bureaucratic issues the procedures for funding the Universities of Ioannina and Patras for gathering all the needed data for the assessment of the species in EMU 1 and 2 were not completed.

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
2018	GR_NorW	63,284	100,296.70	16,121.90	36,116.00	16.07	0.022	0.424	0.446
2018	GR_WePe	4,655	5,300.00	12,714.90	12,714.90		0.05	0.95	1.00
2018	GR_EaMT	26,850	72,240.00	6,607.10	6,607.10	9.15			
2018	GR_CeAe	12,628							
2018	GR_Total		177,836.70	35,443.90	55,438.90	19.93	0.032	0.6074	0.6393

Key:

EMU_code = Eel Management Unit code (see Table 2 for list of codes); 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.

1.2 Recruitment time-series

In the framework of the EU DCF, data on eel fisheries and demographics (age and length composition of the population) are presented. Since the implementation of the EMP, further data are acquired for the preparation of the WGEEL Country Report, such as maturity, parasites infections and mortality by predators (i.e. cormorants).

Data on eel landings in the lagoons are collected from both the Fishermen cooperatives and the Regional Fisheries Department. Additionally, length and weight data are recorded on site every two weeks as to have a complete dataseries for the size composition of the populations in Greece.

2 Overview of the national stock and its management

2.1 Describe the eel stock and its management

The Hellenic Eel Management Plan defines four Eel Management Units (EMU). Their definition is based on the main climatic characteristics, on the spatial distribution of lagoons, lakes and rivers, on the existing Ecoregions (Directive 2000/60/EC), on the distribution of the eel fisheries and on the location of the main authorities involved in water and eel management. The management measures concerning fishing restrictions and environmental aspects are applied to all EMUs. The nature and scale of the proposed specific actions, like stocking or pilot studies, respect the relative importance of the EMUs.

The fishery of eel in Greece is limited to the capture of adults during their migration to the Atlantic for reproduction. In Western Greece there is limited fishery of yellow eels, as part of the local tradition (influences from Italy) of consuming younger eels, a practice that is not found elsewhere in Greece. Concerning the fishery of underage eels or otherwise glass eels, it is not performed despite efforts were made with the purpose to be used in aquaculture units. It should also be mentioned that the fishery of the eels is prohibited and only performed with a special permission from the regional authorities. Moreover, there are no scientific data for eel recreational fishing until today.

EMU-01 (seven Prefectures, three Regions) is located in northwestern Greece. It comprises 70% of the total Hellenic lagoons surface and 45% of the lakes surface. Despite the considerable decrease of the EMU-01 landings (180 t in mid-1980, 50 t the recent years), the unit remains the most important eel producer.

EMU-02 (five Prefectures, two Regions) is located in the Western Peloponnesus. It comprises 5% of the total Hellenic lagoons surface and 3% of the lakes. The eel landings of this EMU increased since the mid-1980s, contrary to the general pattern and now represents about 40% of the Hellenic lagoon landings (about 40 t).

EMU-03 (four Prefectures, one Region) is located in the northeastern part of the country. It comprises 24% of the total Hellenic lagoons surface and 9% of the lakes surface. The landings dropped from 70 t in early 1980s to less than 10 t.

EMU-04 covers the rest of the country, mainly central eastern continental Greece and the islands of the Aegean Sea (35 Prefectures and eight Regions). The landings of the EMU-04 are almost zero.

The eel fishery usually is performed with traditional traps, which catch alive the eels during their reproduction migration carried from September to January every year. The fykenets are also used in certain lagoons, where no permanent installed traps exist or during the year except the period of migration. The fishers' cooperatives usually have the adequate infrastructure to store live eels up to their sale (the largest quantity of these are exported to other European countries, such as Italy and Germany). The total fishery of the eels and the total fishery of the rest species must declared every month to the regional authorities. The fishers' cooperatives are obliged to release 30% of the annual eel production in the framework of the Hellenic EMP.

Also, some of the catches are made in the lakes and in the estuaries but eel fishing in the rivers is prohibited. In the lakes, fishers use special eel traps (fykenets). However, this fishing method, due to the fact that catches have declined significantly during the last decades, has almost disappeared. However, after the implementation of the Ministerial Decision 643/39462/01-04-13 (in

the implementation of the European Regulation 1100/07) an eel fishery with fykenets is also banned.

Since the adaptation of the first Hellenic Eel Management Plan in 2009, a significant number of measures were implemented towards the protection and enhancement of the European eel population.

One of the first measures implemented was the release by the fishermen of 30% of the total eel production. The target was achieved in 2014, when the total releases were slightly higher than 30%. Apart from these releases, the aquaculture units that import glass eels are obliged to release the 10% of the total imported glass eel biomass. Fishing cooperatives, however, constantly declare fewer and fewer quantities of eels. There is an essence of a tendency to conceal real production data. Besides concealing part of the production it has been found that in some specific occasions, fishing cooperatives indicate zero catches while available information from traders report significant catches from the same fishing cooperatives. It seems that the obligation to release part of the eel catches pushed the fishing cooperatives to intensify the concealing of the real catches. As fisheries cooperatives are obliged to release 30% of the catches by declaring smaller quantities, necessarily release less. This was more pronounced at the beginning of the season because in most areas was the first implementation of the measure introduced by the EMP. In the process, given that licences are needed for eel exports, the concealing of real catches decreased.

Also, other important measures for the protection of the species is the ban of eel fisheries in rivers and estuaries with any type of gear and the ban of fisheries with fykenets inside the lagoons. In addition all the eels that are going to be exported in other EU countries or transported inside the country are allowed only after the issue of licence in accordance to the regulations of CITES.

Measures that have not been implemented concerns the further reduction of eel mortality due to the fisheries. This is because the implementation of this measure requires the realization of a study for the modification of the permanent installed traps in the lagoons that will increase the escapement of eels and then the modification of the relative legislation.

With the purpose to describe the population dynamics of eels in Greece, attempts are made to apply the Eel Population Dynamics Model (Aschonitis *et al*., 2015) in Vistonida lagoon, which is located in the area of EMU-03. In the next phase, this model will be calibrated in order to be applied to the whole country.

2.2 Significant changes since last report

There weren't any significant changes, since the last report.

3 Impacts on the national stock

3.1 Fisheries

In Greece, a framework regulating the collection of eel data has been established after the approval of the Hellenic Eel Management plan (HEMP) on 2011, but only landings of silver eels, captured at the permanent installations of the commercially exploited lagoons were recorded. Due to the ban of fykenets in all the lagoons, yellow eels are not fished. There are no data for eel landings at any stage from the freshwater fisheries. It must be mentioned that due to the fact the eel fisheries is implemented by using fixed fishing installations in the lagoons, the fishing effort is considered stable during the years, changing only by the number of lagoons, where fishing is applied. Due to the specific fishing methodology, the fishing capacity is equal to fishing effort, since it is a passive fishing device, and the fishing effort is not affected by any other factor such as fuel consumption.

3.1.1 Glass eel fisheries

Glass eel fisheries are prohibited according to the RD/142/1971, however, some data on glass eels can be found in published research papers (Daoulas *et al*., 2000; Cladas *et al*., 1999; Zompola *et al*., 2008).

3.1.2 Yellow eel fisheries

RD/142/1971 also indicates that both fishing and commercial exploitation of eels smaller than 30 cm is entirely prohibited. Therefore, there are no yellow eel fisheries in Greece. Concerning yellow eel fisheries effort, after the implementation of HEMP, it is prohibited to use fykenets in the lagoons, so there are not legal catches of yellow eel and therefore fishing effort cannot be estimated.

3.1.3 Silver eel fisheries

Most of the eels are caught in the lagoons using fixed barrier fish traps. The lagoons are leased and operated by cooperatives of fishers. Individual fishermen operating around the lagoons and in lakes also catch eels (fishing in rivers and river Deltas is prohibited). Small catches have also been recorded in coastal areas, mainly through the use of static fishing equipment used in coastal fisheries, but some quantities are also fished by trawls and purse-seines. Specialists estimate that 90% of the eel catches come from fishing in the lagoons. Furthermore, in 2018, specifically for River Evros (EMU-03), six special licences are issued for eel fisheries in the river. These licences are used for two years and concerns professional fisheries with boats.

The number of the fishing traps in the lagoons remained unchanged in the last 2–3 decades. Therefore, the main fishing dynamics and effort can be considered stable.

It is characteristic that fishing dynamics and effort in the Messolonghi-Aitoliko lagoons during 2012 remained stable despite an increase of the mesh size in fishing traps. This took place in an attempt to decrease the discards of this type of fishing. Smaller eels are expected to escape these traps, but there are no quantitative data available.

The total landings in 2018 for the three EMUs (EMU-01, EMU-02 and EMU-03) were 39 943 kg. In EMU-1 (GR_NorW) the landings recorded were 28 563 kg, in EMU-2 (GR_WePe) the total landings were 9500 kg and finally in EMU-3 (GR_EaMT) the landings were 1880 kg.

3.2 Restocking

According to the Greek EMP, 10% of the imported glass eels for rearing must be used in stocking actions in selected ecosystems. Since 2009 that the HEMP was officially accepted this action is taking place every year. According to the CITES office, in 2018, one permission was issued for the import of 496 00 kg of glass eel from France, 32,20 kg of which were released in estuaries.

Moreover, the fishing cooperatives that manage the lagoons are obliged by CITES to release the 30% of the annual silver eels catches in order to get a permission to export silver eels to other EU countries. For 2018, the total biomass of silver eels that was released was 15 281 kg, which corresponds to a 38.26% of the total annual silver eels catches, while the limit that was set by the HEMP was 30%.

3.3 Aquaculture

According to the data provided by the Ministry of Rural Development and Food, the annual aquaculture production was 128 010 kg. However, according to CITES office the total amount of processed and alive eels exported in 2018 was 278 925 kg, which probably included eels (both processed and alive) kept from previous years. The eel exporting licence from Greece during 2018, as reported by CITES, were 13, and more specific, seven (7) licences were issued for exporting live eel, four (4) were issued for exports to Italy and three (3) to Holland. Furthermore, six (6) licences were issued for exporting smoked eel to Spain (Canary Islands), Belgium France and Cyprus.

3.4 Entrainment

According to the Public Electricity Company (Argyrakis, 2008), in Greece there are 16 large scale and eight small-scale hydropower stations. However, since the hydropower stations are installed on the mountainous part of the rivers in high altitude, the mortality caused by the turbines, pumps is very low to zero. The main problem for the eel movement is caused by the obstacles that are found in the lowland part of the rivers, such as irrigation dams and “ford” type bridges that disrupt the river connectivity.

3.5 Habitat Quantity and Quality

No available data.

3.6 Other impacts

No available data.

4 National stock assessment

4.1 Description of Method

4.1.1 Data collection

Biological and commercial samplings were conducted during the implementation of the National Data Collection Project. In particular, as regards the biological sampling, samples of eels were collected for further processing. The number of samples taken per region under the DCF was determined by SGRN (STECF) (2007) that suggested 200 specimens per 20 t of production. Thus, 200 specimens were randomly collected from each of the three Greek EMU. This number corresponds to the minimum number of specimens required for the examination of the external morphometric characteristics. For internal organs (gonads, liver, digestive system, otoliths) in any case and for small productions a sample of 30 specimens is the minimum required.

For the measuring of the external characteristics, an ichthyometer specially designed for measuring eels and accuracy of 1 mm was used. Finally for the measurement of the body weight, a digital precision scale (± 0.1 gr) was used. Also, a precision digital scale was used (± 0.01 mm) was used to measure the eye of the fish. This in an important biometric measurement usually associated with other biological and ecological parameters of the species. Finally, for the determination of the age, the method of age determination through otolith reading was used.

4.1.2 Analysis

Age analysis

The estimation of eels' age was conducted according to the European Protocol of Age Assessment of ICES, using otoliths of eels and not scales.

During 2018, there were further efforts to finalize the method, which mention in 2017 Greece report. The method that provided the best results was a modification of the Crack and Burn protocol (ICES, 2009).

4.1.3 Reporting

The results of the above mentioned analysis are reported both in the DCF report and also in the country report submitted to the WGEEL.

4.1.4 Data quality issues and how they are being addressed

No data.

4.2 Trends in Assessment results

No data.

5 Other data collection for eel

5.1 Yellow eel abundance surveys

A project to gather data for the calibration of the Eel Population Dynamics Model (EPDM) (Aschonitis *et al.*, 2015) is in progress. Yellow eels are being captured using fykenets in Lake Vistonida, after the Management Body of the National Park, issued a special research licence for yellow eel fisheries throughout the year. The first results are expected to be presented in the WGEEL Report in 2020.

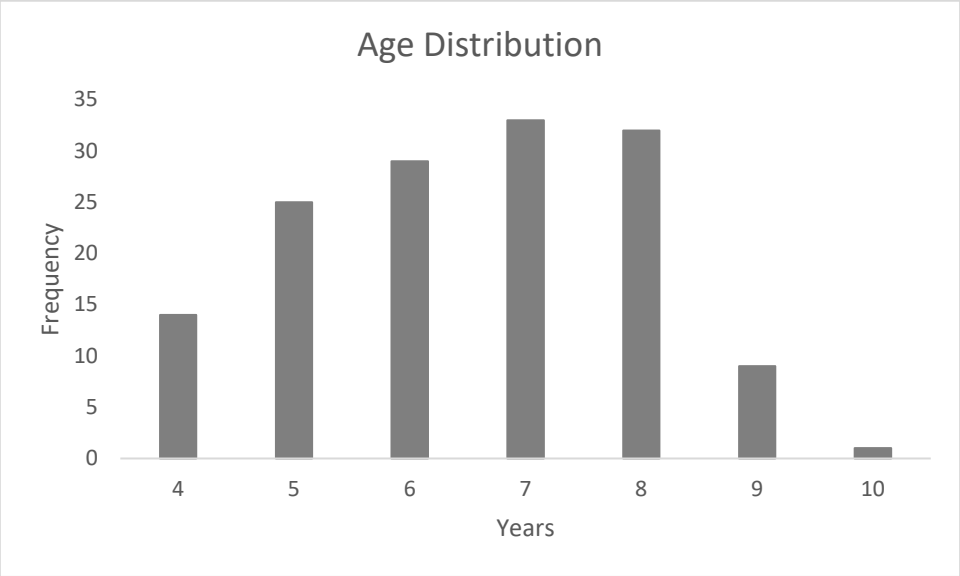
5.2 Silver eel escapement surveys

No available data.

5.3 Life-history parameters

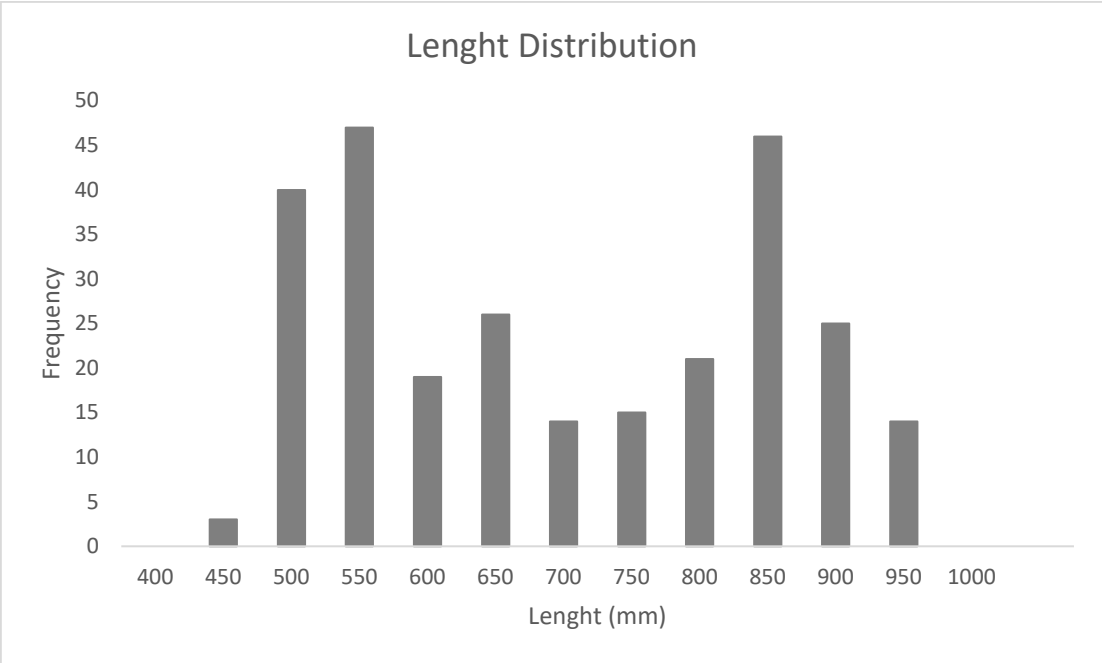
Age distribution

The age was determined using otoliths from 141 samples collected from EMU 3. The youngest eel were 4 years old and the oldest one, ten years old. However, the most abundant class was the seven year olds, and the second most frequent the eight year olds.



Length distribution

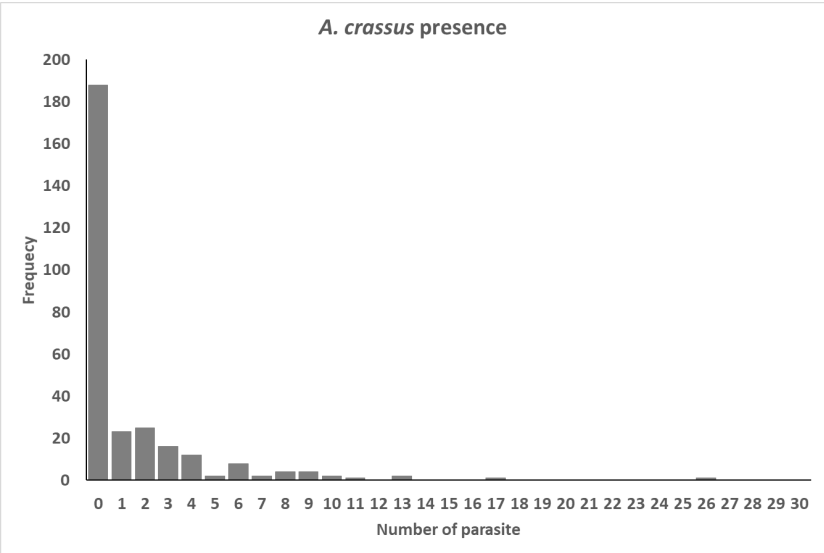
The length from 270 eel samples was used to create the Length Frequency Histogram. The smallest one grew in size of 450 mm, while the biggest one was 950 mm. the most frequent size class was the 550 mm and the 850 mm.



5.4 Diseases, Parasites and Pathogens or Contaminants

Parasites and pathogens

In 2018, 70% of the eel samples examines were not infected by the parasite *Anguillicola crassus*, and 30% were infected by the parasite (in one specimen 26 parasites were counted).



6 New Information

None.

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Report on the eel stock, fishery and other impacts, in Ireland

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Reporting Period: This report was completed in August 2019, and contains data up to 2018.

It should be noted that a comprehensive national report of all the monitoring and assessment activity in 2018 is available as a backup document to this country report: contact Ciara O'Leary.

We would like to note the sad passing of Dr. Kieran McCarthy on the 13th March 2019.

Contributors to the report include

- Electricity Supply Board
- Inland Fisheries Ireland
- Irish Technical Expert Group on Eel
- Marine Institute
- National University of Ireland, Galway

1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

No new data for 2019.

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.

The recruitment data for Ireland 2019 are not available at the time of writing. Monitoring of elvers and young yellow eels is taking place around the country. Preliminary indications suggest that the recruitment is lower than previous years.

Note: Data submitted in 2018 have been updated to include the full monitoring season, 2018.

Recruitment data from the Inland Fisheries Ireland monitoring stations are not publicly available at this time.

2 Overview of the national stock and its management

2.1 Describe the eel stock and its management

No new information since last report Country Report for Ireland 2018.

2.2 Significant changes since last report

No changes since last report.

3 Impacts on the national stock

3.1 Fisheries

All management regions confirmed a closure of the eel fishery for the 2018 season with no commercial or recreational licences issued. The eel fishery, with the exception of the strictly managed L. Neagh, also remained closed in Northern Ireland in 2018.

There were reports of illegal fishing which led to the seizures of gear in the Shannon International River Basin District (ShIRBD), the North West river basin district RBD and the Western river basin district RBD. No seizures of eel dealers transport trucks have been reported and no illegal activity was reported in relation to the silver eel trap and transport programmes. The poor quality of the export data currently available makes it difficult to determine the level of illegal catch. There were no instances of seizures of illegal or undocumented eel shipments.

3.1.1 Glass eel fisheries

There is no authorised commercial or recreational catch of juvenile eel in Ireland as glass eel and elver fishing in Ireland is prohibited by law (1959 Fisheries Act, Sec. 173).

3.1.2 Yellow eel fisheries

There are no new landings data since 2008 as the commercial fisheries were closed in 2009. There are no data available for yellow eel caught by recreational fishermen (only rod angling). Rod angling catches are required by law to be released alive.

3.1.3 Silver eel fisheries

Commercial Silver Eel Fisheries were closed in 2009 and remained closed in 2018.

3.2 Restocking

Stocking has not taken place in Ireland between 2009 and 2019. Currently stocking is not included in the Irish Eel Management Plan.

3.3 Aquaculture

There are no aquaculture facilities in Ireland.

3.4 Entrainment

No new information available since last reported on in the 2018 Country Report. A mortality study was conducted in the North West River Basin District in 2018 and will be repeated in 2019.

3.5 Habitat Quantity and Quality

Water quality

No new information on water quality since reporting in 2018.

Barriers

To fulfil its remit to produce a georeferenced database of barriers to fish passage on the Irish river network, the IFI National Barriers Programme (NBP) team has performed a desk-based survey to identify potential barriers at a national scale, collating significant volumes of geospatial data from state agencies, such as the Office of Public Works (OPW), Ordinance Survey of Ireland (OSi), Transport Infrastructure Ireland (TII), Waterways Ireland, and Irish Rail, as well as historic IFI barrier surveys. This has produced a geodatabase of 72 560 potential barriers, which are being assessed using field surveys and desk-based analysis photographs or video of barrier sites. To date 12 541 have been assessed, 8651 were classified as not a barrier to fish migration and 3890 were classified as potential barrier to fish migration requiring further investigation (Figure 3-1).

In 2018, the NBP undertook 40 SNIFFER surveys on large rivers, focusing on Special Area of Conservation (SAC) catchments: the Boyne, Slaney, Barrow, Nore, Suir and Munster Blackwater. In 2019, the NBP will complete barrier surveys in these catchments and undertake SNIFFER surveys on the main channel of the River Shannon.

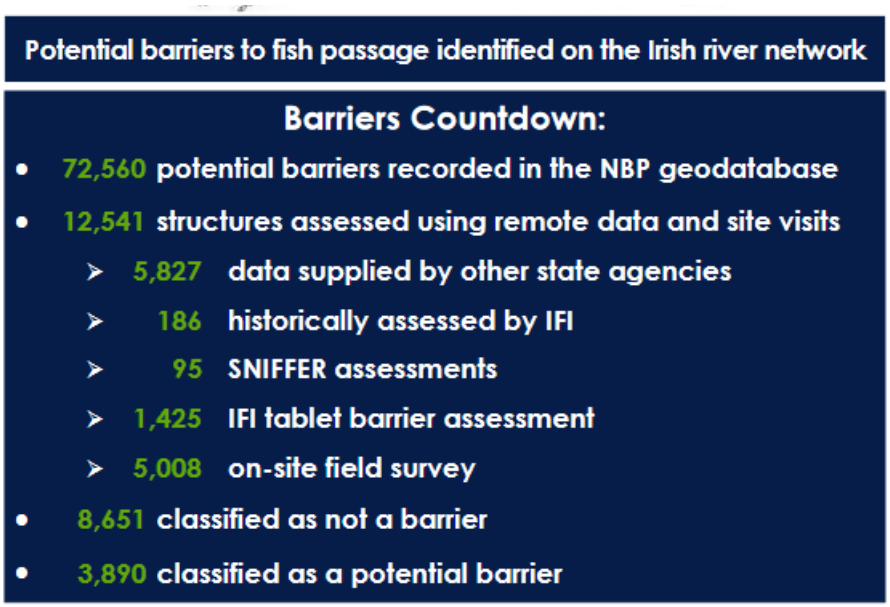

Figure 3-1. Summary description of barrier identification and mitigation.

3.6 Other impacts

Fish kills

There were 40 reported fish kills in 2018 (Table 3-1). This is an increase on numbers recorded for 2017 (14) and 2016 (31) and likely to be due to the low water levels and high temperatures experienced in the summer of 2018. Further information is available on the Inland Fisheries Ireland website http://www.fisheriesireland.ie/Corporate/corporate-publications.html

Table 3-1. Summary Fish kill information 2007–2018.

Year	IE_Total	EMU	EMU	EMU	EMU	EMU
2005	NA					
2006	NA					
2007	22					
2008	34					
2009	16					
2010	34					
2011	31					
2012	10					
2013	52					
2014	22					
2015	23					
2016	31					
2017	14					
2018	40					
2019	NA					

4 National stock assessment

4.1 Description of Method

The stock assessment methods are described in the Irish Eel Management Plan and in the 2012, 2015 and 2018 Irish Management Reports to the EU.

4.1.1 Data collection

Recruitment: mostly using fixed station river ladder traps. With the exception of the Shannon and the Erne, these are partial traps subject to considerable site-specific environmental variation (river flow, tidal height).

Yellow Eel: standard Dutch type double-ended summer fykenets and depletion and single pass electrofishing in shallow rivers.

Silver Eel: Index Rivers using mark–recapture and index fishing stations (Erne, Shannon, Fane, Barrow) and permanent river trap (Burrishoole).

Hydropower mortality: using acoustic tags and arrays of listening stations.

4.1.2 Analysis

Ireland used a system of extrapolating from index data rich catchments to data poor catchments for calculating estimates of pristine and current biomass as described in the Irish Eel Management Plan (Chapter 5) and the WGEEL report (ICES, 2008).

Eel production in transitional waters was estimated using CPUE from fykenet surveys to calibrate an analysis of transitional waterbody types and habitat and this was applied retrospectively back to 2009.

Note: Coastal waters were not included in the production and escapement analysis.

Further information is available in the National reports to the EU.

4.1.3 Reporting

Assessment data collected by the various agencies are collated by the Technical Expert Group on Eel and reported annually. The data are then reported to the EU every three years as required under the Regulation. Key data are included in the Country Report for ICES.

Previous reports are available on the Inland Fisheries Ireland Eel Management webpage

https://www.fisheriesireland.ie/Fisheries-Management/eel-management-plan.html#management-actions

4.1.4 Data quality issues and how they are being addressed

Data are reported to the Irish Technical Eel Group (TEGE - formerly the SSCE) on an annual basis and any issues are discussed and the agencies responsible notified.

An all-Ireland eel age intercalibration workshop was carried out in December 2014.

Identification of subjective variables, such as fish colour, presence of lateral line dots in silver eels, can be interpreted differently between observers.

Very low levels of fishing effort, such as some fykenet effort in transitional waters under WFD sampling, need to be interpreted with caution.

4.2 Trends in Assessments results

No new information since the 2018 report to the EU.

5 Other data collection for eel

5.1 Yellow eel abundance surveys

Yellow eel surveys took place in six lakes, two transitional waters and two riverine catchments in 2018 (Figure 5-1). The lakes surveyed were Lough Corrib (Upper and Lower), Lough Conn, Lough Derg, Lough Muckno and Lough Ramor by IFI, and two lakes in Burrishoole (by MI). Lower Lough Erne was surveyed by AFBI in July 2018 with the pit tagging of eels carried out by IFI staff.

The transitional waters sampled were Lough Furnace Burrishoole and the Waterford Estuary.

River fykenetting was carried out in the Barrow main channel in 2019 in conjunction with a semi-quantitative electric-fishing survey in the upper shallow reaches of the main channel. A repeat fykenet survey was carried out at Clondulane weir on the River Blackwater to estimate the eel population in the impounded section behind the weir.

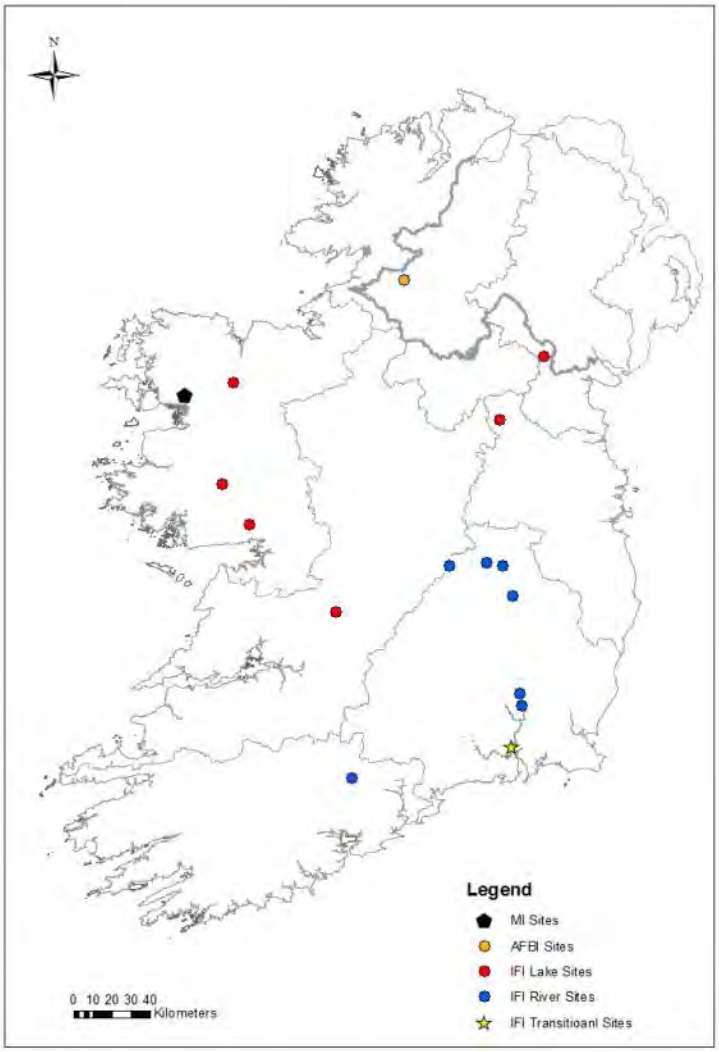

Figure 5-1. Yellow eel abundance surveys 2018.

5.2 Additional multispecies survey

As part of the stock assessments carried out by Inland Fisheries Ireland a total of 24 lakes (spanning 19 catchments), were sampled with eels present in 20 lakes (83% of sites) (Figure 5-2). A total of 221 river sites (across 27 catchments) were covered in the 2017 surveys. The WFD river sites had a 18% eel presence rate, 5% of sites with eels have ≤5 eels, 8% of sites caught between five and ten eels and 7% had >10 eels. The Shannon Estuary was surveyed in 2017, split into three zones (Fergus Estuary, Limerick Dock and the Upper Shannon Estuary).

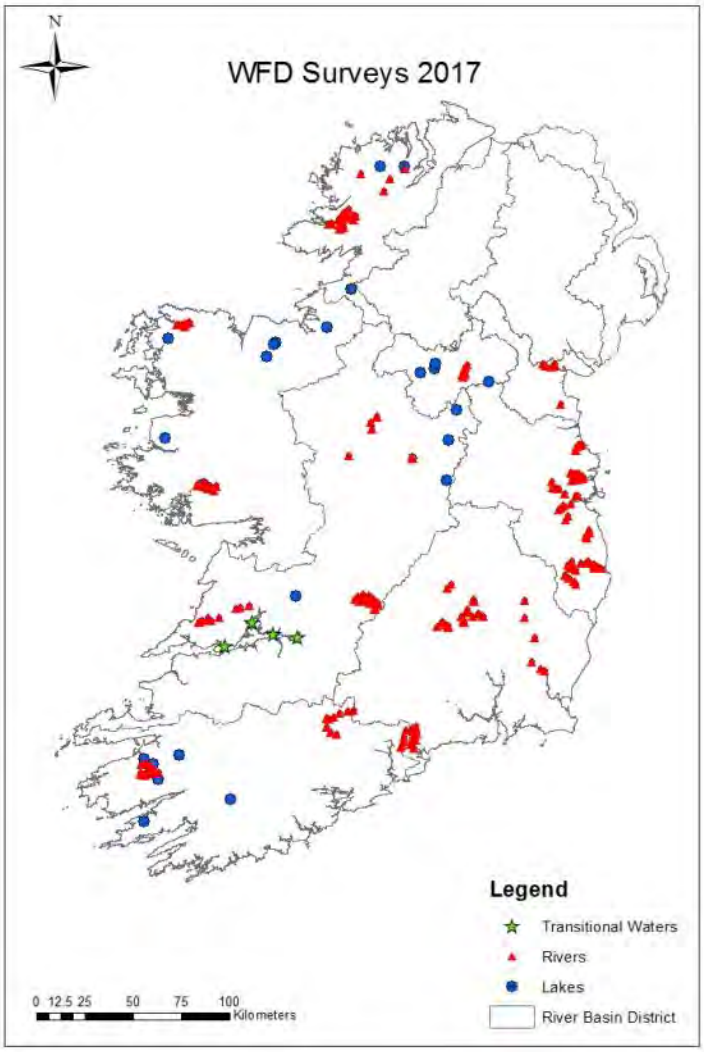

Figure 5-2. Location of multispecies survey sites, 2017.

5.3 Silver eel escapement surveys

Silver eels were assessed by annual fishing stations on the Shannon, Erne, Burrishoole, Fane and Barrow catchments in 2018.

Shannon: IE_ShIRBD

The total Trap & Transport catch in the River Shannon was 16 411 kg. Silver eel production, was estimated to have been 32 850 t. This low production level, which was comparable to the previous year, suggests that a collapse of the Shannon eel stock may be occurring though further years of monitoring would be needed to confirm such a trend.

Burrishoole: IE_WRBD

Silver eel trapping was continued in Burrishoole in 2018. The total run amounted to 1997 eels (end of April 2019); lower than recorded in 2016 or 2017. As in other years, the highest proportion of the total catch (84%) was made in the Salmon Leap trap. In 2018, the timing of the run was 15% migrating in August, 42% in September and 30% in October. Almost 90% of the run was completed by the end of October.

Erne: IE_NWRBD

The total catch contributed to the Trap and Transport programme was 47 004 kg. Fishing started from 1st September to 15th January 2019. The silver eel production is estimated to be 83 t, and escapement was estimated to be 68 t (81.7% of production).

Fane: IE_EEMU

Silver eel catches at the Fane Fishery were high in 2018 with a total catch of 725 kg (1974 eels) and 34 nights fished. An unusually dry September and October resulted in no fishing, increasing rainfall levels in November, led to high flows and the first catches. High catches continued with increasing water flow levels through December.

Barrow: IE_SERBD

A very dry September and October resulted in a very late silver eel season in the Barrow. The total catch for the season over 29 nights was 391 kg (2808 eels) caught in November and December.

5.4 Life-history parameters

Biological measurements are taken on yellow and silver eels such as length, weight, horizontal and vertical eye measurements, pectoral fin length, head diameter in addition to pigment colouration and presence of black spots on lateral line. In key locations, samples are taken back to the laboratory for further analysis.

5.5 Diseases, Parasites and Pathogens or Contaminants

Anguillicola crassus

The parasite prevalence of Lough Conn was 50% in 2018 up from 37% in 2016 but similar to the 52% value recorded in 2009. The mean intensity was 2.62 in 2018 compared with 4.62 in 2016; both years show a drop in intensity from the 7.86 recorded in 2009. Parasite samples were taken from Lough Muckno and Lough Ramor in 2018 as part of a parasite study, and will be reported at a later date. The mean prevalence of *A. crassus* across the zones in Lower Lough Erne was 63%, an increase of 21% from 2016, (mean prevalence in 2011 and 2014 was 72 and 73% respectively).

Contaminants

No new information for 2018.

6 New Information

The TEGE would like to highlight the effect the weather conditions are having on monitoring both recruitment and silver eel escapement. Dry autumn conditions have resulted in a later silver eel migration in many areas, a pattern that has occurred over a number of years. A cold wet April and May can delay the start of the glass and elver migration.

Extreme droughts in 2018 changed the trapping efficiency of some of the recruitment stations, possibly making them more efficient due to lack of alternative flow. The opposite of the flood conditions experience in some previous years.

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Report on the eel stock, fishery and other impacts, in ITALY

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Reporting Period: This report was completed in August 2019, and contains data up to 2018 and some provisional data for 2019.

Acknowledgments: Information and data were gathered by collaboration with MIPAAFT (Ministero delle Politiche Agricole Alimentari, Forestali e del Turismo), UNIMAR Soc. Coop., Research Centre for Animal Production and Acquaculture - Council for Agricultural Research and Economics (CREA) and with Italian Regional Administrations of the nine EMUs (Lombardia, Friuli Venezia Giulia, Veneto, Emilia Romagna, Toscana, Lazio, Umbria, Puglia and Sardegna), within the actions for the implementation of the Italian Eel Management Plan. Marcello Schiavina contributed to the setting up of the eel national database and to the stock assessment.

1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

Stock status parameters (biomass and mortality) have been estimated for all the EMUs that have in place an eel management plan (nine EMUs). In the other 11 Regions there is no fishery and no specific management measures have been foreseen for eel.

In Italy, five habitat typologies have been identified relevant to eel, and the relative wetted areas and eel stocks have been assessed in each region (EMUs): two typologies are freshwater habitats (lakes and rivers) and three are transitional waters (lagoons, managed lagoons and private *valli*).

There are some negligible changes to the indicators previously reported in 2012 and 2015: data relative to 2015–2017 catches have been revised and updated. Considering this, the parameters of the model have been recalibrated from 2007–2017 producing a new series of biomass estimates and mortalities outputs for each year of the series.

Moreover, recruitment series have been modified. In previous versions recruitment was considered to drop exponentially from 1980. As recent years of recruitment are not following this pattern anymore, the recruitment index for "Elsewhere Europe", estimated during the latest WGEEL (2017), was introduced in the model.

Data presented in the tables submitted for the ICES Data Call 2018 and in the Progress report 2018 for art.9 Reg. 1100/2007, have been aggregated as required. In Table 1.1 data have been aggregated for each EMU.

Table 1.1. Stock indicators of silver eel escapement, biomass and mortality rates, and assessed habitat area.

Year	EMU_code	Assessed Area (ha)	B0 (kg)	Bcurr (kg)	Bbest (kg)	∑F	∑H	∑A
2017	IT_Abru	236	1927.81	406.48	472.53	0.01	0.12	0.13
2017	IT_Basi	218	2318.05	557.38	713.83	0.01	0.21	0.22
2017	IT_Cala	192	1579.90	388.61	486.50	0.03	0.15	0.18
2017	IT_Camp	570	4598.88	1493.50	1948.79	0.03	0.19	0.22
2017	IT_Emil	5663	30983.97	9094.20	7589.37	0.05	0.06	0.11
2017	IT_Frio	1356	5840.51	1330.19	1430.25	0.15	0.03	0.17
2017	IT_Lazi	1859	40194.23	5002.67	16868.37	0.84	0.42	1.26
2017	IT_Ligu	344	1683.58	627.58	714.35	0.02	0.07	0.09
2017	IT_Lomb	6163	65560.90	6673.20	11761.10	0.00	1.01	1.02
2017	IT_Marc	228	3515.90	622.99	861.77	0.02	0.27	0.29
2017	IT_Moli	73	902.62	206.37	277.35	0.01	0.25	0.26
2017	IT_Piem	780	15632.05	575.25	2801.16	0.01	1.37	1.37
2017	IT_Pugl	414	1883.14	541.42	579.70	0.01	0.04	0.05
2017	IT_Sard	600	17662.59	422.32	7488.11	2.01	0.15	2.16
2017	IT_Sici	238	2311.36	700.00	978.84	0.03	0.24	0.28
2017	IT_Tosc	1064	9254.46	3749.29	3911.69	0.01	0.25	0.26
2017	IT_Tren	370	7195.46	105.38	1288.16	0.01	1.77	1.77
2017	IT_Umbr	12800	3568.86	0.00	639.37	0.01	NP	NP
2017	IT_Vall	0	1082.24	0.00	193.66	0.01	NP	NP
2017	IT_Vene	10917	138796.53	32167.82	33979.45	0.11	0.09	0.20
2017	IT_Abru	NP	NP	NP	NP	NP	Inf	NP
2017	IT_Basi	NP	NP	NP	NP	NP	Inf	NP
2017	IT_Cala	NP	NP	NP	NP	NP	Inf	NP
2017	IT_Camp	487	9740.00	4059.11	4072.15	0.00	0.00	0.00
2017	IT_Emil	21363	427251.90	74264.55	106467.43	0.49	0.00	0.11
2017	IT_Frio	14360	287192.00	70148.98	71552.10	0.09	0.00	0.09
2017	IT_Lazi	1543	30860.00	9126.29	14228.68	0.15	0.00	0.15

Year	EMU_code	Assessed Area (ha)	B0 (kg)	Bcurr (kg)	Bbest (kg)	∑F	∑H	∑A
2017	IT_Ligu	NP	NP	NP	NP	NP	Inf	NP
2017	IT_Lomb	NP	NP	NP	NP	NP	Inf	NP
2017	IT_Marc	NP	NP	NP	NP	NP	Inf	NP
2017	IT_Moli	NP	NP	NP	NP	NP	Inf	NP
2017	IT_Piem	NP	NP	NP	NP	NP	Inf	NP
2017	IT_Pugl	11533	397888.50	109595.85	123504.97	0.05	0.00	0.05
2017	IT_Sard	7961	192723.71	27655.04	81888.29	0.96	0.00	0.96
2017	IT_Sici	278	5560.00	2236.17	2362.53	0.02	0.00	0.02
2017	IT_Tosc	2700	66150.00	956.41	27651.34	3.36	0.00	3.36
2017	IT_Tren	NP	NP	NP	NP	NP	Inf	NP
2017	IT_Umbr	NP	NP	NP	NP	NP	Inf	NP
2017	IT_Vall	NP	NP	NP	NP	NP	Inf	NP
2017	IT_Vene	81717	1634336.00	356543.06	407287.24	0.11	0.00	0.11

Legend:

EMU_code = Eel Management Unit code (see sheet 'EMU names and codes' for list of codes).

B0 = the amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the stock (kg).

Bcurr = The amount of silver eel biomass that currently escapes to the sea to spawn (in the assessment year) (kg).

Bbest = 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).

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.

The recruitment dataseries supplied in the past to the Working Group were relative to a fishery-based monitoring (commercial catch) on the river Tiber estuary, specifically carried out within a series of research projects for the resource assessment. The fishery ceased its activity in 2001, but some monitoring of recruitment (com. catch + sci. monit.) continued within research projects up to 2006. When the mentioned projects stopped, this monitoring ceased as well. As this fishery has ceased to exist, no monitoring on the Tiber is at present in place on a similar basis, even if this site is now one of the sites where monitoring is carried out by the Regional Administration for eel in the EMU Lazio (see below).

No information on a continuative basis can be derived at present, and no centralised monitoring programme of recruitment is currently in place anywhere in Italy.

Table 1.2 reports available time-series and/or monitoring of glass eel recruitment in Italy, and monitoring that have been activated within the Regional Eel Management Plans or other Eel specific projects. Since 2013, in some regions recruitment monitoring has been progressively activated on a local basis (EMU Toscana, EMU Lazio, EMU Puglia) by the Regional Administrations, each following a specific methodology but based on a common approach. Most of these monitoring are active within specific programmes for Eel Regional Plans implementation supported by the European Fisheries Funds as well as by funding at the local level (regional).

For the EMU Lazio, a regional monitoring has begun, that takes into account some sites in the region (rivers and coastal lagoons), the river Tiber and the river Marta among others. Even if the methodology is not exactly the same, because of the closure of the fishery, it is be important to have again in place these monitoring sites in central Italy, for comparison with the past time-series. Some other monitoring are carried out in other EMUs, such as Tuscany (TOS) and Emilia Romagna (EMR), but no details have been provided by the regions for the present report, nor in the report for the EMP, for what concerns sites, data and methodologies.

Table 1.2. Available time-series and/or monitoring of glass eel recruitment in Italy, and monitoring that have been activated within the Regional Eel Management Plans or other Eel specific projects.

EMU	Habitat	SITE	SAMPLING TYPE	UNIT	Time-scale	min	max
LAZ	F	Tevere	com. catch	kg	year	1974	2001
LAZ	F	Tevere	com. catch+sci. monit.	kg	daily	1990	2006
LAZ	F	Tevere	weekly monit.	Number	1 week/month	2013	2018?
LAZ	F	Marta	com. catch+sci. monit.	kg	daily	1999	2008
LAZ	F	Marta	weekly monit.	Number	1 week/month	2013	2018?
LAZ	T	Fogliano	weekly monit.	Number	1 week/month	2013	2018?
LAZ	T	Caprolace	weekly monit.	Number	1 week/month	2014	2018?
LAZ	T	Lungo_San Puoto	weekly monit.	Number	1 week/month	2014	2018?
LAZ	F	Garigliano	com. catch	kg	daily	1999	2002
PUG	T	Lesina	sci. monit.	Number	daily	2013	2018?
PUG	T	Varano	sci. monit.	Number	daily	2013	2018?
PUG	T	Torre Guaceto	sci. monit.	Number	daily	2014	2018?
PUG	F	Fiume Morelli	sci. monit.	Number	daily	2014	2018?

Monitoring is carried out on each site on a daily basis for a week each month (weekly monitoring) for the whole duration of the ascent season (five months, October–March). At the moment, no time-series can be derived because monitoring with such a methodology have begun only recently, but it is foreseen to process data in order to compare present results with historical dataseries.

Since 2017, within the EU MAP 2017–2019 module 1E: "Anadromus and catadromous species data collection in freshwater", a pilot study started aimed at establishing a standardized methodology for the monitoring of *Anguilla anguilla* (glass eel + yellow and silver eel); in a short while the methodology should ensure the gathering of comparable data in the long period.

2 Overview of the national stock and its management

2.1 Describe the eel stock and its management

Eel (*Anguilla anguilla* L.) exploitation in Italy has a long-standing tradition, and is still important, despite a progressive and increased loss of interest towards this species. Fisheries still concern all continental stages, i.e. glass eel, yellow and migratory silver eel.

Administrative responsibility for eel fisheries is still fragmented, despite the coordination required by the application of the Regulation 1100/2007: sea fisheries and sea fishing up to river mouths are under the responsibility of central government (Ministry of Agricultural, Food and Forestry Policy - Directorate-General for Sea Fishing and Aquaculture), whereas Regions are responsible for inland waters fisheries, including eel fishing, because Presidential Decrees No 11 of 15 January 1972 and No 616 of 24 July 1977 gave them this responsibility. Therefore, the only eel fisheries under a central Administration are glass eel fisheries practised in estuaries, as no marine adult eel fishery is allowed in marine water in Italy (Ministry decree n° 403 25 July 2019). With regards to inland fisheries, that include lagoon as well as lake and river fisheries, each Region has its own regulation. Since 2009, specific regulations for eel are being issued in relation to the application of the Eel Management Plans. Up to now, no specific eel fishing licences are foreseen, and as a rule individual professional fishing licences for inland water fishing are issued valid for six years, by each Region, and are enlisted in registers. The permitted gears vary from region to region, also in relation to local traditions, and are specified by each Administration, together with authorised times and places.

Italy has established, since 2009, its Data Collection Framework for Eel, as foreseen by the Regulation 199/2008, and therefore eel has been included in the DCF Italian National Programme. The Eel Fisheries Data Collection (under Reg. 199/2008, DCF) is at present definitively in place, now as National Data Collection Program (PLNRDA 2017-2021 (under EC Decision C(2016) 8906 – 12/19/2016), and concerns all eel fisheries in inland and coastal waters, commercial as well recreational. Most data presented in this Report for the year 2018 are derived from the PLNRDA, presented at the national level or environmental typology (such as inland or coastal waters), and/or disaggregated by Region (EMU) as well.

The management framework for DCF is the same that has been set up for the Eel Management Plan under Regulation 1100/2007. In the 11 Regions that preferred to delegate eel management to the central government (Directorate-General for Sea Fishing and Aquaculture of the Ministry of Agricultural, Food and Forestry Policy) where commercial eel fishing has been stopped completely since the year 2009, no data collection is carried out (Figure 2.1). In the remaining nine regions -EMUs, where eel fisheries are still ongoing, eel fishery data, both commercial and recreational, are collected with a standard methodology, as foreseen by the Italian National Plan for the Data Collection Framework (Figure 2.1).

Figure 2.1. The 20 Italian Regions (EMU). Nine produced an Eel Regional Management Plan (green); eleven Regions have closed commercial eel fisheries (white), and have/are closing recreational fisheries.

Figure 2.1 shows the geographical distribution of the regions (EMU) that have provided their regional Plans. In all of these, areas of particular importance for eel fishing are included, either in terms of the presence of wetland areas (Grado and Marano Lagoons, the Venice Lagoon, the Po Delta and Valli di Comacchio, Lesina and Varano Lagoons, Orbetello Lagoon, Pontini Lakes and Sardinia's coastal wetlands) or in terms of the historical importance of eel fishing in the region's inland waters (Lombardia, Umbria, Lazio). For what concerns the assignment of Italy and its EMU to ICES Ecoregions, it must be considered that Italy is located in the Mediterranean, lying across two ecoregions, the Western Mediterranean Sea and the Adriatic Ionian Sea. Therefore, some Management Units fall within the WMS ecoregion and some lookout on the AIS.

In each Region/Management Unit, different habitat typologies (such as coastal lagoons, with or without fish barriers, lakes and rivers) have been considered. In fact, in the different Italian EMUs, great ecological heterogeneity exists, that reflects also in diversified productivity of the different aquatic environments within each Region/Management Unit. The habitat categories that were identified are as follows: coastal lagoons, lakes, rivers. In the case of coastal lagoons, for those regions that follow different management strategies an explicit distinction has been introduced, within the lagoons specifically managed (fish stockings, the presence of fish barrier) from the lagoons where only artisanal fisheries are present.

A distinctive feature of the IT-EMP, which reflects on management at the national level, concerns the reforming of the regulation for glass eel fishing. Up to 2008, professional glass eel fisheries were regulated by the Ministero delle Politiche Agricole Alimentari e Forestali by a national legislation (DM March 22, 1991; D.M August 7 1996) that did not contain specific indications for the eel, *Anguilla anguilla*, because generally targeting juvenile fish of all euryhaline species caught for aquaculture purposes. Glass eel fisheries did occur in many river mouths, and in many channel mouths as well. Most of the glass eel yield was from the Central and Southern Tyrrhenian area (Western Mediterranean Sea). The main sites of glass eel catches were the estuaries of rivers

such as the Arno and Ombrone in Toscana, the Tiber and the Garigliano in Lazio, and the Volturno and Sele in the Campania region. Occasionally fry fishers from other regions, who reached those sites with trucks equipped with oxygenated tanks to collect mullet, sea bass, sea bream and eel fry, frequented those sites usually used by local fishers. Local fishers were usually single or cooperative fishers that are were equipped with boats and structures to store the product alive. Fishing instruments vary depending on the characteristics of the site.

The Italian National Management Plan has contemplated the implementation of a new legislation specific for glass eel fishery, on the basis of the fact that this fishing takes place in sites (estuarine areas and low river courses) legally partitioned between State and Regions. The new legislation prepared by the Ministero delle Politiche Agricole Alimentari, Forestali e del Turismo (MIPAAFT) (DM 12/01/2011, 26/01/2011 OJ, 20 - "Regulation of fishing and marketing of juvenile eels, glass eel and elvers of the species *Anguilla anguilla* L.") regulates fishing of glass eels (eels <12 cm) in *marine and brackish waters* of the Italian territory. This new legislation lays down rules regarding monitoring of the fishing and end-use of the product, and gives priority to use for restocking purposes (thus aiming to reach the target of 60% of catches by 2013, as provided in Article 7 of the regulation), specifying that this quota relates to restocking into waters which flow into the sea, so that the measure will contribute to recovery of the eel stock. One of the ways envisaged for meeting the obligations under the Council regulation is to create a system to include a national register of fishers authorised to fish glass eel, allocation of quotas and the obligation to submit catch returns. This new legislation has come in force in 2011, and, together with reinforced controls by the Carabinieri Forestali, should ensure that information on recruitment in Italy is available from year to year, that most glass eels are conveyed to restocking and that illegal fishing is definitively broken off.

Glass eel fishing in *inland waters*, i.e. in rivers above the limit of salt and brackish waters, are under Regional regulations. Therefore, the EMUs (Regions) that have their own Regional Eel management Plans have taken steps to regulate glass eel fishing in inland waters in a manner consistent with the National law. Glass eel fisheries are currently allowed in inland waters of two EMUs on the Tyrrhenian coast: Toscana (TOS) and Lazio (LAZ, D.G.R. n. 76 of 2/3/2012). Tuscany has, through a Regional Document for the implementation of the Eel Management Plan, set up the instrument for the implementation of the measures provided for Eel Regional Plan, financed by regional laws that regulate the fishing industry (LR 66/2005 and L.R. 7/2005).

Among these actions, the provinces of Grosseto and Pisa have created two facilities for stocking glass eels fished within the region. The EMU Lazio has taken steps to enact a specific discipline for glass eel fishery, which provides *inter alia* that the juvenile eel caught in inland waters of the Lazio region are exclusively for farming or restocking inland waters of the region. Glass eel fisheries are explicitly prohibited fishing in inland waters of the Veneto region (VEN, DGR n. 91 18/05/2012), Emilia Romagna (EMR) and Friuli Venezia Giulia (FVG), while the remaining EMUs are not interested in this fishery for natural reasons (no access to the sea, scarce glass eel ascent) or have not yet enacted specific rules. In the eleven regions that have not submitted any Eel Management Plan, glass eel fishing is prohibited, as well as any other activity involving eels, such as commercial and recreational fishing for eels. For the moment, only five regions (Piemonte, Valle d'Aosta, Liguria, Marche and Sicilia) have implemented such forbiddance with explicit rules, the other six regions are still providing.

In the last two years, the responsibility for the management framework of glass eel fishing/restocking, and all eel related measures have encountered a complication related to the fact that for due to a decree of the Government for a spending review, in most regions the number of provinces has been reduced (in most cases by the elimination of some provinces or by fusion of some). Therefore, competences for fisheries in many cases have fallen back to Regions. This has created some confusion, and difficulty in managing operations and as a consequence getting data for the year 2018/2019.

2.2 Significant changes since last report

During the last three years, several coordination meetings have been held among MIPAAFT (Ministero delle Politiche Agricole Alimentari, Forestali e del Turismo) and the representatives of Regional Administrations, technicians, and scientists. Purposes of the meetings have been: updating the current state of the implemented measures provided for Regulation 1100/2007; setting up a coordination framework for the new EU MAP Regulation; carry out a shared quality-check of eel landings and fishing effort data of the last years for the evaluation of the parameters required to assess progress achieved by Article 9 of Regulation 1100/2007; provide guidelines for the monitoring of all eel life stages in order to harmonize the survey methods as required by the new EUMAP Regulation. These activities have been aimed at a greater coordination and agreement between the Ministry and the Regions, and therefore greater access to the data required for the eel scheduled assessment for 2018 (Art. 9 Reg. 1100/2007).

Notwithstanding this, a number of critical issues have emerged clearly. In light of these critical issues, some corrective measures are underway, also on the basis of what emerged by a Coordination meetings between MIPAAFT, Directorate for Fisheries, and Regional Administrations.

The most consistent critical points are the following: need for interaction with multiple Administrations (Regions) for the fishery data collection in order to quantify the fishers universe and identify the sample of fishers to be interviewed; difficulties in the interactions with fishermen; difficulty in operating for sampling and monitoring, high costs; presence of fishing, transport and/or commercialization that are difficult to check and describe, and consequent potential bias of the quality of estimates obtained from the Data Collection system.

In addition in the last year, several coordination issues have arisen: need for coordination with other activities at national and international level for the eel species (CITES); need for coordination with the monitoring and assessment activities foreseen by Regulation 1100/2007 for the management and restoration of the eel stock; need for coordination with activities required by further international frameworks for the management and restoration of the eel stock (Recommendation GFCM / 42/2018/1 on a multiannual management plan for European eel, whose transitional measures are implemented by the EU Regulation No. 2019/124 of the Council of 30 January 2019; EU Evaluation ROADMAP of Eel Management Plans).

The corrective measure to this situation, in order to implement the data collection system, has been identified in the opportunity to involve the Regional Administrations in a specific Coordination Program. This hypothesis is being discussed with the Fishery Directorate of MIPAAFT, to be set up within the EMFF, and may envisage a coordination for some common activities of Eel Management Plans, delegating to the Regions some data collection activities and monitoring, sharing and coordinated methodologies. This will allow to set up a shared framework also for the Eel Data Collection, which satisfies both the requirements of EU-MAP in the next years and those imposed by the need to assess the eel stock pursuant to Art. 9 of EC Regulation 1100/2007, as well as all additional frameworks that are being defined at various national and international levels (CITES; GFCM, etc).

3 Impacts on the national stock

3.1 Fisheries

The most distinctive exploitation pattern for eel in Italy has been in the past coastal lagoon fishery, that yielded most of yellow and silver eel extensive culture and fishery production (Ciccotti, 1997; Ciccotti *et al*., 2000; Ciccotti, 2005; Ciccotti, 2015, Aalto *et al*., 2016). Inland eel fisheries are still found in main rivers and lakes, even if a relic activity. Professional eel fisheries in rivers have never been important, confined to the low course of a small number of rivers even in the past, and further reduced now.

Total fishing capacity for eel in Italy has proved to be difficult to assess. Theoretically, it would coincide with the whole amount of fishers licensed for fishing in inland waters (river and lakes) and coastal lagoons, both commercial and recreational, even if in the practice fishers really interested and involved in eel fishing are only a part of the whole universe of fishers. To these, authorized glass eel fishers in coastal and inland waters must be added.

For both commercial and recreational fisheries, targets are both the yellow and the silver eel stage that are exploited by fishers on a seasonal basis.

The methodology to describe the commercial fishing effort is based on direct and detailed interviews to a sample of fishermen, extracted on a statistical basis for each habitat typology in each MU. Most eel catch is from fykenets fisheries, used in all habitat typologies in all MUs, to which seasonal eel catches at fish barriers used in managed coastal lagoons must be added. Longlines are used sporadically only in one or two lakes.

The interviews consist of questionnaires where each fisher reports catch data (yellow and silver eel separated), type of gear, number of gears used daily, and number of fishing days per year. A detailed cpue in each habitat typology of all nine EMUs is derived from a reliable subset of interviewed fishers: an average parameter of fishing effort (number of gears * number of fishing days) is multiplied by the total fishermen operant in each habitat typology. Yellow and silver eel catches are assessed with the same method. The same methodology (interviews to a sample of fishers) is used to assess data for recreational anglers.

Annual mean cpue for 2018 for commercial landings and recreational landings are reported and available within Technical National Report relative to the Data Collection Framework 2017–2019, modules "Work Package 2 – Biological sampling - Task 2.3a *Anguilla* Work Package 3 – Recreational Fishing - Task 3.1 *Anguilla*", and have been provided with the ICES Data Call 2019.

3.1.1 Glass eel fisheries

The glass eel regulation foresees that glass eel fisheries can continue on a local scale, provided that 60% is used for restocking in national inland waters open to the sea, and provided that fishers compile specific and detailed logbooks of catches and sales. This system, together with reinforced controls by the Carabinieri Forestali, should ensure that information on recruitment in Italy is available from year to year, that most glass eels are conveyed to restocking and that illegal fishing is definitively broken off. With regard to the destination of glass eel catches and to the proportion retained for restocking, on the basis of the forms returned to administrations, it has been possible to document the destination of glass eel only in a generic way. Glass eel destination from national fisheries seems documented, while import data apparently escape registration.

In some EMUs, there are still quantities whose origin and destination are only generically declared. Only for some sites in some regions (Toscana, Lazio), it is possible to document where exactly restocking were performed, while other provinces and regions have not provided documentation that allows to follow the exact destination. Probably, in some regions in the northeast, part of the captures was released in lagoons and other basins, or in *valli*, where fishery has ceased, to allow silvering growth for release, while a share has been possibly been designated to aquaculture facilities.

At present (2018), filling of the forms as foreseen by the glass eel national regulation is still lacking, and the details of the documents of purchase and sale are also deficient. This does not allow complete traceability of movements on the Italian territory. To overcome this problem, a full traceability system is currently under study, developed in collaboration with the Carabinieri Forestali - Unit CITES. This system should ensure the full traceability of all glass eel movements, either from national waters or imported, also aiming to definitively eradicate illegal fishing of glass eels.

For the season 2018/2019 there are no declared glass eel catches to the Central Administration, as inferred by the fishers declarations. Under regional frameworks, only 243 kg of glass eel catches in IT_Lazio have been declared.

In relation to the underreporting catches or illegal fishery targeting all eel life stages, the administrations, both central and regional, at present fail to ensure a species control system and did not provide for a methodology to control trade, although this necessity has often been highlighted.

3.1.2 Yellow eel fisheries

Tables 3.1.2.1 and 3.1.2.2 show *yellow eel catches for commercial and recreational fisheries* in Italy since 2009. Annual catches of yellow eel for the year 2018 accounted for 67 446 kg (commercial + recreational catches), as evaluated under the DCF programme.

Table 3.1.2.1. Commercial catches (kg) of yellow eels for habitat type reported per EMUs since 2009.

Year	Habitat type	IT_Lomb	IT_Vene	IT_Frio	IT_Emil	IT_Tosc	IT_Umbr	IT_Lazi	IT_Pugl	IT_Sard
2009	F	2,000	8,718	969	1,333	306	5,594	8,953		9,594
	T		7,081	1,263	6,840	20,000		25,051	23,635	65,820
2010	F	358	5,994		790	120	7,317	10,975		1,832
	T		11,656	2,121	7,800	13,402		3,375	4,691	23,704
2011	F	107	6,884	2,208	233		7,853	4,493		1,362
	T		2,789	1,625	8,087	14,364		638	3,330	17,904
2012	F	949	5,051	1,374	144		4,346	8,458		1,401
	T		5,581	1,549	12,747	14,033		5,306	12,449	13,890
2013	F	81	6,968		131		4,782	6,812		
	T		5,280	2,157	7,573	8,159		688	4,998	22,171
2014	F	1,035	6,800	505	130		3,642	5,481		
	T		5,180	2,154	7,500	9,966		715	5,543	21,820
2015	F	654	4,862	326	415		2,965	4,738		1,130
	T		5,324	856	7,633	6,061		660	7,344	21,007
2016	F	222	7,887	108	750		3,593	6,228		1,128
	T		5,780	2,028	6,561	3,928		110	4,278	18,112
2017	F	60	4,350	75	480		1,050	4,760		1,105
	T		10,980	2,520	8,193	13,778		2,662	5,378	8,744
2018	F	68	1,255	75	1,175		101	2,137		1,105
	T		4,046	1,818	8,681	5,153		743	4,571	8,744

Table 3.1.2.2. Recreational catches (kg) of yellow eels for habitat type reported per EMUs since 2009.

year	Habitat type	IT_Lomb	IT_Vene	IT_Frio	IT_Emil	IT_Tosc	IT_Umbr	IT_Lazi	IT_Pugl	IT_Sard	Other
2010	F	15,307	91,334		13,457	876	7,960				7,302
	T										
2011	F	4,670	6,563		7,610	421	4,367	1,296			17,574
	T		5,312								
2012	F	16,988	3,834		8,303	4,114	1,679	11,705			14,189
	T										
2013	F	29,657	17,707	217	7,526	1,348	1,361	1,619			8,923
	T										
2014	F	29,693	17,771	217	7,693	1,428	1,378	1,364			8,988
	T										
2015	F	6,712	6,381	113	1,174	3,364	6,260	5,638			4,830
	T		5,264								
2016	F	6,063	6,175	897	4,698	2,931	2,905	4,596			607
	T		5,290								
2017	F	4,710	5,962		5,638	2,998	2,003	5,340			84
	T										
2018	F	4,711	5,962	1,301	5,637	2,998	2,003	5,079			84

In relation to the underreporting of catches or illegal fishery targeting all eel life stages, it is emphasised that Administrations, both central and regional, at present fail to ensure a species control system and did not provide for a methodology to control trade, although this necessity has often been highlighted.

Table 3.1.2.3 shows the *effort parameters* for commercial fishery in Italy in 2018 for yellow eel. For the eel commercial fishing capacity relative to the nine EMUs where eel fisheries are present, fishing being prohibited in the remaining eleven Regions where no EMP is in place, the best estimates of the total number of fishermen involved in eel fishing are from census returns (the first carried out in 2007 and then revision in 2011, 2014 and 2017). Overall, 1116 operators are involved in eel fishing, in the nine regions, all typologies included. These fishers are licensed fishers as well as employees in the managed lagoons, and they do not target only eel, but other freshwater or euryhaline fish as well. In most cases, eel importance in catches is quite low.

For recreational fisheries, potential fishing capacity coincides with all licensed fishers in all of the national territory, all regions included (333 407 in number). The effective number of recreational anglers involved in eel fishing is obviously much lower. The estimate of the total amount of eel

recreational anglers is obtained within the DCF programme, on the basis of the information provided by the two main recreational fishermen's organizations (FIPSAS and ARCI Pesca) in Italy that account for most of inland waters recreational fisheries. Table 3.1.2.4 shows the effort parameters for recreational fishery in Italy in 2018. Estimate of effective number of eel recreational fishers estimated for 2018 amounts to 3323.

Table 3.1.2.3. Effort parameters used for eel commercial fishing in Italy in 2018, disaggregated by EMU and habitat typology.

EMU	Habitat type	FAO area	Eel stage	Gear type	Number of gears per day	Total number of fishers by method	Average No. Fishing Days for Season	Eel catch per GEAR (kg)	n° of active licences
IT_Emil	F		Y	Fykenet	31	15	93.0	1175	15
IT_Frio	F		Y	Fykenet	23	12	16.0	75	12
IT_Lazi	F		Y	Fykenet	44	30	75.0	2137	30
IT_Lomb	F		Y	Fykenet	5	27	90.0	68	27
IT_Sard	F		Y	Fykenet	6	26	116.0	1105	26
IT_Umbr	F		Y	Fykenet	19	23	88.0	101	23
IT_Vene	F		Y	Fykenet	47	69	142.0	1255	69
IT_Emil	T	37.2.1	Y	Fykenet	17	125	94.0	8681	125
IT_Frio	T	37.2.1	Y	Fykenet	37	65	28.0	1818	65
IT_Lazi	T	37.1.3	Y	Fykenet	50	11	78.0	743	11
IT_Pugl	T	37.2.1	Y	Fykenet	60	50	100.0	4571	50
IT_Sard	T	37.1.3	Y	Fykenet	10	486	83.5	8744	486
IT_Tosc	T	37.1.3	Y	Fykenet	33	25	170.0	5153	25
IT_Vene	T	37.2.1	Y	Fykenet	52	152	210.0	4046	152

Table 3.1.2.4. Effort parameters used for eel recreational fishing in Italy in 2018, disaggregated by EMU and habitat typology.

EMU	Habitat type	FAO area	Eel stage	Gear type	Number of gears per day	Total number of fishers by method	Average No. Fishing Days for Season	Eel catch per GEAR (kg)	n° of active licences
IT_Emil	F		Y	Fishing rod	2	863	15	5637	34268
IT_Frio	F		Y	Fishing rod	2	100	5	1301	16008
IT_Lazi	F		Y	Fishing rod	2	115	9	5079	42305
IT_Lomb	F		Y	Fishing rod	2	689	9.31	4711	85000
IT_Piem	F		Y	Fishing rod	2	9	2.5	10.6	28800
IT_Piem	F		Y	Shore lift net		10	12.27	11.8	28800
IT_Sici	F		Y	Fishing rod	2	38	6	38	2200
IT_Tosc	F		Y	Fishing rod	2	354	5.45	2156	27249
IT_Tosc	F		Y	Shore lift net		50	14.55	305	27249
IT_Tosc	F		Y	Umbrella		88	10.23	537	27249
IT_Umbr	F		Y	Fishing rod	2	170	15	2003	11500
IT_Vene	F		Y	Shore lift net		20	30	225	58218
IT_Vene	F		Y	Fishing rod	2	756	20.65	5737	58218

3.1.3 Silver eel fisheries

Tables 3.1.3.1 and 3.1.3.2 show *silver eel catches for commercial and recreational fisheries* in Italy since 2009. Annual catches of silver eel for commercial and recreational fisheries in the year 2018 accounted for 130 399 kg, as evaluated under the DCF programme.

Table 3.1.3.1. Commercial catches (kg) of silver eels for habitat type reported per EMUs, since 2009.

Year	Habitat type	IT_Lomb	IT_Vene	IT_Frio	IT_Emil	IT_Tosc	IT_Umbr	IT_Lazi	IT_Pugl	IT_Sard
2009	F	2,000	8,400	969	2,083	100	1,830	9,449		4,244
	T		17,280	6,263	22,743	25,000		2,783	14,891	24,731
2010	F	2,906	12,572		131	49		12,656		1,671
	T		26,137	15,836	25,256	35,705		3,690	7,423	27,054
2011	F	534	6,984	92	3			5,007		4,473
	T		17,040	7,569	24,441	30,772		913	5,116	14,691
2012	F	283	4,657	57			1,307	4,940		3,838
	T		18,635	7,281	24,631	13,680		154	3,837	11,846
2013	F	97	6,706	2,416				1,961		
	T		19,177	6,280	24,287	16,649		1,788	3,720	19,332
2014	F	1,215	6,525	27				2,016		
	T		19,077	6,273	24,253	23,441		1,760	10,360	19,195
2015	F	89	5,342	326	20			1,460		3,041
	T		19,710	2,039	25,219	12,823		330	8,824	27,057
2016	F	88	4,373	83	30			3,672		2,405
	T		18,080	2,472	26,506	31,207		1,953	3,629	49,818
2017	F	337	3,185	125	12		2,543	4,910		3,608
	T		18,270	1,782	29,694	22,938		880	5,428	42,193
2018	F	383	1,295	93	40		1,621	2,028		3,608
	T		17,243	2,086	28,331	14,855		1,403	4,614	42,193

Table 3.1.3.2. Recreational catches (kg) of silver eels for habitat type reported per EMUs, since 2009.

year	Habitat type	IT_Lomb	IT_Vene	IT_Frio	IT_Emil	IT_Tosc	IT_Umbr	IT_Lazi	IT_Pugl	IT_Sard	Other
2010	F	458	2,760	120	7,200	630		1,260			840
	T										
2011	F		2,760	120	7,200	630		1,260			840
	T										
2012	F		2,760	120	7,200	630		1,260			840
	T										
2013	F	849			429	17					
	T										
2014	F	898			345	41					
	T										
2015	F	2,962	4,456	143	7,439	1,959		1,652			998
	T		849								
2016	F	2,800	4,844	150	8,317	1,675		1,609			1,050
	T		2,234								
2017	F	3	2,267	150	8,036	1,501		1,578			990
	T										
2018	F	3	1,842	100	5,250	1,411		1,252			750
	T										

In relation to the underreporting catches or illegal fishery targeting all eel life stages, it is emphasized that Administrations, both central and regional, at present fail to ensure a species control system and did not provide for a methodology to control trade, although this necessity has often been highlighted.

Tables *3.1.3.3 and 3.1.3.4* show the *effort parameters* for commercial and recreational fishery in Italy in 2018 for silver eel. For further details see Section 3.1.2.

Table 3.1.3.3. Effort parameters used for eel commercial fishing in Italy in 2018, disaggregated by EMU and habitat typology.

EMU	Habitat type	FAO area	Eel stage	Gear type	Number of gears per day	Total number of fishers by method	Average No. Fishing Days for Season	Eel catch per GEAR (kg)	n° of active licences
IT_Emil	F		S	Fykenet	31	15	93.0	40	15
IT_Frio	F		S	Fykenet	23	12	16.0	93	12
IT_Lazi	F		S	Fykenet	44	30	75.0	2028	30
IT_Lomb	F		S	Fykenet	5	27	90.0	383	27
IT_Sard	F		S	Fykenet	6	26	116.0	3608	26
IT_Umbr	F		S	Fykenet	19	23	88.0	1621	23
IT_Vene	F		S	Fykenet	47	69	142.0	1295	69
IT_Emil	T	37.2.1	S	Fykenet	17	125	94.0	431	125
IT_Emil	T	37.2.1	S	Barrier	2		48.0	7900	
IT_Frio	T	37.2.1	S	Fykenet	37	65	59.0	1379	65
IT_Lazi	T	37.1.3	S	Fykenet	50	11	78.0	1403	11
IT_Pugl	T	37.2.1	S	Fykenet	60	50	100.0	4614	50
IT_Sard	T	37.1.3	S	Barrier	13		120.0	19811	
IT_Sard	T	37.1.3	S	Fykenet	10	486	83.5	22382	486
IT_Tosc	T	37.1.3	S	Barrier	2		150.0	2392	
IT_Tosc	T	37.1.3	S	Fykenet	33	25	170.0	12463	25
IT_Vene	T	37.2.1	S	Fykenet	52	152	210.0	2243	152

Table 3.1.3.4. Effort parameters used for eel recreational fishing in Italy in 2018, disaggregated by EMU and habitat typology.

EMU	Habitat type	FAO area	Eel stage	Gear type	Number of gears per day	Total number of fishers by method	Average No. Fishing Days for Season	Eel catch per GEAR (kg)	n° of active licences
IT_Emil	F		S	Shore lift net	350		15.0	5250	34268
IT_Frio	F		S	Shore lift net	3		15.0	100	16008
IT_Lazi	F		S	Shore lift net	39		15.0	897	42305
IT_Lazi	F		S	Fishing rod	2	135	9.0	355	42305
IT_Lomb	F		S	Fishing rod	2	124	5.0	3	85000
IT_Tosc	F		S	Fishing rod	2	354	5.5	691	27249
IT_Tosc	F		S	Shore lift net	50		15.0	548	27249
IT_Tosc	F		S	Umbrella		88	10.2	172	27249
IT_Vene	F		S	Fishing rod	2	376	15.3	444	58218
IT_Vene	F		S	Shore lift net	75		15.0	1398	58218

3.2 Restocking

No data are available for 2018.

Table 3.2 shows a reconstruction of time-series of stockings, on the basis of data gathered for the Italian progress report under Art.9 of Regulation (CE) n°1100/2007.

Table 3.2. Reconstructed time-series of stocking since 2009.

	Local Source				Foreign Source			
Year	Glass Eel	Quarantined Glass Eel	Wild Boot-lace	On-grown cultured	Glass Eel	Quarantined Glass Eel	Wild Boot-lace	Ongrown cultured
2009 *	100		9639 ◦					
2010 *	26		8040.3 ◦					
2011 *	102.50		6857 ◦		130°°			
2012	44.80		1775 ◦		200°°			
2013	264.75		8229					
2014	445.50		4866				500°°	
2015	122		750				6414°°	
2016	70		1158.6					
2017	145.80		4100					
2018	NA							

*** in the years 2009, 2010 and 2011 glass eel fisheries were closed, apart from a few particular cases of experimental fishing or Province authorizations for stocking purpose. Glass eel fisheries under the new rule began again in 2011/2012**

° bootlace and yellow eels used for stocking are in part wild eels from France (Camargue), and part from on-grown cultured (Italy, Netherlands), but the exact quantities of each source are not available.

°° glass eel and bootlace of foreign source used for stocking are not verified and the exact quantities of each source are not available, therefore these data are not considered in the Italian progress report under Art.9 of Regulation (CE) n°1100/2007.

3.3 Aquaculture

Data are not available for 2018 national eel aquaculture production since deadline for the EUROSTAT data call (under Reg. 762/2008) is December 2019. Table 3.3.1 shows total aquaculture production in Italy since 2009. Information requested in this section is collected under the DCF (Task "Aquaculture") and used for SIPAM databases and for EuroStat (Regulations 788/96 and 762/2008 on the submission by Member States of Statistics on Aquaculture production).

Table 3.3.1. Aquaculture production in Italy from 2009 to 2017.

Year	Value (kg)	EMU	Yellow eels	Habitat typology
2009	397820	IT_total	Y	F
2009	279603	IT_total	Y	T
2010	565510	IT_total	Y	F
2010	75292.6	IT_total	Y	T
2011	469050	IT_total	Y	F
2011	41302	IT_total	Y	T
2012	574485	IT_total	Y	F
2012	162788	IT_total	Y	T
2013	585734	IT_total	Y	F
2013	56410	IT_total	Y	T
2014	527700	IT_total	Y	F
2014	44195	IT_total	Y	T
2015	416100	IT_total	Y	F
2015	43740	IT_total	Y	T
2016	387470	IT_total	Y	F
2016	44630	IT_total	Y	T
2017	477500	IT_total	Y	F
2018	NA	IT_total	Y	F

3.4 Entrainment

No available data.

3.5 Habitat Quantity and Quality

No available data.

3.6 Other impacts

No available data.

4 National stock assessment

4.1 Description of Method

As illustrated above, Italy has a mixed Eel Management Plan that includes a National EMP and nine Regional EMPs. The former deals only with coastal waters, and hence only with glass eel fisheries, while the RMPs deal with inland waters of the nine regions where eel stock is exploited. The stock assessment for eel was, however, carried out for all the 20 Italian Regions, i.e. including also the other eleven regions where no recovery plans for the eel were foreseen.

Within each Region, a habitat-based approach was used for assessments, considering separately lake, river and estuarine waters and lagoon surfaces. Local stock assessment was performed at the EMUs level (i.e. regions) for wetted areas and also taking into account specific habitat typologies (lakes, lagoons, rivers). A demographic model tuned on available data on recruitment, fishing effort and age/size structure or on bibliographic data was used The model (DemCam), developed by Bevacqua *et al*., 2009 from University of Parma and Politecnico di Milano and evaluated in the ICES working group SGIPEE, was used, specifically revised for this purpose.

The same methodology used in the preparation of the Plan was used for the estimates provided in the Progress Report – year 2018 under Art.9 of Regulation (CE) n°1100/2007, but with a different and improved version of the DemCam model to the current version for the stock assessment, called ESAM (Eel Stock Assessment Model, Schiavina *et al*., 2015).

Biomass and mortalities are estimated using a deterministic model based on most recent scientific knowledge on eel dynamics. Model parameters are systematically calibrated on actual catches data to reproduce patterns and biomasses. The model is able to produce abundances and biomasses in pristine conditions and in current condition, turning on and off all anthropogenic mortalities to evaluate the effect of each one.

The ESAM model covers the whole continental phase of the European eel's life cycle, from the recruitment at the glass eel stage up to the escapement of migrating silver eels. It defines the eel stock and the harvest structured by age, length, sex and maturation stage (yellow or silver) on an annual basis. The model allows also considering the system in pristine conditions by using the extension of pristine habitat in the absence of human pressure (fishing mortality and presence of dams) and the abundance of recruitment calibrated to produce the set pristine production.

Melià *et al*. (2006) estimates were used for body growth modelling: for each EMU and habitat type parameters calibrated with the data obtained from DCF biological samplings in the respective reference site of the habitat typology have been used, or from other available data, extending these parameters in those cases where no other data were available.

The probability of reaching sexual maturity, and natural mortality were estimated with the model proposed by Bevacqua *et al*. (2006; 2011).

Fishing mortality rate (F) was calculated as the result of the effort applied, the selectivity of the nets used (depending on the length and the mesh size of the gears, and the catchability, calibrated on catches data; Bevacqua *et al*., 2009).

In the case of managed lagoons, where fishing barriers are present, all silver eel caught by these traps were deducted from the total silver eel biomass estimated by the ESAM model in these habitat typologies.

The model allows to consider other anthropogenic mortalities such as the silver eels survival during the downstream migration, by considering the number of dams with hydroelectric turbines and their correspondent probability of survival of each plant (ς=0,682; ICES, 2011).

On the basis of the escapement pristine data, Bo, (assessed with different levels of productivity for each habitat typology, from 3,2 to 34,5 kg/ha taken from scientific literature) and the pristine available wetted areas (in hectares), the model estimates the pristine level of recruitment. With regards to recruitment, an estimation of the fraction of actual recruitment by considering in Italy four macro areas differing in recruitment level. With this procedure, it was estimated that recruitment is currently 10% for the pristine inland waters (not directly connected to the sea), 15% for the Northern Adriatic Sea, 20% for the Southern Adriatic Sea and 30% for the Tyrrhenian area and the islands. From the pristine recruitment value and considering a recruitment series from 100% in 1950 following the ICES recruitment index for elsewhere Europe, the current actual available wetted areas calculated with GIS approach, it simulates the system until equilibrium is reached in the absence of human pressure to obtain an estimate of the potential silver eel biomass (Bbest).

It has been clearly stated in earlier Reports that the Italian approach for the assessment is to provide at each assessment step an update and improvement also of previous estimates, based on the fact that the national dataset, as a whole and for single EMUs, takes advantage of in-depths, new information and experience gained, new data acquired through monitoring and data collection frameworks. Hence, the estimates provided in the Progress Report Art. 9 Reg. 1100/2007 have been obtained by a supplemented dataset (integrated also for years prior to 2017 for some EMUs) and achieved based also a revision of the assessment methodology. Therefore, some indicators have changed from those previously reported.

With regard to the 2018 Progress report Art. 9 Reg. 1100/2007, new data related to 2015–2017 catches were introduced, and the parameters of the model on the whole catches series from 2007–2017 were recalibrated producing a new series of biomass and mortalities output for each year of the series.

Also the recruitment series were modified. In previous versions, recruitment was considered to drop exponentially from 1980. As recent years of recruitment are not following anymore this pattern, this model was substituted with the actual recruitment index for "Elsewhere Europe" estimated during last ICES, WGEEL 2017.

The estimates have been performed on a yearly basis, taking as a reference for the period before 2009 the year 2007, for each year since 2009. The Italian Plan was approved in the year 2011, but some actions for its implementation already had begun in 2008, and therefore estimates and information for the whole period 2008–2017 are provided.

Further information is available in "Italian progress report under Art.9 of Regulation (CE) n°1100/2007 – Year 2018", Rapporto Italiano Del Piano Nazionale Di Gestione (PNG) dell'Anguilla europea Art.9 Reg. (Ce) N° 1100/2007 Anno 2018.

4.1.1 Data collection

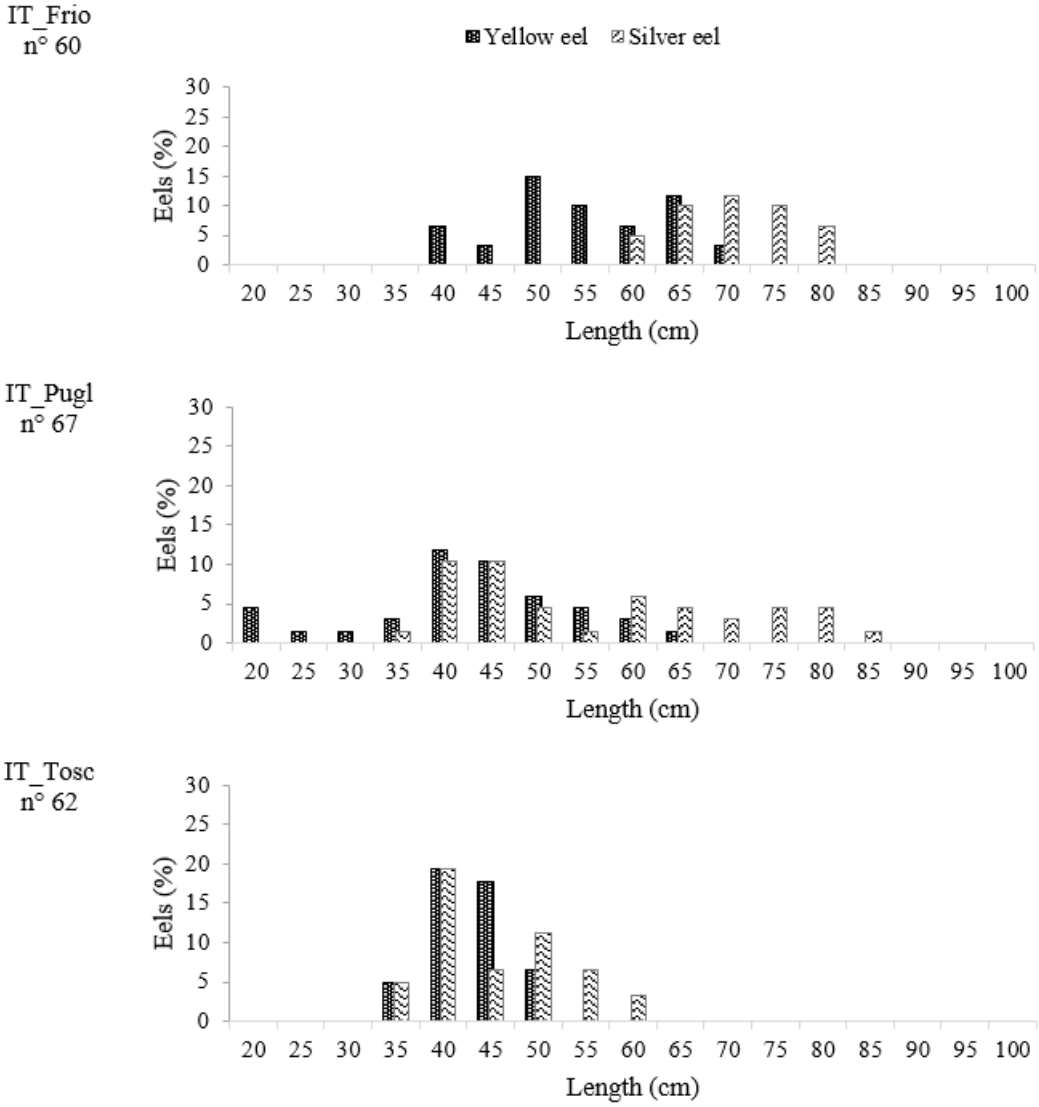
Surveys are currently carried out on a regular basis under the DCF since 2009. Samplings are foreseen for every Eel Management Unit (EMU) that are the nine regions where eel fishing is still ongoing.

Since 2017, the new DCF establishes that the biological samplings are to be carried out in three EMU (region) in a single site, be it a lagoon or catchment, most representative of the EMU in terms of habitat extent and/or amount of eel landings, for a total of 60 individuals each (yellow and silver eel).

In 2018, a total of 189 individuals (yellow and silver eel) were sampled in order to assess stage composition (reconfirm yellow or silver stage), length and weight. Samplings were carried out by taking a random batch of eels from a single fisher cumulated catch of the day or of the week. Sample processing foresees different procedures depending on data to be obtained from the samples. Usually, length and weight are measured directly on anaesthetized eel, and digital pictures for subsequent specific morphometric measurements are obtained. For 2018, samples were released because no other observations were due.

Table 4.4.1. Yellow and silver eel biological samplings carried out in three EMUs for DCF 2019–year 2018.

EMUs	IT_Frio	IT_Pugl	IT_Tosc
Habitat	LGN	LGN	LGN
Site	Grado Marano	Lesina	Orbetello
Total number	60	67	62
n° yellow eel	34	32	30
n° silver eel	26	35	32
TL (cm)			
Mean ± S.D.	59.60 ± 10.81	42.36 ± 5.75	47.64 ± 14.82
min	36.46	32.03	17
max	80	57.35	84.35
Weight (g)			
Mean ± S.D.	415.44 ± 215.75	138.85 ± 63.57	250.10 ± 236.92
min	80.8	41.98	17.57
Max	1008.6	318.03	1123.33



4.1.2 Analysis

For 2018, no analysis of age and sex determination have been performed because not requested within DCF. Anyway, procedure and methods usually used for the evaluation are described below.

Age determination

The procedure used provides a reliable method for processing eel otoliths and assessing the age of the eel by counting the annuli illuminated via polarized or transmitted light as a result of the grinding and polishing. This method has been developed at the Cemagref laboratories (Bordeaux, France) but has been modified in several steps in our laboratories (Carbonara *et al*., 2015).

Life stages

Maturation stage is determined by combining gonad development assessment, Pankhurst's (1982) ocular index (OI), which reflects changes in eye diameter during metamorphosis to the silver stage (Acou *et al*., 2005) and Durif's silvering index (Durif *et al*., 2005).

Sex determination

Sex is assessed macroscopically whenever possible, or by histological examination of gonads (Colombo and Grandi, 1996) when determination is uncertain.

4.1.3 Reporting

Data concerning the eel modules "Work Package 2 – Biological sampling - Task 2.3a *Anguilla* Work Package 3 – Recreational fishing - Task 3.1 *Anguilla*", relative to the year 2017 are reported annually to the Ministero delle Politiche Agricole e Forestali, Direzione Generale della Pesca e dell'Acquacoltura in a Technical National Report (PLNRDA - Programma Nazionale Italiano per la raccolta e l'uso dei dati nel settore della pesca per il periodo 2017–2019- annualità 2018 Regolamento CE 199/2008 Work Package 2 – Campionamento biologico - Task 2.3a *Anguilla* Work Package 3 – Pesca Ricreativa - Task 3.1 *Anguilla*) that includes the results of all Units that collect fishery data for all species and for all GSA and for all activities, aquaculture included. Data are aggregated and prepared in accordance with the requirements of Reg. CE 199/2008 and tables are uploaded to the National Database "Banca Dati 199".

Data will be used for Data Call 2018 GFCM-DCRF in compliance with Recommendation GFCM/40/2016/2.

There is no objection to the disclosure of the central part of the CR and of the Annexed Tables to any third party, while for the disclosure of any additional information a previous notification to the Italian Ministero delle Politiche Alimentari e Forestali is required, for its eventual authorization.

4.1.4 Data quality issues and how they are being addressed

With regard to the level of assessment and the data quality used, it has been clearly stated in earlier CRs that the Italian approach for the assessment is to provide at each assessment step an update and improvement also of the previous estimates, based on the fact that the national dataset, as a whole and for single EMUs, takes advantage of in-depths, new information and experience gained, new data acquired through monitoring and data collection frameworks.

The whole set of data used for the assessment for single EMUs has been prepared and checked by scientists, based on the whole and best available information from all possible sources.

Among the activities that have to be mentioned for the data gathering, undoubtedly, the DCF, with the eel modules concerning the commercial and recreational fisheries, and the biological samplings, proved to be important, but also the specific monitoring carried out by Regions at local level, but with a standardized methodology, are an irreplaceable tool and indeed the availability of the results of these activities influenced the results of the estimates.

4.2 Trends in Assessment results

The results of the 2018 Italian progress report under Art.9 of Regulation (CE) n°1100/2007 shows that the measures envisaged for the first phase of implementation of the EMP have been applied, first above all, a fishing effort reduction, that involved all the EMUs and all eel life stages.

This led to an immediate improvement in the B*current*, which, however, did not persist, did not lead to an increase in recruitment, and did not substantially influence the trend of emigration levels at the national level and therefore the achievement of the target.

With regard to the national targets, it is emphasized that the improvement of biomass parameters (B*current* and B*best*) depends on natural recruitment, at a global scale, as well as on actions implemented by Member States, such as the reduction of actions, such as fishing effort and the restoring of habitats.

In many EMUs, the process of implementing the measures envisaged for the second phase of the EMP has begun and includes medium–long-term measures, based essentially on restocking and habitat restoration measures.

5 Other data collection for eel

5.1 Yellow eel abundance surveys

At the moment data not available. Since 2017 within the EU MAP 2017-2019 module 1E: "Anadromus and catadromus species data collection in freshwater", a pilot study started aimed at establishing a standardized methodology for the monitoring of *Anguilla anguilla* (glass eel + yellow and silver eel); in a short while the methodology should ensure the gathering of comparable data in the long term.

5.2 Silver eel escapement surveys

At the moment data not available. Since 2017 within the EU MAP 2017-2019 module 1E: "Anadromus and catadromous species data collection in freshwater", a pilot study started aimed at establishing a standardized methodology for the monitoring of *Anguilla anguilla* (glass eel + yellow and silver eel); in a short while the methodology should ensure the gathering of comparable data in the long term.

However, a number of scientific monitoring on eel local stocks in Italy have been carried out in the past, and some scientific surveys are currently underway within the framework of many projects in many EMUs, most of which carried out under the European Fisheries Funds containing specific measures for the implementation of Eel Management Plans. It is not possible to mention here specific Projects, nor to report here specific results.

Most results are conveyed to a national working group, supported by the Ministero delle Politiche Agricole Alimentari e Forestali and up to now coordinated by the University of Rome Tor Vergata and CREA (Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria) (Research Scientists E. Ciccotti, F. Capoccioni, M. Schiavina, C. Leone), who have also provided until now, the assessments and reporting required by the Regulation 1100/2007.

Outputs of monitoring, research projects and scientific surveys are all stored in a database that is progressively implemented. Compared to 2008, when the work for the compilation of the IT-EMP was initiated, this database is now significantly incremented because many sites are covered and biological information is available for many local stocks. Therefore, the updated dataset is used each year for the assessment of the required reference points and year-on-year assessments are more accurate.

5.3 Life-history parameters

No available data.

5.4 Diseases, Parasites and Pathogens or Contaminants

No relevant data here, because new data are not available and no routine monitoring has been implemented on a centralised basis. Scattered information is available, because of a number of scientific monitoring on eel local stocks carried out in the past or some scientific surveys but it is not possible to mention here specific projects, nor to report here specific results.

With regards to contaminants, scattered information is available, because some lake fisheries have been closed since 2012. These concerned also eel (such as the Lago di Garda, Lombardia),

in relation to fish contamination by dioxin or other contaminants. Contaminant data are not available here, even if carried out by local Health Agencies because neither centralised nor regional implementation carried out on purpose for eel.

During the last two years, a research project between CREA and Tor Vergata University have been carried out. The project foresaw the study of eel quality by means of analysis of contaminants, in two coastal lagoons of the central Tyrrhenian coast of Italy. Results in Capoccioni *et al.*, *submitted* shows that the contamination profile of silver eels in the two lagoons, assessed on a large number of compounds including OCs, pesticides and metals, showed no evident differences on site basis. Anyway, the overall observed contamination pattern stands for a low level of contamination with respect to other coastal lagoons of the Mediterranean area.

6 New Information

No available data.

7 References

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Report on the eel stock, fishery and other impacts, in Latvia

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Reporting Period: This report was completed in August 2019, and contains data up to 2018 and some provisional data for 2019.

1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

There are no data to provide good and reliable stock indicators for eel in Latvia. Eel landings in coastal waters of Latvia have fallen down to value less than 0.2 t per year. Only the part of freshwaters are accessible for eel. Eel fisheries in inland waters of Latvia depends from eel restocking carried out since 1990, i.e. in previous USSR times. In the frame of eel recovery since 2011, glass eel restocking is carried out again in waterbodies without manmade obstacles.

The total amount of waters in Latvia, where eel have been found historically in pristine or nearly pristine conditions, is unknown. For many watercourses, there is no reliable historical information about whether eels have historically been found in these watercourses before the construction of the milldams. According to rough estimates it could be 151 394 ha and historic silver eel biomass (B_0) accordingly about 259 600 kg.

There is no research done on silver eel potential production on habitat unit in Latvia. Only fishing data are available, that allows to produce a rough estimation of silver eel production. An average landing of eel in ten lakes included in the Latvian EMU has been 0.7 kg/ha, while in 1980s, just 0.05 kg/ha. The highest landings in one of these lakes was 2.0 kg/ha. In the rivers the corresponding landings were 0.29, 0.05 and 1.7 kg/ha.

An average silver eel landings in the lakes restocked by eel outside of EMU (lakes inaccessible for natural recruitment) was 0.35 kg/ha, with maximal catches of 5.6 kg/ha.

An average landings of eel in Latvia's coastal waters were 0.12 kg/ha before year 1980 and only 0.01 at present. The highest landing (0.7 kg/ha) was observed in 1938.

Based on historical fisheries data, potential silver eel escapement could be estimated as 3 kg/ha for the rivers, 3.5 kg/ha for lakes and 2 kg/ha for coastal waters.

In 2018, silver eel escapement in two study sites was very low due to low water levels and possibly due to high water temperatures also. From Lake Lilastes it was only 0.018 kg/ha of silver eel.

No data available on mortality rates.

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
2016	LV_Latv	114001	259600	3420	4542	1.3	NA	NA	NA
2017	LV_Latv	114001	259600	5130	6813	2.0	NA	NA	NA
2018	LV_Latv	114001	259600	2052	2725	0.8	NA	NA	NA

Key:

EMU_code = Eel Management Unit code (see Table 2 for list of codes); 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.

1.2 Recruitment time-series

Latvia does not have historical data and no regular surveys on eel recruitment trends. Some research has been done on otolith microchemistry (Sr:Ca ratios) to discriminate restocked and naturally recruited European eels in Latvia. To evaluate the efficiency of the eel restocking programme and reveal the migratory life histories of European eels in 2011 in Latvian waters, a total of 75 individuals were collected from the mouth of River Daugava (Daugavgrīva, brackish), a nearby lake (Lake Ķīšezers, freshwater), and a coastal site (Mērsrags, brackish). The naturally-recruited eels consisted of two saltwater types: eels that lived in saltwater and did not enter freshwater (SW, 0–7%) and eels that experienced both freshwater and saltwater, referred to as inter-habitat-shifter (IHS, 60–85%). Restocked eels consisted of purely freshwater types (FW, 7–36.7%) without any exposure to saltwater. The proportion of restocked eels was 36.7% in Daugavgrīva, 31.2% in Lake Ķīšezers, and 7.1% in Mērsrags (Lin *et al*., 2011). Similar studies need to be continued in the future as eel restocking increased.

2 Overview of the national stock and its management

2.1 Describe the eel stock and its management

In comparison with 1990s, several countrywide restrictions were introduced for inland fisheries since early 2000s (before eel Regulation) like: prohibition for use of seines and longlines, prohibition (with exception for river lamprey fishing) of commercial fishing in the rivers. At present eel fishing at commercial value is carried out only in the 12 inland lakes and rivers between these lakes (inaccessible for eel migration). These lakes were restocked by glass eel several times in 1960–1980; they are not accessible for migrating eel for many years due to HPS or old mill dams.

Basic principles of fisheries regulation are:

- regulation by effort – number of gear are limited for waterbody and municipality in inland waters;
- different between fisheries – different regulations for commercial and recreational fisheries (bag or day limit for anglers and recreational fishermen);
- technical measures – type of gear, construction elements of gear (size, mesh size), size of eel, limitation of rivers blocking by gear.

There are several main management actions provided to increase the silver eel escapement in Latvia:

- restocking of inland waters (without HPS dams downstream, free way out to the see) with glass eel;

All together more than 4.4 million glass eel were restocked in 2011, 2012, 2014, 2017 and 2018 in the rivers and lakes of Latvia. In 2019, restocking of glass eel was continued (690 000 glass eel restocked).

- mitigation of fisheries impact;

This management measure was not planned for EMP in the period for 2009–2013. Due to low and negligible impact on eel stock, fisheries were severely decreased and regulated by other reasons (not eel problems) in early 2000s. However, looking forward, after realisation of planned restocking of glass eel some technical regulation measures enforced, increased size limit from 40 to 50 cm, decreasing of bag limit for anglers from five to three individuals per angling occasion (bag limit).

Some research activities related to eel management carried out:

- tagging experiment of silver eel to assess the eel mortality in different fisheries at different regions of Baltic Sea;

Results of previous tagging indicated that 50% of silver eel tagged in Latvia were caught by fishermen in other Baltic Sea countries;

- drawing up recommendations on the best practice of glass eel restocking;

Taking into account frequently unsuccessful restocking of glass eel in Soviet period in 1970–1980 some rules regulating restocking practice were established regarding stocking density and season.

- monitoring effectiveness of glass eel restocking;

Monitoring of yellow eel density carried out in the lakes and rivers restocked by glass eel in 2011–2017.

- study of eel quality;

Study results are published in:

Rudovica V., Bartkevics V. 2015. Chemical elements in the muscle tissues of European eel (*Anguilla anguilla*) from selected lakes in Latvia. Environ. Monit. Assess. 187: 608. DOI 10.1007s/10661-015-4832-8.

Zacs D., Rjabova J., Fernandes A., Bartkevics V. 2016. Brominated, chlorinated and mixed brominated/chlorinated persistent organic pollutants in European eels (*Anquilla anquilla*) from Latvian lakes. Food additives and Contaminats: Part A. V.33., issue 3.

- study of predators (cormorant) impact.

Identification of problems scale has been done in Latvia. Impact consider as negligible. Taking into account insignificant effect, no measures have been taken regarding the control of predators.

Fishing effort in Latvia is regulated at the level of the Cabinet of Ministers annually, limiting the number of fishing gears in each of the water bodies where it is carried out. These restrictions apply both to public and private waters. In accordance with Latvian legislation, amendments to fishing effort for commercial and self-consumption can be made in each calendar year, changing the number of fishing gears or the type of fishing gear authorized. This change requires a scientific justification.

Starting from 2018, closed season is set for eel fishing, angling from November till January in coastal waters of Latvia.

2.2 Significant changes since last report

No big changes in status of eel and management of human impacts since last country report.

3 Impacts on the national stock

3.1 Fisheries

All eel caught in EMU waters are bycatch, proportion of eel is less than 1% from total catch by traps, fykes and longlines.

Effort and eel landings in costal fisheries:

			2013	2014	2015	2016	2017	2018
Commercial fisheries	FYK	Number of gear	308	356	445	418	385	436
		Days in operation	4318	4920	4745	5306	4773	4712
		Landings, kg	40.5	30.8	6.5	33	31.7	123
		CPUE (kg/gearday)	0.00003	0.00002	0.000003	0.00001	0.00002	0.00005
	FFN	Number of gear	22	39	12	33	32	13
		Days in operation	978	1304	676	1401	1051	825
		Landings, kg	104.2	37.8		17.1	13.8	22.8
		CPUE (kg/gearday)	0.005	0.001	0	0.0004	0.0004	0.0021
	HOK	Gear days	10900	14600	28598	2800	500	17009
		Days in operation	48	34	41	28	5	22
		Landings, kg	22.9	48	38.8	19.6	14	22
		CPUE (kg/100 hooks*day)	0.210	0.329	0.136	0.7	2.8	0.129
Self consumption fish-	FYK	Number of gear	141	119	100	76	91	80
		Days in operation	7812	8620	6982	5721	5778	4482
		Landings, kg	19.4	8	3.5	2.6	8.8	2
		CPUE (kg/gearday)	0.00002	0.00001	0.00001	0.00001	0.00002	0.000005
	HOK	Gear days	16075	13530	8998	3854	3755	4265
		Days in operation	167	147	107	42	45	51
		Landings, kg	17.4	29.5	3.8	6	1	2.5
		CPUE (kg/100 hooks*day)	0.108	0.218	0.042	0.156	0.027	0.058

There are only two lakes accessible for eel migration in Latvian EMU waters where eel occur in commercial catches. Starting from 2019 eel fishing is banned in Lake Liepājas (previously - overall eel catch: 50 kg per year). More substantial eel fishing is going on in inland lakes inaccessible for eel migration, restocked by glass eel in 1980–1990.

Eel landings in lakes of Latvia:

	2012	2013	2014	2015	2016	2017	2018
Landings in Latvian EMU lakes accessible for eel migration (kg)	287	381	315	320	270	403	398
Landings in eel growing lakes outside EMU inaccessible for eel migration (kg)	5581	4037	3890	4766	3749	7646	5159

3.1.1 Glass eel fisheries

There are no glass eel fisheries in Latvia.

3.1.2 Yellow eel fisheries

All eel fisheries carried out in EMU waters are mixed type, there are no specialized fisheries targeting on of life stages of eel. Eel size limit is 50 cm.

3.1.3 Silver eel fisheries

There are no specialized silver eel fisheries in the waterbodies of EMU, landings are mixed. In coastal waters eel landings are about 0.2 t per year in different types of fishery. In 2018, eel commercial landings in coastal fishery were 203 kg but in inland waters 5581 kg, most of it landed in eel growing lakes inaccessible for eel migration.

According to the survey of anglers done in 2007, the amount of eel caught in angling is up to 4 t per year in Latvia, but the biggest part of that is caught in eel growing lakes outside of EMU where they have been restocked in Soviet times. In 2018, eel recreational landings in the inland waters were 162 kg.

Historical data on self-consumption fishery (without rig=hts to sell the fish) in coastal waters are available. The landing of eels on an effort unit in this type of recreational fishery is very small. At the present landings has dropped to 4.5 kg per year.

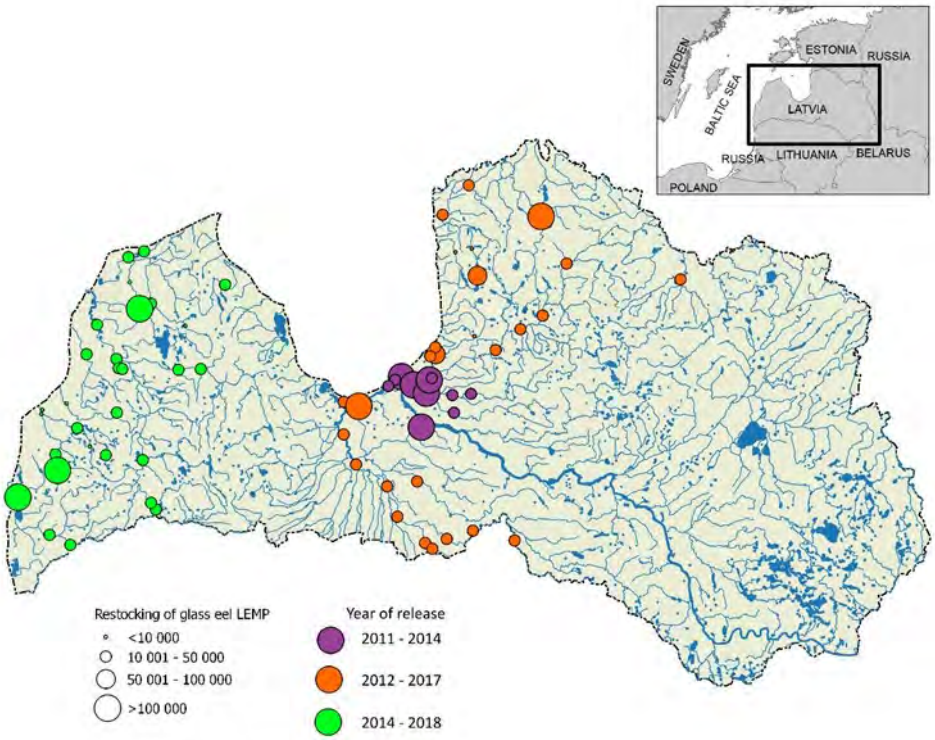
The biggest share of eels as a bycatch in coastal fisheries is caught from July till August; same month for biggest landings in inland waters.

3.2 Restocking

Waterbody selection criteria for restocking:

- no HPS and milldams on the eel downstream migration way (no turbine mortality);
- no eel weirs or no any fisheries targeting eels- of course some eel bycatch possible ir river lamprey fishery;
- at least moderate water quality;
- no fish winterkills.

Restocking of glass eel in frame of EMP_Latvia



Number of restocked glass eel (average weight 0.26 g).

Year	Lakes	Rivers	Total
2009	0	0	0
2010	0	0	0
2011	303 800	0	303 800
2012	740 300	289 700	1 030 000
2013	0	0	0
2014	805 000	581 200	1 386 200
2015	0	0	0
2016	0	0	0
2017	740 300	289 700	1 030 000
2018	521 400	196 800	718 200
2019	303 800	386 200	690 000
Total	3 414 600	1 743 600	5 158 200

No restocking is planned or done within the EMP in the inland waters with migration obstacles in the way to the sea that can lead to excess mortality in downstream migration. Eel restocking in inaccessible waters for downstream migration can be done only from private funds.

In 2018 and 2019, glass eel bought from UK Glass Eel as in previous years.

20 000 glass eel in 2017 were bought for pre-growing in institute BIOR hatchery "Tome" before release in the Lake Usmas in Venta River basin. From 20 000 glass eel 1000 eel survived and were released in Lake Usmas. In 2018, also 20 000 glass eel were bought for pre-growing in institute BIOR hatchery "Tome" before release. 1800 eel survived and were released in Gauja and Daugava river basin waterbodies.

Rest of the glass eels in different years released directly after delivery without pre-growing.

3.3 Aquaculture

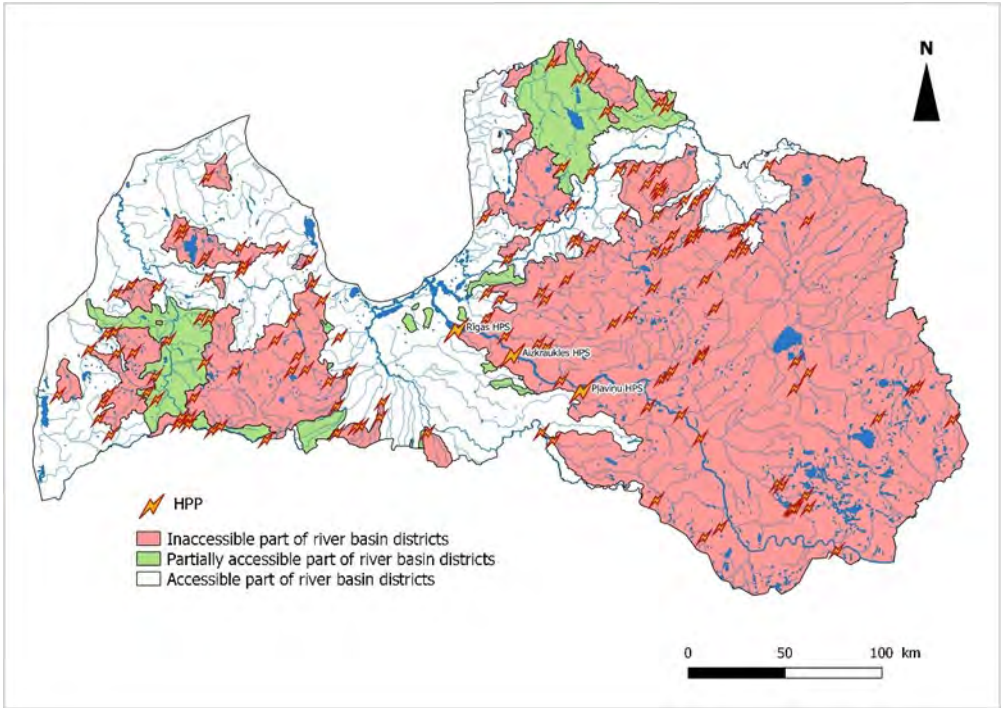
There is no eel aquaculture in Latvia.

3.4 Entrainment

~14% of inland waters are accessible for eel migration. The river Daugava, historically the largest eel river, has been heavily modified by building three HPP dams, between 1939 and 1974, which made this river inaccessible for migratory fish. Now it is not possible to ensure eel downstream migration from the upper Daugava river basin that excludes anthropogenic mortality. Pļaviņas HPP is equipped with the Francis-type turbines while Ķeguma and Rīgas HPP are equipped with Kaplan-type turbines. Two of these HPP (Pļaviņu and Rīgas) does not have fish paths built, and it is not currently planned to build them. In the period until building of Rīgas HPP in 1966, natural eel upstream migration through Ķeguma HPP fish path was recorded. In 1954, in total 1000 young yellow eels were caught in Ķeguma HPP fish path for restocking in Lake Odzes situated in Daugava river basin district.

In the small rivers, starting from the 1990s, 164 small HPP were installed in existing watermill dams by private owners. Therefore, the contribution of restocked eels from eel growing lakes to downstream sites in Latvia is constrained (Lin *et al*., 2011).

Distribution of hydropower plants in the rivers of Latvia.



In 2010 a study on eel migration trough the Rīgas HPP turbines 246 silver eel were tagged with T-bar anchor tags, recapture rate was 2.4%. Total mortality in the Daugava HPP cascade could reach 100%. Unfortunately, in Latvia, a complex study on eel mortality in the Daugava HPP cascade has not been carried out using telemetric tags, which would allow a more accurate estimate of mortality, neither in other rivers with HPP.

3.5 Habitat Quantity and Quality

Accessible inland and costal water habitats for eel:

River basin district	River		Lakes	
	Number	Area (ha)	Number	Area (ha)
Daugava	5	3461	4	3038
Gauja	6	1637	5	4700
Lielupe	4	1255	1	2555
Venta	12	2365	5	5214
TOTAL	27	8718	15	15 507
TOTAL in inland waters				24 225
Coastal and transitional waters				89 776
TOTAL of habitats accessible for eel				114 001

Since EMP implementation in 2009, no significant changes in habitat area and quality have taken place.

3.6 Other impacts

No available data.

4 National stock assessment

4.1 Description of Method

4.1.1 Data collection

The collection of biological data of eel in Latvia is rather complicated as the catch volumes are very small. In the fishery, eels are not sorted into silver and yellow eel, and it is not determined by Latvian legislation as well. Proportion of silver and yellow eel in the fisheries can be assessed using the results of biological analyses. The collection of biological data on eel from commercial fishing in Latvia has a rather short history, it was started in 2006, and only data from 2008 can be used to estimate proportion of silver and yellow eel in catches. Data from biological analyses in Lake Ķīšezers and the Gulf of Riga until 2011, indicate that all analysed eel were silver eel females at various silvering stages according to Durif *et al*. (2009).

Sampling of eels from commercial fishery is carried out by sampling of all landed eels from one selected trap in the Gulf of Riga. Number of sampled eels was <100 in last three years. All landed eels are sampled: length, weight, sex, eye diameter, weight, pectoral fin length, *Anguillicola crassus* presence/absence in swimmingbladder registered. Otoliths are collected for age reading that was started in 2017.

4.1.2 Analysis

Silvering stage determined according to Durif *et al*. (2009).

4.1.3 Reporting

Reported in annual country report, also in national report for Ministry of Agriculture.

4.1.4 Data quality issues and how they are being addressed

No available data.

4.2 Trends in Assessment results

5 Other data collection for eel

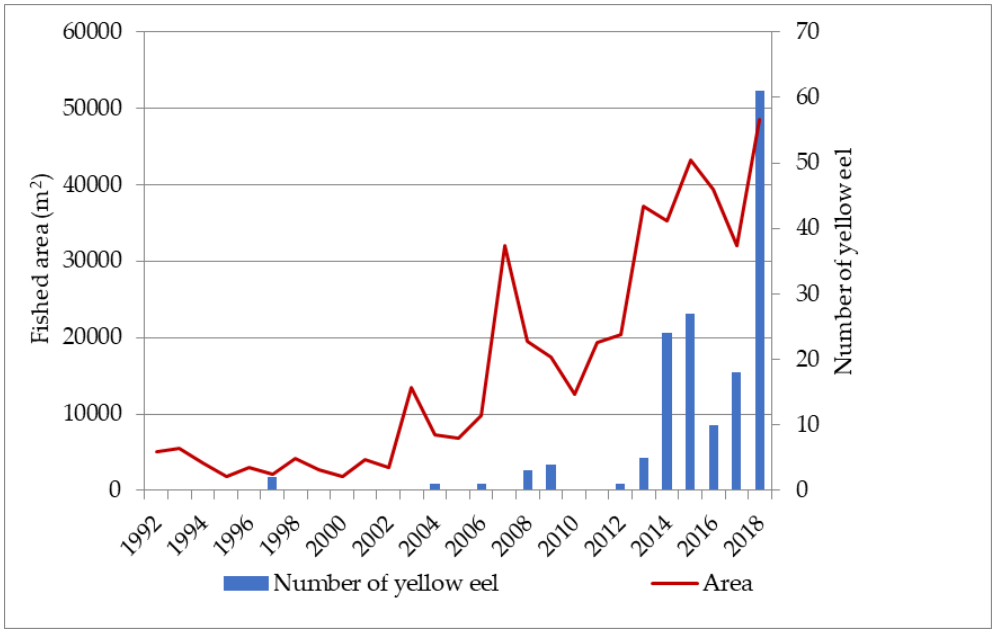
5.1 Yellow eel abundance surveys

Yellow eel abundance in the rivers surveyed by electrofishing. Survey carried out mostly in the rivers where restocking was done in the previous years. Data on species, abundance and size/weight collected from 1992. Lakes restocked by glass eel also surveyed every year in the same transects.

Yellow eel abundance in the rivers is surveyed by electrofishing. Data on species, abundance and size/weight collected starting from 1992. Lakes restocked by glass eel are also surveyed every year in the same transects. All young yellow eels caught in rivers and lakes are sampled: length, weight, sex, eye diameter, pectoral fin length and *Anguillicola crassus* presence/absence in swimmingbladder registered. Otoliths are collected for age reading.

Electrofishing results indicate that yellow eel density and occurrence in the rivers of Latvia increases.

Figure below: Number of yellow eel in the rivers of Latvia (electrofishing results).



Number of yellow eel in electrofishing.

Rivers	Num.of sampled sites	Num of rivers	Effort (hours)	Sampled area (Ha)	Num of eel
2015	117	42	76.0	4.02	27
2016	82	26	52.9	3.49	10
2017	90	32	54.8	3.22	18
2018	117	31	73.4	4.86	61
Lakes	**Num of transects**	**Num of Lakes**	**Effort (hours)**	**Sampled area (ha)**	**Num of eel**
2015	18	7	10.8	1.16	21
2016	16	7	8.4	1.15	30
2017	13	7	8.1	1.25	20
2018	41	13	15.5	1.88	24

5.2 Silver eel escapement surveys

The set of four small mesh size (8–10 mm from knot to knot) fykenets were used in the lower part of the river Daugava to catch yellow and silver eel. All caught eels (Table 2.) were held alive in net–cage until sampling procedure. All caught eel were analysed: total length, weight, sex, eye diameter, pectoral fin length registered. Life stage of eel recognized by Silvering Index calculated according to (Durif *et al*., 2009). All eel were tagged with Carlin tags and released. The aim of tagging was to estimate silver eel escapement and mortality rates in the fisheries.

Fykenet with side arms closing the lake Lilaste outlet (mesh sizes 20–14 mm) was used to catch yellow and silver eel migrating from the lake to the Gulf of Riga. Number of days in operation and number of eel caught were registered in the logbook. All caught eels (Table 3.) were held alive in net–cage until sampling procedure. All caught eel from this gear were analysed at harbour, tagged with Carlin tags and released.

In 2017, 52 days after tagging one specimen caught in Öresund.

Data on the river Daugava yellow/silver eel test fishing:

Year	Days in operation	Number of Yellow eel	Number of Silver eel	CPUE Yellow eel	CPUE Silver eel	Total CPUE
2014	135	6	5	n.a.	n.a.	n.a.
2015	153	59	7	0.49	0.06	0.56
2016	70	26	4	0.34	0.07	0.42
2017	108	47	1	0.44	0.01	0.45
2018	77	14	0	0.18	0.00	0.18

Data on the river Lilaste yellow/silver eel test fishing.

Year	Days in operation	Number of Yellow eel	Number of Silver eel	CPUE Yellow eel	CPUE Silver eel	Total CPUE
2017	97	96	3	0.99	0.03	1.02
2018	103	7	9	0.06	0.09	0.16

5.3 Life-history parameters

In 2018, 125 eel caught in scientific fishery (fykenets and electrofishing) of different life stages were analysed and aged using otolith thin sections. According to results, population is dominated by four to seven year old eels mostly corresponding to restocking years.

Age structure of eels caught in scientific fishery in inland waters of Latvia accessible for eel migration:

Age class	Average length	Average weight	number of males	number of females	Undefined
1	136.5	3.1	-	-	2
2	190.1	8.7	-	-	8
3	254.5	25.5	-	3	3
4	316.3	56.3	13	29	7
5	546.5	310.1	1	12	-
6	512.0	285.5	2	6	-
7	685.3	645.2	-	30	-
8	630.0	464.0	-	2	-
9	685.0	596.5	-	2	-
10	560.0	222.0	-	1	-
11	700.0	610.0	-	1	-
12	900.0	1560.0	-	1	-
17	570.0	327.0	-	1	-
20	630.0	457.0	-	1	-

5.4 Diseases, Parasites and Pathogens or Contaminants

Eels sampled in the frame of DCF are also examined for presence of Anguillicola. Results are summarized in table below. The prevalence of *Anguillicola crassus* in the territory of Latvia is generally not identified but it is found both in the eel natural distribution waters and in the eel growing lakes.

Anguillicola crassus in eel samples:

Waterbody	Year	Life stage	Number of eel sampled	Eel with Anguillicola	
				number	%
Gulf of the Riga	2009	S	103	2	1.9
Gulf of the Riga	2011	S	37	11	29.7
Gulf of the Riga	2012	S	56	9	16.1
Gulf of the Riga	2013	S	86	7	8.1
Gulf of the Riga	2014	S/Y	76	13	17.6
Gulf of the Riga	2015	S/Y	57	12	21.1
Gulf of the Riga	2016	S/Y	49	7	14.3
Accessible rivers	2016	Y	10	1	10.0
Accessible lakes	2016	Y	9	2	22.2
Accessible lakes	2016	S	3	2	66.7
Gulf of the Riga	2017	Y	39	4	10.3
Gulf of the Riga	2017	S	4	1	25.0
Accessible rivers	2017	Y	17	3	17.6
Accessible lakes	2017	Y	20	5	25.0
Gulf of the Riga	2018	Y	37	2	5.4
Gulf of the Riga	2018	S	3	0	0
Accessible rivers	2018	Y	54	17	31.5
Accessible lakes	2018	Y	26	4	15.4

A complex study on eel parasites in freshwater habitats in Latvia was made in 2015. A total of 75 European eels from six freshwater sampling sites in Latvia were investigated in respect of their parasites communities. Overall 19 different parasite species were identified: four protists (*Trypanosoma granulosum*, *Myxidium giardi*, *Myxobolus portucalensis*, *Trichodina* spp.), 12 helmiths (*Pseudodactylogyrus anguillae*, *P. bini*, *Diplostomum* spp., *Sphaerostomum bramae*, *Bothriocephalus claviceps*, *Proteocephalus macrocephalus*, *Anguillicola crassus*, *Camallanus lacustris*, *Raphidascaris acus*, *Spinitectus inermis*, *Pseudocapilaria tomentosa*, *Acanthocephalus lucii*) and a copepod (*Ergasilus sieboldi*), a leech (*Piscicola geometra*) and a glochidia (*Anodonta* spp.). The overall prevalence of infection reached 93.3% (95%CI 85.5–97.5) with mean intensity 13.4 ± 35.2 parasites per fish. Three different parasite communities with different species richness, diversity, evenness and dominant species were defined. This was a first report about *M. portucalensis* and *S. inermis* in eels from lakes in Latvia and this is a new geographic record for those species (Deksne *et al*., 2015a; Deksne *et al*., 2015b).

In 2015, also, study has been made on microhabitat preference and relationships between metazoan parasites on the gill apparatus of the European eel from freshwaters of Latvia (Zolovs *et al.*, 2015).

A recent research results demonstrated that PCBs, PBBs and other POP's groups chemical compounds concentration in eels muscle tissues are below the Concentrations determined in Regulation EK 1259/2011. The concentration of main elements determined in muscle tissues varied within the following ranges: for Pb, 0.019–0.047; Cd, 0.0051–0.011; Hg, 0.13–0.36; Cu, 0.76–0.92; Zn, 28–42; and As, 0.13–0.23 mg kg−1 wet weight. In 7% of eel samples mercury (Hg) concentration exceeded determined limitation (Rudovica, Bartkevis, 2015; Zacs *et al*., 2016).

Eel quality survey planned for 2019, analyses of fat proportion, is it enough for migratory needs.

6 New Information

No available data.

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Report on the eel stock, fishery and other impacts, in Lithuania; 2018–2019

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1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

The most recent data (for 2017) on assessed areas and stock indicators for Lithuanian national EMU are presented in Table 1. Source: Ložys *et al*. (2018).

Table 1. EMP Progress Report (2018) summary table for stock indicators in 2017 (Ložys *et al*., 2018).

EMU_code	Assessed Area (ha)	B_0 (kg)	B_{curr} (kg)	B_{best} (kg)	Bcurr/B_0 (%)	∑F	∑H	∑A
LT_Lith	116 854	87 000	0	8581	0	>100%	5,1%	>100%

Key:
EMU_code = Eel Management Unit code (see sheet 'EMU names and codes' for list of codes).
B0 = the amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the stock (kg).
Bcurr = The amount of silver eel biomass that currently escapes to the sea to spawn (in the assessment year) (kg).
Bbest = 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 (%).
∑H=anthropogenic mortality excluding the fishery, summed over the age groups in the stock (%).
∑A=all anthropogenic mortality summed over the age groups in the stock (%).

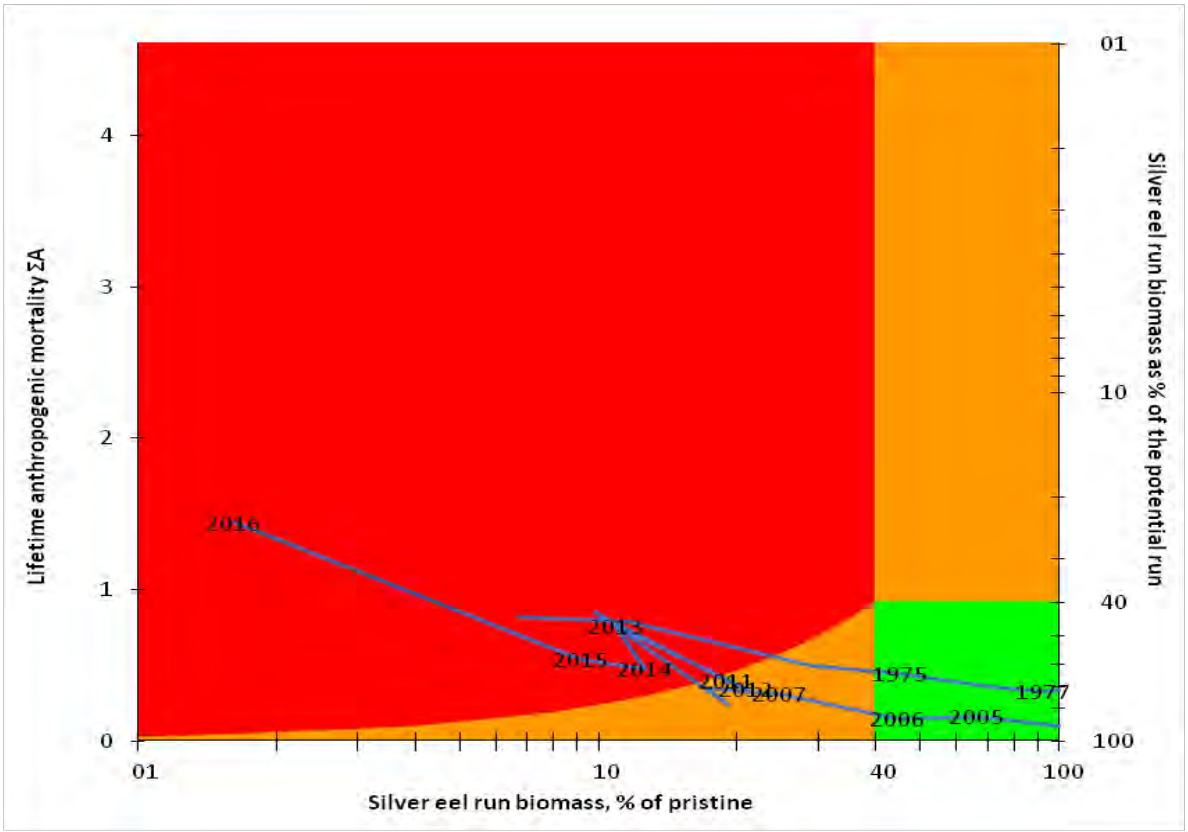

Figure 1.1. Precautionary diagram for the Lithuanian eel stock in inland waters.

1.2 Recruitment time-series

No data on recruitment level. Inland stock is of the restocked origin.

2 Overview of the national stock and its management

2.1 Describe the eel stock and its management

2.1.1 Eel stock in Lithuania

Typical eel habitats in Lithuania are lakes, ponds, Curonian lagoon and coastal waters of the Baltic Sea. Rivers, especially small, in Lithuania are not considered as typical eel habitats (Anon. 2008); however, in some rare cases single eels are caught during research surveys or by anglers. According to Dr T. Virbickas (pers. com. 2008 and 2016) in Lithuania only single eels are caught during electrofishing surveys in rivers and in all cases in close distance from stocked lakes. On the other hand, in recent years, some eels were stocked to large rivers and of course rivers serve as ways for eel, including silver eel, migration.

It is known that eels in the inland waters are of stocked origin (Anon. 2008). However, according to otolith microchemical analyses, eels in the Curonian Lagoon and the Baltic Sea coastal zone 80% and 98% respectively are of natural origin and 20% and 2% are stocked (Schiao *et al*., 2006; Lin *et al*., 2007).

Even in the past when eel stock was in good condition in the all distribution range and stocking was not launched yet, large eel fishery was known in the Curonian lagoon, while there are no data on specialized fishery for eels in the inland waters. Study done on eel otoliths in 2015 suggests that 94% of eels caught in the Curonian lagoon are of stocked and only 6% of natural origin. However, most of caught and analysed eels (80%) were at silver eel stage and caught during autumn, i.e. likely migrated from lakes for spawning in the Atlantic Ocean.

According to historical data (Schiao *et al*., 2006) first stockings in Lithuanian inland waters were performed during 1928–1939 in Vilnius region (currently part of stocked lakes belongs to Belarus). Stocking of lakes resulted in later rise of eel fishery in continental part of Lithuania. Commercial catches until the beginning of sixties were registered almost only in waterbodies of Vilnius region where eels were stocked during 1928–1939, while in the rest part of the country fishery for eels did not exist or was negligible. After first post-war stockings (starting from 1956), eel catches during 1970–1991 reasonably increased in the entire territory of Lithuania. It is evident, that inland stock and its abundance directly depends on stocking; natural eel stocks in the Curonian lagoon and coastal waters of the Baltic Sea are in steep decline due to overall decline of the stock in all range of the species distribution.

2.1.2 EMU and EMP

ICES estimated eel stock to be outside safe biological limits and continuously (1999–20006) recommended to take urgent international measures to protect the stock by reducing fishery mortality as much as possible until plan to protect and restore eel stock will be developed. As the result EC prepared a Communication entitled "Development of a Community Action Plan for the management of European Eel (COM(2003) 573 final)" in 2003. In 2005, EC announced the initial proposal for a Council Regulation establishing measures for the recovery of the stock of European eel. The final decision concerning the Council Regulation has been approved in 2007 ((EC) No 1100/2007). The Regulation obligates Member States to define the current state of their stocks, identify measures necessary for the recovery of stocks, implement these measures and assess the effectiveness of these actions.

Despite the fact that eels in Lithuania are not abundant and the national fishery only accounts for 0.1–0.2% of the total European eel catch, the country, abiding by the principle of solidarity, participated in the discussions for the preparation of the Council Regulation, initiated scientific research on eels and took the first preventive measures to minimise the impact on fishing of stocks prior to the entry into force of the Regulation.

Despite the lack of detailed information on the past state of eel stocks in the country, Lithuania sought, in developing the Eel Management Plan, to collect the most accurate information possible about the past and current state of eel stocks in the country and, taking into account the information available, to take adequate measures for preventing the decline, to seek the recovery in the future and to establish a system for monitoring of the stock.

Lithuania has designated one Management Unit for the EMP based on Council Regulation (EC) 1100/2007 where Article 2(1) stipulates such a possibility and developed one EMP for the whole territory of the country. Following assumptions were considered:

The commercial catch is low and eels are not abundant in Lithuania (around 15 t annually over the past 10 years prior preparation of the EMP),

The Nemunas RBD comprises 74% of the territory of Lithuania and 81% of eel habitats,

About 99% of eels were stocked to the Nemunas RBD since 1983,

About 99% of eel catch and stocks are attributed to the Nemunas RBD,

The Nemunas RBD includes 96% of lakes of reservoirs from which eels can escape unaffected by turbines or at least through fish-passes installed on HPP dams,

Although the Daugava RBD comprises a fairly large part of lakes and reservoirs (11.6%), escapement to the sea is restricted by three large HPs in Latvia,

Conditions in the other RBDs are similar (except for the different impacts of HPPs), thus no specific measures for implementation of the plan in the other basins are needed.

The EMP Management Unit has been designated according to Lithuania's division into RBDs under Directive 2000/60/EC (Figure 2.1). The EMP also includes the Baltic Sea coastal zone.

Lithuania submitted national EMP to EC at the end of 2008 and after positive evaluation by experts the EMP was approved by the decision C(2009)10244/F1 on 22/12/2009. Implementation of the EMP was started at the beginning of 2011; first and second reports on the implementation of the EMP were submitted to EC in 2012 and 2015 accordingly.

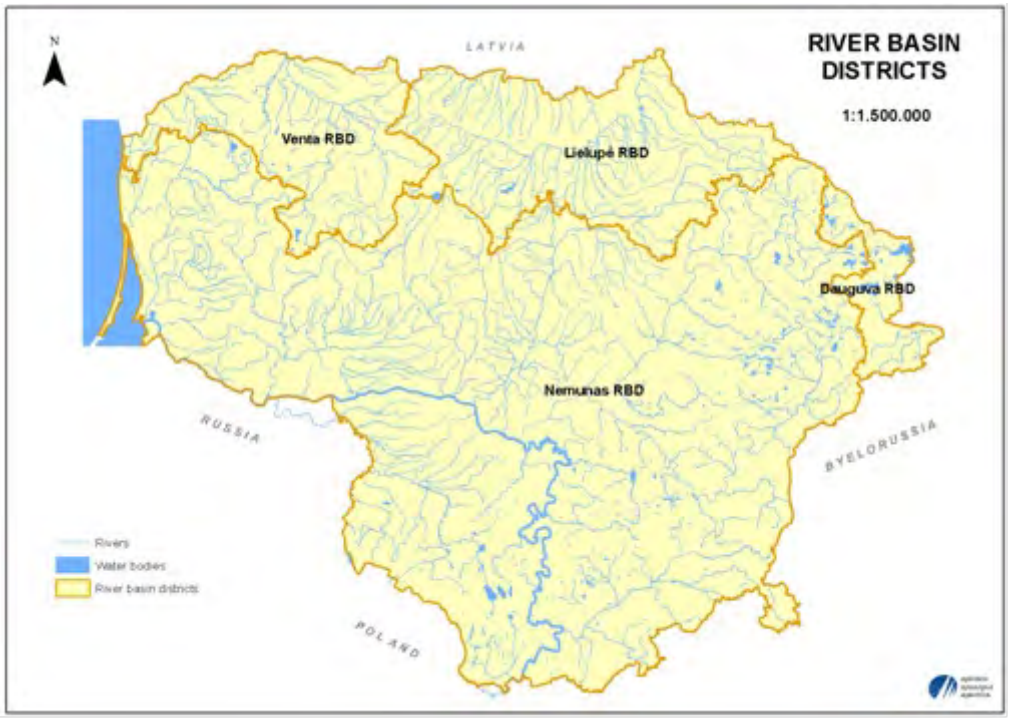

Figure 2.1. Lithuanian River Basin Districts (map produced by Environmental Protection Agency).

2.1.3 Management authorities

Management authorities in the fisheries sector in Lithuania are:

***The Ministry of Agriculture*:** creates and implements Lithuanian fisheries policy, conducts management of the fisheries sector, implements the fisheries policy according to the European Union regulations, measures related to conservation of fish stocks and controls fishery in maritime waters. The Ministry regulates commercial fishery in maritime waters; owns and uses a fisheries data information system (sea catches, fishery companies, economic and biological data, etc.). The Fisheries Service under the Ministry of Agriculture of the Republic of Lithuania implements Lithuanian Eel Management Plan and eel recovery activities in Lithuania. Until 2018, the Fisheries Service was responsible for the collection of the eel data under the National data collection programme. As of 2019, Klaipėda University has been appointed as responsible organisation for the collection of eel data under the programme.

***The Ministry of Environment*:** is responsible for inland fish stock conservation and control policy, conducts management of the fisheries sector in country's inland waterbodies. The Ministry regulates commercial and recreational fisheries in inland waterbodies; manages and uses a data system of fisheries in inland waterbodies (catches, fishery companies, etc.). The Ministry of Environment is responsible for the exploitation of fish stocks in inland waterbodies, including the Curonian Lagoon.

The Eel Regulation contains the obligation to prepare and implement the EMP (in the eel case especially for inland waters), both ministries assume the responsibility for implementation of the EMP. In addition, conservation measures for protected fish species, their habitats and migratory routes (including the eel) is area of responsibility of the Ministry of Environment. The activities related to improving aquaculture, reproduction and migration pathways of protected fish species is area of responsibility of the Ministry of Agriculture. Fish stocking programmes for state waterbodies (including eel stocking) are approved by the both Ministries.

2.1.4 Regulations

The fishery for eels has been regulated in several ways in Lithuania. Licensing for particular number of fishing sites on streams/rivers goes through auction performed by the Fisheries Service; the commercial fishery is restricted to two months per year, commercial eel fishery in lakes is banned. In the Curonian lagoon number of fishing gears (fykenets) is reduced (eels are caught as minor bycatch). All companies operating in commercial fishery must have licences and fill in logbooks daily. Daily bag limit in recreational fishery is reduced. In the Baltic Sea fishery is not allowed to target eel, and practically is banned (see additional details related to fishery restrictions in Chapter 2.1.5).

2.1.5 Management actions

Preparing national EMP some practical precautionary measures were planned and included into the EMP, aiming to reduce anthropogenic mortality in order to stop stock decline and to ensure stock recovery: to introduce some restrictions for eel fishery in the Curonian Lagoon and the Baltic Sea, to shorten overall fishing season in the inland waters, to restrict fishing season for yellow eels to three months/year, to introduce restrictions related to longline fishery, to reduce bag limit in recreational fishery (i. e. angling), etc.

Aiming to reduce silver eel mortality the Ministry of Environment reduced number of fishing sites for migrating eels on small rivers by 43% in 2009 (however, later increased, and reduction from the starting point has been 34% currently), and banned specialized eel fishery using eel fykenets in lakes and ponds for period from 15 of March until 30 of June. In addition, aiming to improve protection of migrating fish commercial fishery was banned in three northernmost fishing sectors of the Curonian Lagoon (closest to the Klaipeda Strait). Bag/day limit in recreational fishery was reduced from five eels to three. Season for migrating (silver) eel fishery was considerably shortened to two months from 2010: it is allowed from 1 of April until 1st of June; autumn season for the fishery has been banned (used to be from 1 of September to 31 of October). Aiming to reduce bycatch of young eels it was banned to use earth worms in longline fishery.

In 2015 in Lithuanian inland waters commercial fishery has been banned by the Ministry of Environment, however, fishery for migrating eels, lake smelt, vendace and river lamprey is still allowed. However, specialized fishery for eels using fykenets and longlines is actually banned and only fishery for migrating eels in rivers allowed from 1 of April until 1st of June.

Number of Lagoon fyke-nets was reduced by 46% in the Curonian Lagoon: from 413 in 2008 to 223 currently. In the Baltic Sea, specialized eel fishery is banned. It is complicated to estimate illegal fishery extent for migrating eels in rivers, however, despite very high fines (290 euro per fish) it still might take place and make some impact on the stock.

Since the beginning of the EMP implementation bag limit has been reduced from five to three eels in recreational fishery (under the definition „recreational fishery“ falls not only angling but also spearfishing). Spearfishing was allowed in eleven waterbodies (12 in 2012) but now number has been reduced to seven (six lakes and coastal waters of the Baltic Sea). However, in case of waterbody is rented, owner of a lake personally decides to allow spearfishing or not. Impact of recreational fishery is not well known, and still is under discussion among experts despite some attempts to make such estimation.

After EMP was approved by EC first stockings were performed in 2011 and until 2016, 154 waterbodies (mostly lakes) were stocked with almost 3 million of young eels, i.e. 0,6 million annually on average during the period from 2011 to 2018. Due to unsuccessful public tender in 2017 stocking has not been done, although, in 2018 1650 million of glass eels where stocked. According to the national EMP, eels in Lithuania should not be stocked to basins upstream hydropower.

2.2 Significant changes since last report

For the first time after the beginning of the implementation of the national EMP scientific-based assessment of eel stock and human caused impacts has been made in Lithuania in 2018; however there is no update in 2019.

3 Impacts on the national stock

3.1 Fisheries

3.1.1 Glass eel fisheries

There is no fishery for glass eels in Lithuania.

3.1.2 Yellow eel fisheries

According to eel fishery statistics during last two decades (1997–2017), eel landings marginally increased in the inland waters (most eels fished are silver eels, ca. 1/4 yellow; Dainys, 2017) but at the same time it was steep decline of catches in the Curonian Lagoon. Most eels fished in the Curonian lagoon were yellow eels; however, proportion of silver eels is increasing recently due to decline in natural local stock and migrating eels through the Lagoon from inland waters (Figure 3.1).

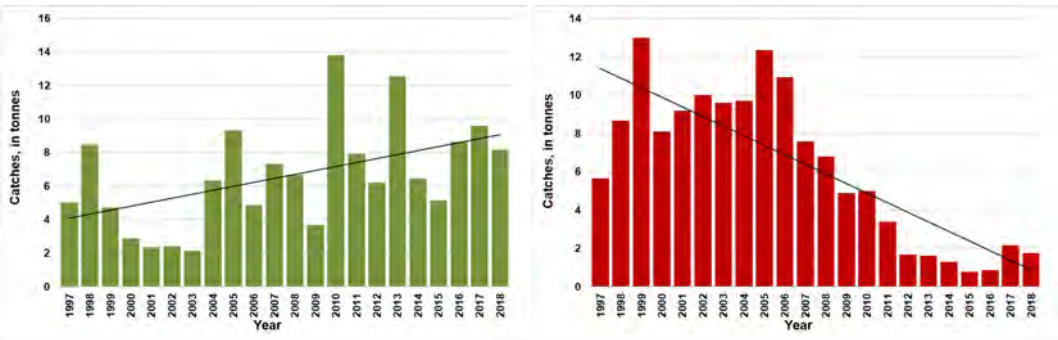

Figure 3.1. Eel catches in commercial fishery in inland waterbodies (green colour) and the Curonian Lagoon (red colour) during 1997–2018.

However, tendencies of the decline of eel landings in the Curonian Lagoon (mostly natural recruits) started at the end of sixties or beginning of seventies (Figure 3.3), while landings from inland waters fishery (stocked eels) seem to be more stable (Figure 3.2)

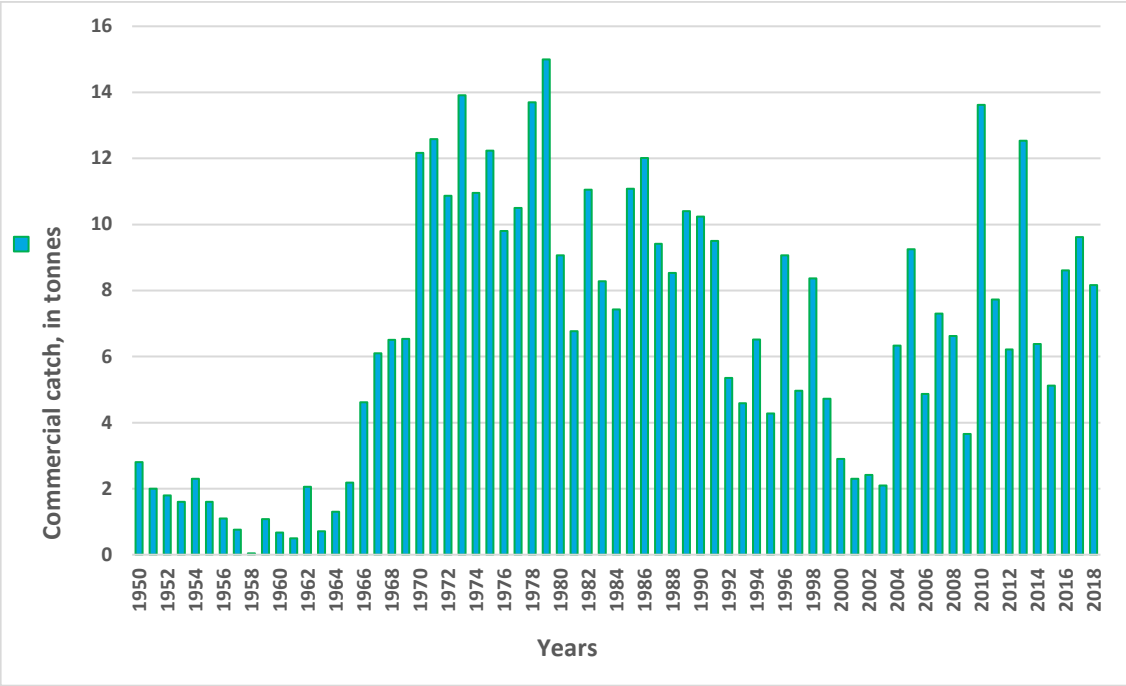

Figure 3.2. Time trend in the reported catches from the inland fishery since 1950 (without the Curonian lagoon).

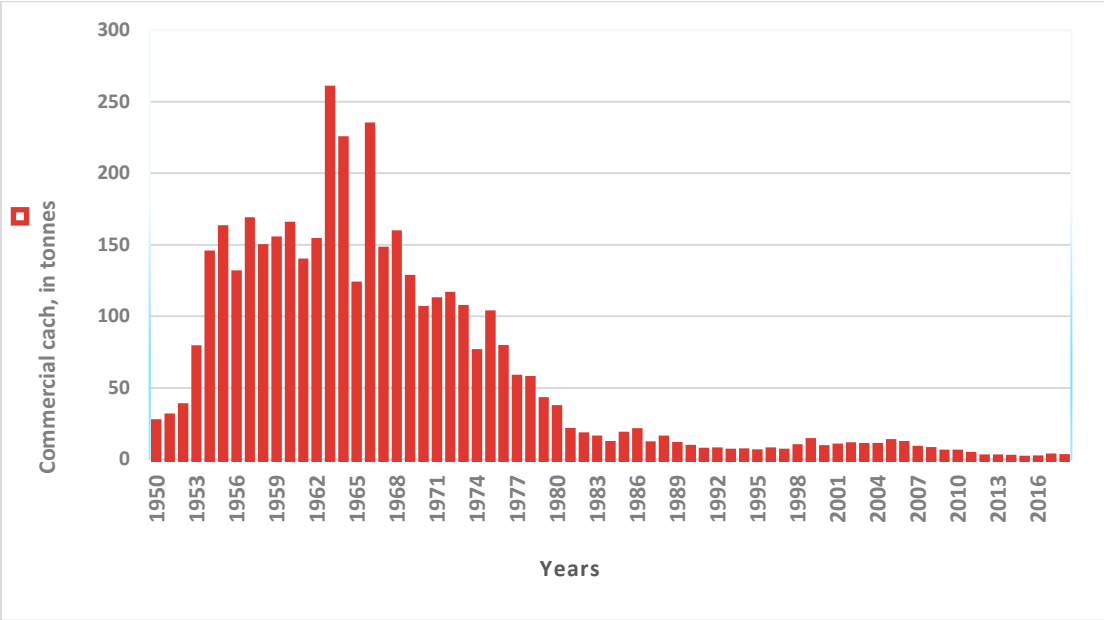

Figure 3.3. Time trend of reported catches from the Curonian lagoon fishery since 1950 (only Lithuanian part of the Lagoon, ca. ¼ of total area, except Russia).

3.1.3 Silver eel fisheries

In Lithuania, eel fishery is mixed (yellow and silver) (see Chapter 3.1.2).

3.2 Restocking

Stocking of Lithuanian waters with glass eels started in Vilnius region during 1928 and lasted until 1939. During that period, approximately 3.2 million glass eels were released (Mačionis, 1969). Subsequent stocking with glass eels (originating from France or Great Britain) was carried

out in the post-war period during 1956–2007. According to official data, a total of 148 lakes and ponds were stocked with 50 million glass and ongrown eels (on average 1.25 million per year) (Ložys *et al*., 2008). The most intensive stocking period was during 1960–1986 (in total 33.2 million eels were released), while later stocking activities became irregular and only in low numbers. The last considerable stocking, prior to implementation of the Lithuanian Eel Management Plan, was made in 2004 when 70.1 thousand eels were released into Lithuanian waterbodies.

After EMP was approved by EC first stockings were performed in 2011, and until 2016, 154 waterbodies (mostly lakes) were stocked with almost 3 million of young eels, i.e. 0,6 million annually on average during the period from 2011 to 2018. Due to unsuccessful public tender in 2017 stocking was not done. In 2018, 1,65 million of glass eels were purchased and stocked.

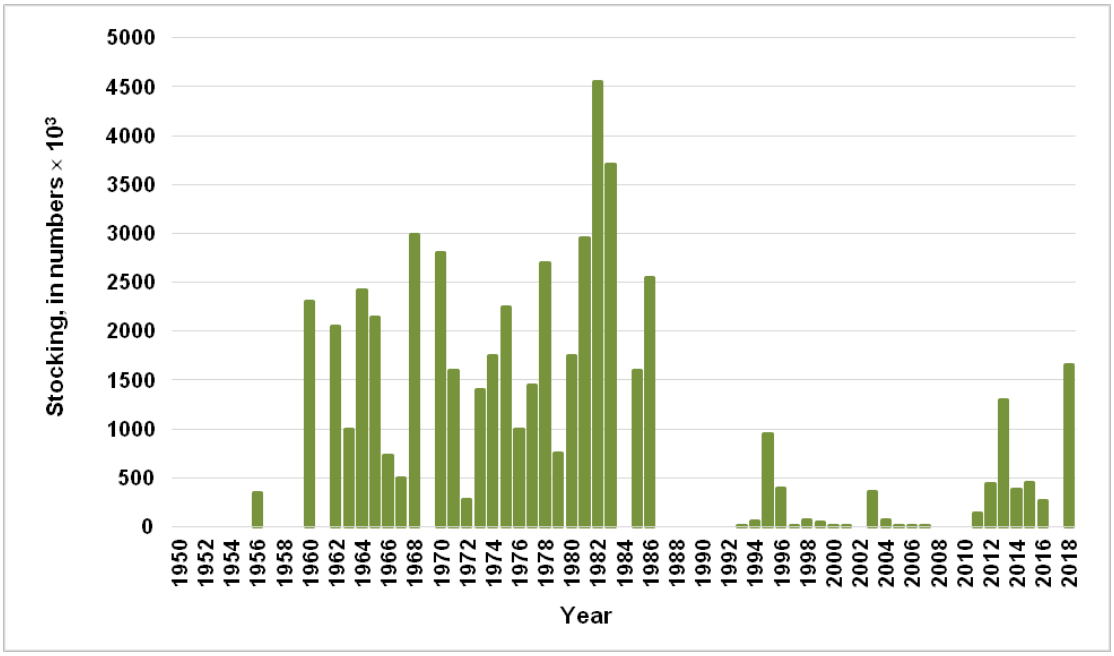

Figure 3.4. Stocking of inland waterbodies with glass eels in the period 1950 to 2018 (thousand individuals).

Table 3.1. Eel stocking activity in Lithuanian inland waters carried out by the Fisheries Service during 2011–2018*.

Year	Purchased eels G/OG, in numbers or kg	Released eels, in numbers	Stocked eels, weight in g	Country of origin
2011	134 000	134 000	10–11	UK, LT
2012	440 000	440 000	2.5	DK, PL
2013	400 kg	1 300 000	0.3–1	FR
2014	120 kg	380 500	1–1.2	UK
2015	160 kg	449 400	0.8–1.4	FR
2016	100 kg	265 700	0.8–1.4	UK
2017	-	-	-	-
2018	505 kg	1 650 000	0.8	UK

*** Fisheries Service under the Ministry of Agriculture of the Republic of Lithuania data.**

3.3 Aquaculture

In Lithuania, eels were farmed by one company since 1998. In 2016, three companies have been farming eels and reported their production in recirculation systems (Table 3.2). However, in 2017 and 2018 only one aquaculture company reported on production of farmed eels.

Table 3.2. Eel production in aquaculture during 1998–2018.

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	
Production, in kg	2000	2000	1000	5000	17 000	20 000	9000	8000	12 000	13 000	
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Production, in kg	10 600	12 000	8300	12 600	3500	3466	7148	205	36 400	*	*

*** Since only one company has been farming eels in aquaculture in Lithuania, according to recent EU legislation data are confidential, and therefore not provided.**

3.4 Entrainment

A database on hydropower plants was created based on information available at the „Rivers, lakes and ponds cadastre of The Republic of Lithuania“, booklet issued by Lithuanian hydropower association ”Hydropower in Lithuania” (2011) and ”Small hydroenergetics” (Bilys *et al.*, 2017). In most cases, detailed information on ownership of hydropower plants, turbine types and capacity, location and year of construction or reconstruction is available.

Stocking of eels in Lithuania during 1950–2009 (before the implementation of National eel management plan), was carried without aim to allow later migration to the sea for spawning, thus significant part of stocked eels had to pass HPP turbines during their downstream migrations (Figure 3.5). Eel stockings carried during 2011–2017 were performed in accordance with approach of the Lithuanian EMP: eels were stocked to waterbodies from which eel migration route to the sea is free or HPP's, if any, has fish pass.

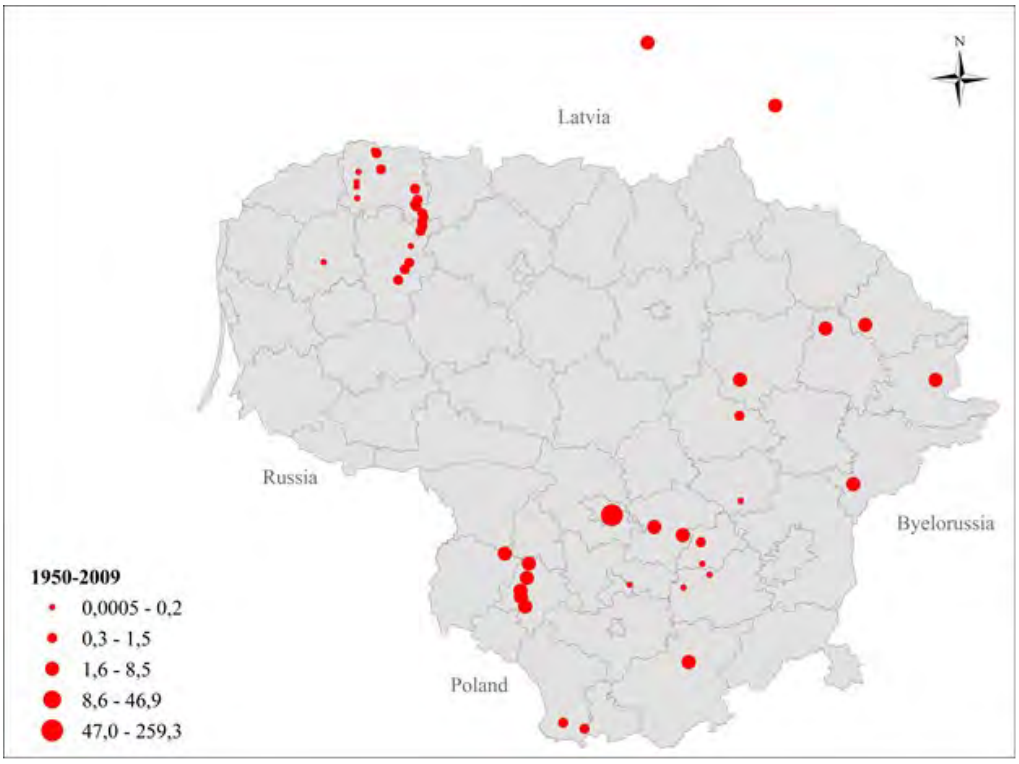

Figure 3.5. Spatial distribution of the HPPs having an eel stock upstream (stockings were carried during 1950–2009, before the implementation of the Lithuanian EMP). The size of the symbols in this figure is proportional to the number of eels (in million) stocked upstream of each station.

Most of the eels were stocked to the waterbodies that are free from HPP impact, and eel migration routes to the sea goes in free-flowing rivers or river sections. However, in some cases a HPP had been built or reconstructed downstream the waterbody which was previously stocked with eels. Such situation occurred after the Ramučiai pond was stocked in 2012 (this pond was identified as without HPP downstream in the Lithuanian EMP). According to the data of the „Rivers, lakes and ponds cadastre of The Republic of Lithuania“ and ”Small hydroenergetics” (Bilys *et al*., 2017) Tūbausiai HPP was equipped with Kalpan turbine and started operating in 2012 (the same situation occurred in six other cases, see Table 6.1). In 2012, the Plateliai lake was stocked with the eels, although in Lithuanian EMP this lake was assigned to the waterbodies upstream of HPP (Gondingos HPP was built in 1961 and reconstructed in 2000; Table 3.3). According to Lithuanian hydropower association (Bilys *et al*., 2017), Plungė HPP was reconstructed in 2011 and one 37 kW turbine was installed. In other stocking cases eels were released to HPP-free waterbodies, or HPPs downstream stocked lake were equipped with fish pass. According to guidelines set in Lithuanian EMP, eel stocking in such waters is possible, however study by Dainys *et al*. (2018) demonstrated that only one third of all downstream migrating eels migrate through the fish pass. Therefore, more effective eel protection measures are needed to be implemented. According to the assessment of the HPP impacts in Lithuania (Ložys *et al*., 2018), in 2017 5,1% of silver eels produced in Lithuanian inland waters were killed in HPP installations.

Table 3.3. Eel stockings to the lakes upstream HPP without fish pass.

Stocked waterbody	Year of stocking	Year of HPP (re)construction	HPP name	Waterbody status given in Lithuanian EMP (year 2008)
Janušonių Pond	2012	2010	Janušonių	No HPP downstream
Lake Karklėnų	2012	2013	Kelmės	No HPP downstream
Lake Pikeliškių	2012	2012	Liubavo	No HPP downstream
Lake Gauštvinis	2012	2012	Pagryžuvio	No HPP downstream
Pajiesio Pond	2012	2008	Pajiesio	No HPP downstream
Lake Plateliai	2012	2011	Plungės	Upstream HPP
Ramučių Pond	2012	2012	Ramučių	No HPP downstream
Tūbausių Pond	2012	2011	Tūbausių	No HPP downstream

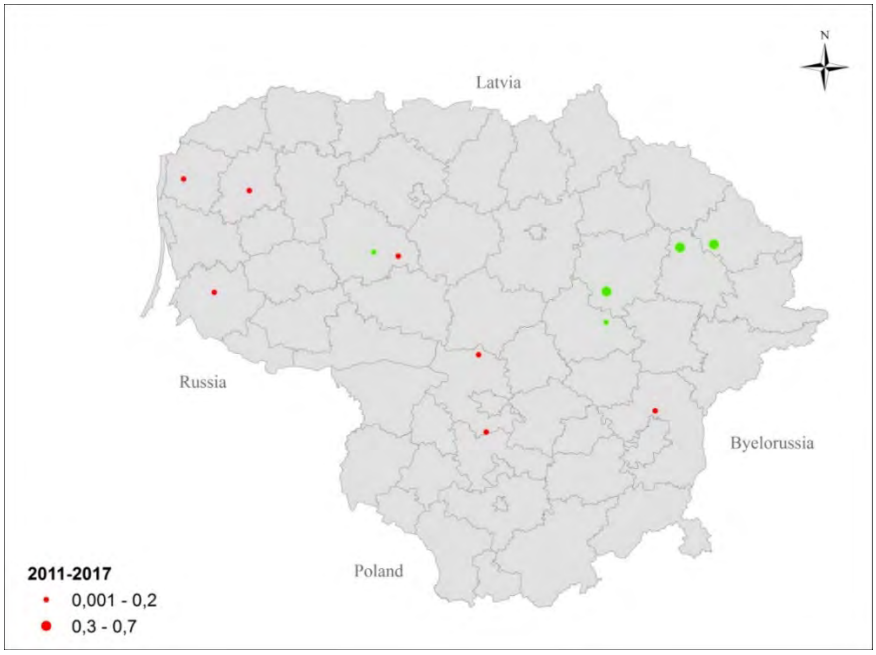

Figure 3.6. Spatial distribution of the HPPs having an eel stock upstream (stockings were carried during 2011–2017 after start of the implementation of the Lithuanian EMP). The size of the symbols in this figure is proportional to the number of eels (in million) stocked upstream of each station (green colour indicates HPPs with installed fish pass).

3.5 Habitat Quantity and Quality

There are numerous, different in size, lakes and rivers well suited for eel production in Lithuania. The restricted restocking in combination with migration obstacles are the limiting factors. Hydropower turbines are the limiting factor for restocking to inland lakes and water reservoirs. According to estimations of the national EMP, in total, 75.8% of lakes and reservoirs (by area) are located upstream hydropower plants. 15.3% (out of the 75.8%) of the waterbodies are situated in basins upstream hydropower plants with passes for fish. Hence, it is most limiting factor for the restocking.

3.6 Other impacts

No available data.

4 National stock assessment

4.1 Description of Method

In Lithuanian inland waters most anthropogenic interactions with the eel stock happen to relate to either the youngest (glass eels and elvers) or the oldest stages (silver eel, or yellow eel close to the silver eel stage) due to fishery (F) and hydropower (H) related mortality; impacts during the long growing stage are much more infrequent. Developing a simple conversion between the youngest and the oldest stages, the silver eel production over the past seven decades is reconstructed based on eel restocking (import from abroad), in a spatially explicit reconstruction. Subtracting the fishing harvest and downsizing for the mortality incurred when passing hydropower stations, an estimate of the biomass of silver eel escaping to the sea is derived.

A reconstruction of the silver eel production from historical data on their youngest ages, requires an extrapolation over many years, assumptions on growth and mortality, and a comparison between reconstructed (production) and actually observed (catch) variables. Though this makes the best use of the available information, it might not reflect the results to be fully reliable in all detail. Production estimates for individual lakes in specific years will certainly be much less reliable than nation-wide estimates, or decadal averages, and so forth. Hence, the presentation of results will be restricted to nation-wide averages.

4.1.1 Data collection

Statistics of commercial catch and eel restocking, specifying year, quantity (number), life stage (glass eels), destination location (name of the lake/river) have been collected in various Lithuanian archives and covered years since 1928, but in some cases detailed time-series are not complete or data are missing. Dataseries of higher reliability start in 1950 and continue until nowadays. However, even during this period part of total catches and part of stocked eels was not possible assign to exact waterbody, thus in the analysis this part of commercial catch or stocked eels was assigned to "unidentified waterbody". However, for some waterbodies, continuous dataseries exist since the beginning of eel fishery or stocking in the particular waterbody, and these series are considered to be complete and highly reliable. To increase reliability of the further analysis, historical records of catches/stockings were merged into the smaller sets of lakes (in total 80 groups) that allowed unique assignment of all data based on river basin and HPPs that are affecting those waterbodies. These data represent eel catches and stockings only in inland waters (without the Curonian lagoon).

The current assessment reconstructed the production of silver eel available to the fishery by lake and year, from information on restocking. For the eel derived from restocking, the release location is known (lake/river name); it is assumed that within-river migration has not notably altered the spatial distribution – or more often, that downstream migration in the silver eel stage brought the eel back to the lake from which it had migrated upstream after stocking.

A database of hydropower plants was made based on information available at the „Rivers, lakes and ponds cadastre of The Republic of Lithuania", book issued by Lithuanian hydropower association "Hydropower in Lithuania" (2011) and "Small hydroenergetics" (Bilys *et al.*, 2017). In most cases detailed information on ownership, turbine types and capacity, location and year of construction or reconstruction was available. The mortality of eel passing a hydropower station depends on type and size of the turbine, thus mortality rate of eels passing different turbines was based on previous studies carried in Lithuania and neighbour countries (Dainys *et al.*, 2018;

Larinier and Travade, 2002; Dêbowski *et al*., 2016). If migrating eels had po pass 6 or more HPPs during their downstream migration, it is assumed that mortality of these eels is 100% regardless of what turbine type is installed in each HPP.

For all locations where eel had been stocked, the route towards the sea was traced and the list of HPPs on that route derived. Individual routes pass from 0 up to 14 HPPs. For each HPP, the biomass of the escaping silver eel was reduced by a certain percentage. Summing the biomasses over all HPP gives an estimate of the total hydropower related mortality (ΣH), while the remaining biomass gives an estimate of the escapement towards the sea.

As consistent sampling of eels from Lithuanian waters (waterbodies of different trophic level; eels of different age groups, etc.) started in 2017 only, the conversion from glass eels to silver eels, eel length-weight relation and eel "silvering at age" was estimated as described by Dekker (2015). However, further sampling of eels for length, weight, maturity and age analysis will continue in order to obtain silvering curves for eels stocked into Lithuanian waterbodies.

There are no studies on natural eel mortality (M) in Lithuania. However, we assume that M in Lithuanian and Swedish waters should be very similar. For that reason, we refer to Dekker (2015) where M=0.10.

4.1.2 Analysis

Given the time-series of restocking, silver eel production is derived from the growth, silvering pattern and natural mortality:

$$Production = f(stocking, growth, mortality, maturation\ )$$

The fisheries are targeting this migrating eels (ΣF), resulting in an effective silver eel run of:

$$Silver\_eel\_run = Production - Catch$$

Passing hydropower generation stations reduces the silver eel run to:

$$Escapement = Silver\_eel\_run \times exp^{-\sum H}$$

The hydropower-related mortality $\sum H$ is summed over all hydropower stations on the route towards the sea, which is a different sum for each location (and year), and Escapement is the silver eel biomass escaping towards the sea, on their route towards the spawning places. It is assumed that, other than fisheries and hydropower, no other mortality during the migration towards the sea occurs.

Rearranging the above yields:

$$Escapement = (Production - Catch) \times exp^{-\sum H} = Production \times exp^{-\sum H} - Catch \times exp^{-\sum H}$$

The latter splits the production data (first term) from the fishery data (latter term) and post-hoc sums them up; this allows processing different spatial entities for different datasets (e.g. point-locations for release of recruits vs. lake-totals for fisheries).

Recent restocking will contribute to the escapement of silver eels about fifteen years from now, but some slow-growers or late-maturing eels may be found for up to twenty-five years or more. By that time, the stock will be dominated by year classes that have not been stocked yet and will be under the influence of management measures taken in coming years. That is: the effect of today's actions can only be assessed by analysing their effect in the future, but future trends are also influenced by yet unknown actions. Not knowing those future trends and actions, the result of today's actions are assessed by extrapolating the status quo indefinitely into the future. It is assumed that future stocking is equal to the average observed value during 2011–2018 and that future fisheries and hydropower generation have an impact equal to the most recent estimate

(constant mortality rate). Keeping the *status quo* unchanged, results for future years will express the expected effect of today's actions but will not provide an accurate prediction of the real developments (continued upward or downward trends, extra actions, and autonomous developments).

4.1.3 Reporting

Results of the assessment were reported to the Fisheries Service under Ministry of Agriculture and the European Commission in 2018 as country report.

4.1.4 Data quality issues and how they are being addressed

During the implementation of the EMP and evaluation of the progress of eel stock restoration in Lithuania some new data for improvement of the estimations (and reduction of biases) of eel stock in the country were collected. However, aiming to improve it further, it is needed to improve knowledge about mortalities in recreational fishery (particular study is needed) as it is still under discussion. It is also not well known about silver eel mortalities in the Curonian Lagoon fishery during their migration from lakes to the sea. There are no detailed studies on predation, despite it is not likely to be very high. These additional data would allow to adjust the model built for this assessment and more precisely estimate production of silver eels in the context of measures taken under EMP and effects of natural or anthropogenic factors. But most essential: aiming to improve assessment of all EMPs in the Baltic region it is urgently needed pan-Baltic standardized and internationally recognized/approved methodologies.

4.2 Trends in Assessment results

Overall predicted silver eel production was relatively low in 1950–1970, ranging between 0.05 and 15 t. Later silver eel production sharply increased and in 1998 reached its maximum of 280 t. However, since 2000 silver eel production started decreasing and in 2007–2017, it was on average 20.5 t per year. If stocking intensity will remain same as it was since beginning of EMP implementation, silver eel productions is expected to increase up to ca. 63 tons in 2030–2040 (Figure 4.1).

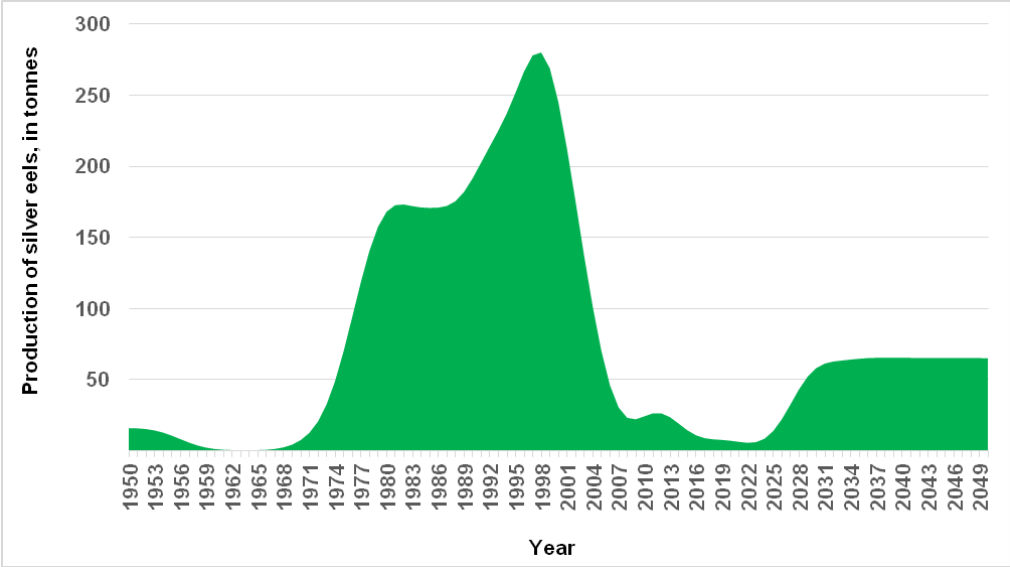

Figure 4.1. Production of silver eel by year: the estimated total production in inland waters before the impact of fishery and hydropower (1950–2050). For these results, a natural mortality rate of M=0.10 was assumed. Future forecast is made on the assumption that stocking will be carried at the same intensity as in 2011–2018 (0.6 million of glass eels per year).

For the fishery in inland waters, catch varied between 0.05 t (in 1958) and 15 t (in 1979). This is on average 31% of the production, with rather high variation over the years from 1 to more than 100% (Figure 4.2–4.3). For the period from 1961 to 1971, an extremely high (more than 100%) fishery mortality rate was calculated. If true, this might reflect intense commercial fishery on yellow eels in lakes using e.g. fykenets, longlines, electrofishing and other fishing gears, in the years before those eels would have become silver. Data on commercial catch of silver and yellow eels were pooled, and it was impossible to separate them out as of today. The assessment, however, assumes that all eels were caught as silver eels, which in later years was true. For this reason, "earlier" catch of silver eels artificially increases the estimates of fishery mortality. A similar effect might have occurred in 2017: catches were higher than the estimated production (mortality exceeds 100%). In 2014 and 2015, hydrometeorological conditions were disadvantageous for eel migration. It might be possible that eels delayed their migration during unsuitable conditions and intensively migrated when hydrometeorological conditions for the migration were good (e.g. heavy rainfall and high water level in 2017). Alternative explanation might be that we are underestimating growth of freshly stocked eels in virgin waters, but this explanation seems to be less likely.

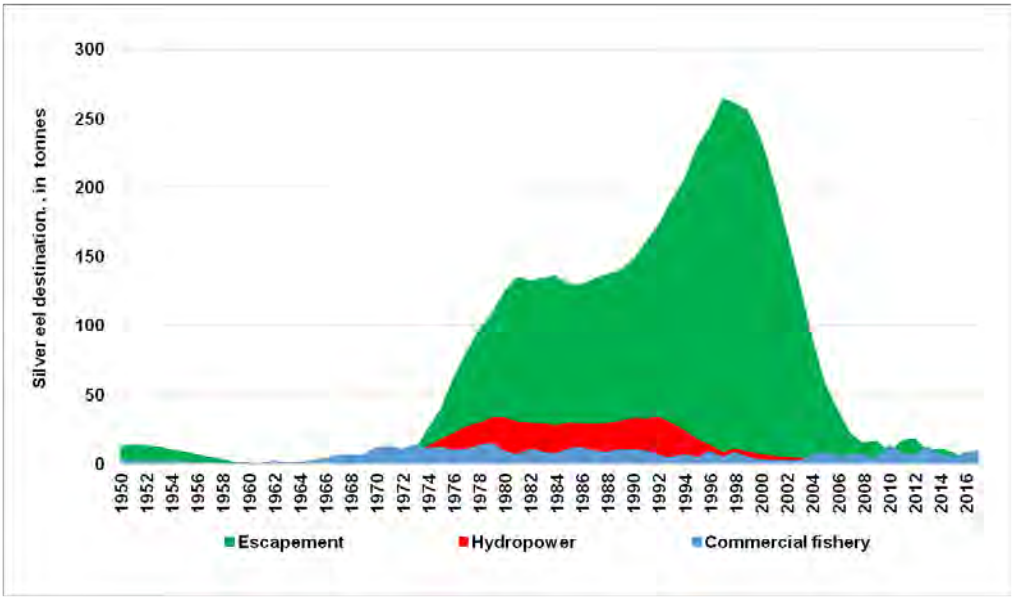

Figure 4.2. Time trends in the destination of the silver eel produced in Lithuanian inland waters (1950–2017).

For the hydropower, the estimated impact varied between close to 0 t (in 1950–1970) and 34 t (in 1992), that is approximately 8.7% of the total production (range 0%–26%). The estimated impact in 2017 was 0.44 t.

In some cases, negative hydropower mortalities were calculated (erroneously indicating that eels were produced by hydropower plants). This happens when the estimated eel production is below the reported eel catch e.g. stocking data are missing. This is clearly an unrealistic situation. In order to minimise under- or overestimation of eel mortalities, these "negative" data were omitted from further analysis.

Predicted escapement of silver eel ranged from 0 t (e.g. in 1961–1971) to 265 t (in 1997), on average 61% of the total production (range 0%–99%). The 2017 escapement is estimated at 0 t., while 2011–2017 annual average is ca. 9 tons (Figure 6.8).

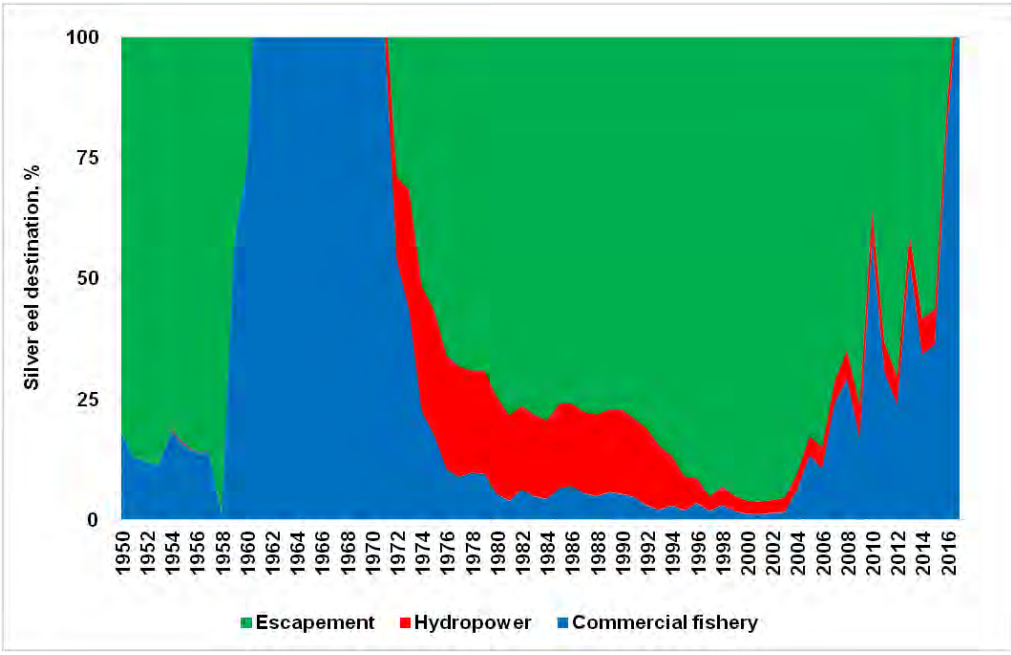

Figure 4.3. Time trend in the estimated anthropogenic mortality and escapement, expressed in percentage impacts on the silver eel production in 1950–2017.

Table 4.1. Trends over time (2011–2017) in eel stock indicators (in kg and % or rate (table below)).

	B_0	B_{target}	B_{best}	$B_{current}$	ΣF	ΣH	ΣA
2011	87 000	35 000	26 049	16 510	30,4%	6,2%	36,6%
2012	87 000	35 000	26 015	18 280	23,9%	5,8%	29,7%
2013	87 000	35 000	23 293	9 460	53,9%	5,5%	59,3%
2014	87 000	35 000	18 821	10 960	34,3%	7,5%	41,7%
2015	87 000	35 000	14 172	7 990	36,3%	7,3%	43,6%
2016	87 000	35 000	10 613	1 400	81,4%	5,4%	86,7%
2017	87 000	35 000	8 581	0	>100%	5,1%	>100%

	B_0	B_{target}	B_{best}	$B_{current}$	ΣF	ΣH	ΣA
2011	87 000	35 000	26 049	16 510	0,36	0,06	0,46
2012	87 000	35 000	26 015	18 280	0,27	0,06	0,35
2013	87 000	35 000	23 293	9 460	0,77	0,06	0,90
2014	87 000	35 000	18 821	10 960	0,42	0,08	0,54
2015	87 000	35 000	14 172	7 990	0,45	0,08	0,57
2016	87 000	35 000	10 613	1 400	1,68	0,06	2,03
2017	87 000	35 000	8 581	0	-*	0,05	-*

*Observed mortality exceeds estimated biomass.

5 Other data collection for eel

Lithuanian waters are not recruited with eels at glass eel stage.

DCF data on eels in the Curonian lagoon in 2018 were regularly sampled in harbours from May to October. In inland waters, eels were sampled in rivers at two sites during April–May, and at one site from April to June. Eel sampling was carried out in five lakes using longlines and small fykenets.

Until November 1st 2018, 202 eels were caught in lakes. Age, length, weight and other parameters were estimated. From 1 April until May 31, 2018 there were 178 eels analysed by length and weight from two river sites. From April to June there were 64 eels analysed by length and weight from one river site. 100 eels from the Curonian Lagoon commercial fishery and additional 100 eels from inland fishery (rivers) were purchased for the research purposes.

During 2017–2018 study on recreational eel catch was carried out by the Fisheries Service.

5.1 Yellow eel abundance surveys

There are no yellow eel abundance surveys carried out in Lithuania (except one case mark–recapture study in 2014). Regular yellow eel sampling in some lakes is focused on collection of biological data. In 2017–2018 yellow eel sampling started in 6 waterbodies: Paežerių lake, Ūkojas lake, Balsys lake, Kretuonas lake, Aisetas lake and Krokų estuary. Eels were caught and analysed by age, length, weight, and other parameters.

5.2 Silver eel escapement surveys

After stocked eels mature and reach silver eel stage, they start migrating downstream towards the sea or ocean. During these migrations, substantial mortality can drastically reduce the number of successful spawners. Success of Eel Management Plans and restoration activities is gauged in the context of EU Regulations by determining in the numbers of silver eels leaving inland waters to spawn. Barriers, especially hydropower installations, are considered to be one of the major threats for eels' downstream spawning migration. First attempt to evaluate silver eel migration success from Lithuanian inland waterbodies was carried in 2014. The results of this study are presented by Dainys *et al*. (2017).

A total of 63 silver eels were caught in four rivers in the Eastern Lithuania during their spawning migrations using fykenets of 16–20 mm mesh size and tagged with Vemco acoustic tags in spring and autumn of 2014. After implantation of acoustic tags, eels were released back to three free-flowing and one dammed river. Eel migration was tracked using four Vemco VR2W receivers that were installed in the vicinity of the Kaunas HPP water intake to detect eels entering turbines and four receivers were installed just below the Kaunas HPP to detect those eels that had passed through. To detect eels that successfully migrated downstream, four receivers were installed on navigational buoys in the Nemunas Delta and four in the Klaipėda Strait (Figure 5.1).

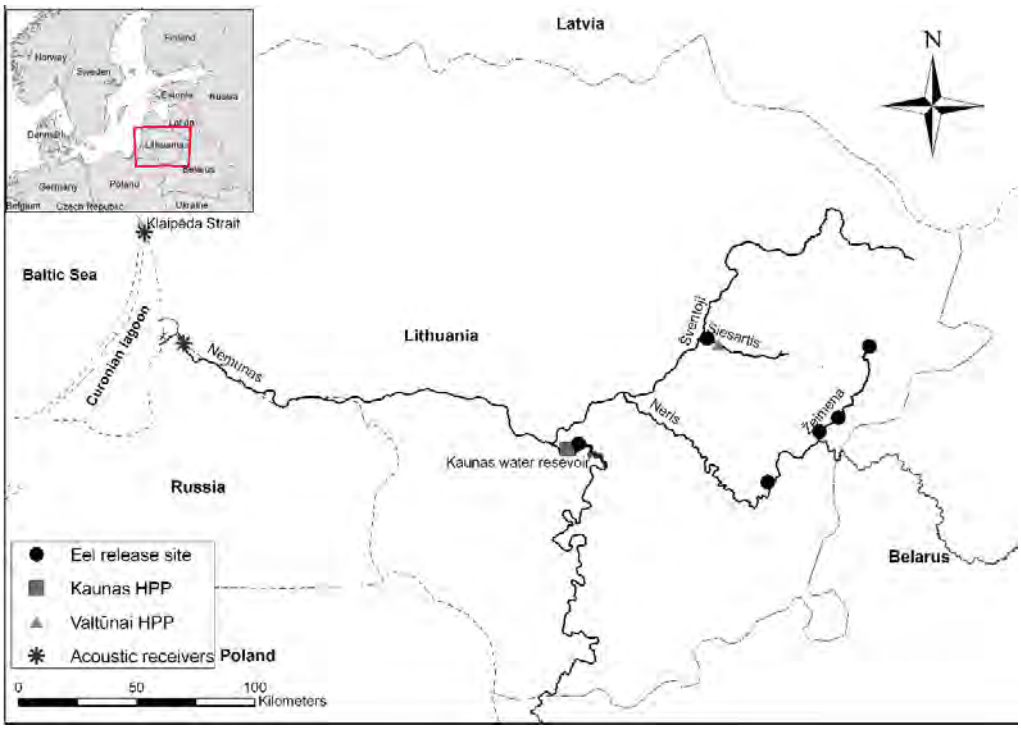

Figure 5.1. Eel release sites.

Eighteen out of the 38 silver eels released into free-flowing rivers of the Eastern Lithuania during May–June 2014 were never detected post-release, consequently their fate is unknown. The remaining 20 eels successfully migrated downstream and reached the Nemunas Delta (Migration Success = 53%).

Out of 25 eels released upstream of the Kaunas HPP, 21 (84%) moved downstream through the turbines and were detected below the HPP. Twelve eels migrated within 24 hours after release, while nine eels delayed passing through by one to 47 days. Four tagged eels did not migrate downstream and stayed in the Kaunas Reservoir until at least when the transmitter battery was discharged. Their fate remains unknown. Absence of a fish ladder at HPP means that all eels must pass directly through the turbines. Out of the 21 eels which migrated through the HPP, eleven were detected in the Nemunas Delta (Migration Success = 52.4%).

In the rivers of Eastern Lithuania, most of the tagged eels (N = 54, 86%) were released during late May–early June and nine eels (14%) were released in September. Thirty-one eels (49.2% of all eels released) were detected migrating through the Nemunas River Delta: one eel (3%) arrived in May, five eels (16%) were detected in June, eight (26%) in July and one (3%) in September. The majority (N = 15, 49%) were detected in October and the one remaining (3%) was detected in November.

Out of 31 eels, which were detected entering the Curonian Lagoon, at least four (13%) were caught in fykenets by fishermen. Until the end of transmitter battery operation, 22 eels (Migration Success = 71%) were detected in Klaipėda Strait prior to entering the Baltic Sea, while the fate of the remaining five eels (16%) remains unknown.

The peak period of eels entering the Baltic Sea was observed during late fall: 18 eels (82%) were detected in the Klaipėda Strait during October–November while the remaining four eels were detected once each in June, July, December and January, respectively.

Overall migration success (including HPP effect) of all tagged and released eels in Lithuanian rivers and the Curonian Lagoon was 35%.

Eels from the Curonian lagoon were regularly sampled in harbours from May to October in 2018 under DCF. Eels from inland waters were sampled at the Žeimena river and in a river connecting the Galuonai lake and the Vašuokas lake. Fishing traps in rivers were operated for 440 hours in total; as the result there were 178 eels caught, and measured for the length and weight. In 2018, silver eel escapement surveys were carried out from 1 April to June in the Lakaja river. Fishing traps in the Lakaja river were operated for 160 hours in total; as a result, there were 64 eels caught, and measured for the length and weight. 100 eels from the Curonian Lagoon commercial fishery and additional 100 eels from inland fishery (rivers) were purchased for the research purposes.

5.3 Life-history parameters

All eels handled, recently are analysed with respect to size, weight, sex, stage, age, in some cases subsample for the prevalence and intensity of parasites. Fat is measured only occasionally.

As part of our DCF/EU MAP data collection, eels from a number of commercially fished streams/rivers and the Curonian lagoon were sampled since 2010.

5.4 Diseases, Parasites and Pathogens or Contaminants

Eel viruses and diseases have not been monitored in Lithuania. No large-scale or long-term studies on eel parasites and pathogens were carried out in Lithuania. Consistent sampling of eels from Lithuanian waters (waterbodies of different trophic level; eels of different age groups, etc.) has started in 2017 only, thus since then all eels are analysed at the Nature research centre and/or the Fisheries Service under the Ministry of Agriculture of the Republic of Lithuania are screened by the naked eye for *Anguillicola crassus*. Most of analysed eels were infected with *A. crassus*. Infection intensity was relatively low: usually ranging between one and four nematodes (highest observed intensity was 23 parasites for one eel). Additionally, two other parasite species (*Diplostomum spathaceum* and *Pseudodactylogyrus* spp.) were found in analysed eels in 2017 (analysis was carried by the Fisheries Service).

6 New Information

In 2017, a PhD thesis on eels was defended: Dainys J. 2017. Migration of stocked European eels (*Anguilla anguilla* L.) in Lithuania and potential contribution to spawning stock restoration. Vilnius, 98 p.

Most recent publications of studies on eels in Lithuania:

Dainys J., Stakėnas S., Gorfine H., Ložys L. 2018. Mortality of Silver Eels Migrating Through Different Types of Hydropower Turbines in Lithuania. River Research and Applications, 34: 52–59. DOI: 10.1002/rra.3224.

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Reporting Period: This report was completed in September 2019, and contains data up to 2018 and some provisional data for 2019.

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1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

Table 1. Stock indicators of silver eel escapement, biomass and mortality rates, and assessed habitat area for the period 2014–2016 derived from Van de Wolfshaar *et al*. (2018), assessed area from Tien and Dekker (2004).

Year	EMU_code	Assessed Area (ha)	B_0 (tonnes)	B_{curr} (tonnes)	B_{best} (tonnes)	Bcurr/B_0 (%)	∑F	∑H	∑A
2014–2016	NL_Neth	378 700	10 400	1365	2647	51.6	0.54	0.12	0.66

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) ; B_{best} = the amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the current stock; ∑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.

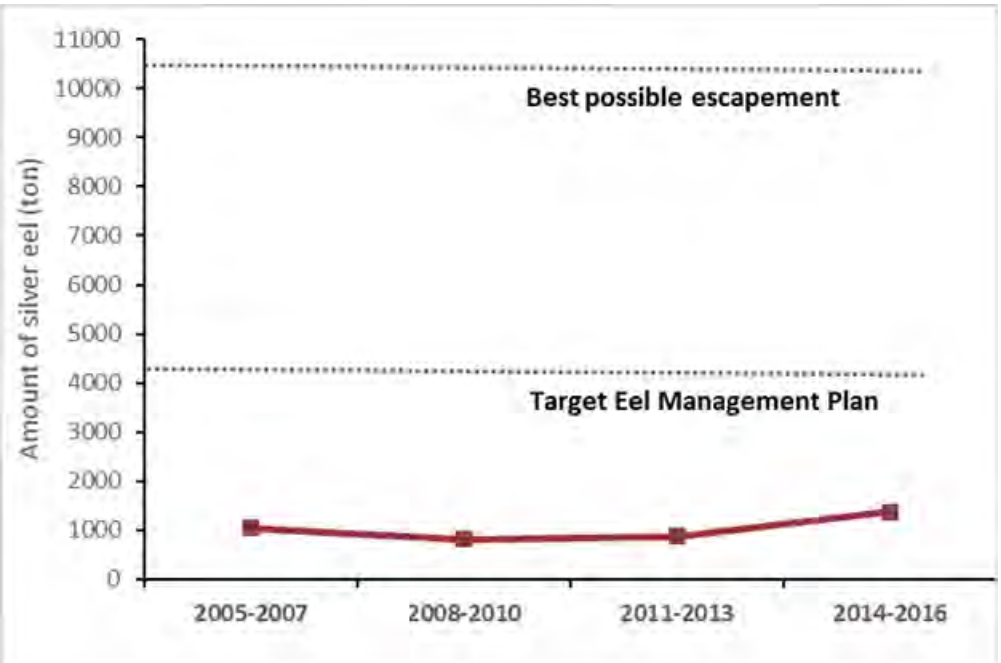

Figure 1. Estimated amount of silver eel that escapes to sea to spawn (red line); best possible escapement when only natural mortality occurs (upper dotted line); target of the Eel Management Plan (lower dotted line). The target of the Eel Management Plan is 40% of the best possible escapement.

1.2 Recruitment time-series

The WGEEL uses recruitment time-series from several countries to calculate Recruitment Indices, relative to the reference period of 1960–1979. 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.

Recruitment of glass eel in Dutch waters is monitored at 12 sites along the coast (Figure 3, *Table 2*; see Dekker (2002) for a full description). The time-series in Den Oever (Figure 3, *Table 2*) is the most extensively sampled and had been running since 1938. In Den Oever recruitment levels are very low compared to the reference period (1960–1979). Recruitment was slightly better in 2013 and 2014, but in 2015 recruitment level reached a historic low. After a slight increase in 2016, in the past three years, the recruitment at Den Oever is at a similar low level as that of the 2000s. The data from the other locations (Figure 4, *Table 3*) confirmed the overall trend of Den Oever, though individual series may deviate (e.g. recruitment at location Katwijk was relatively high this year). Glass eel data are presented as the average number of glass eels per haul in the months April and May, between 18:00–8:00 and only years with >5 hauls are included (details in Griffioen *et al.*, 2017).

Figure 2. Locations of glass eel monitoring in the Netherlands.

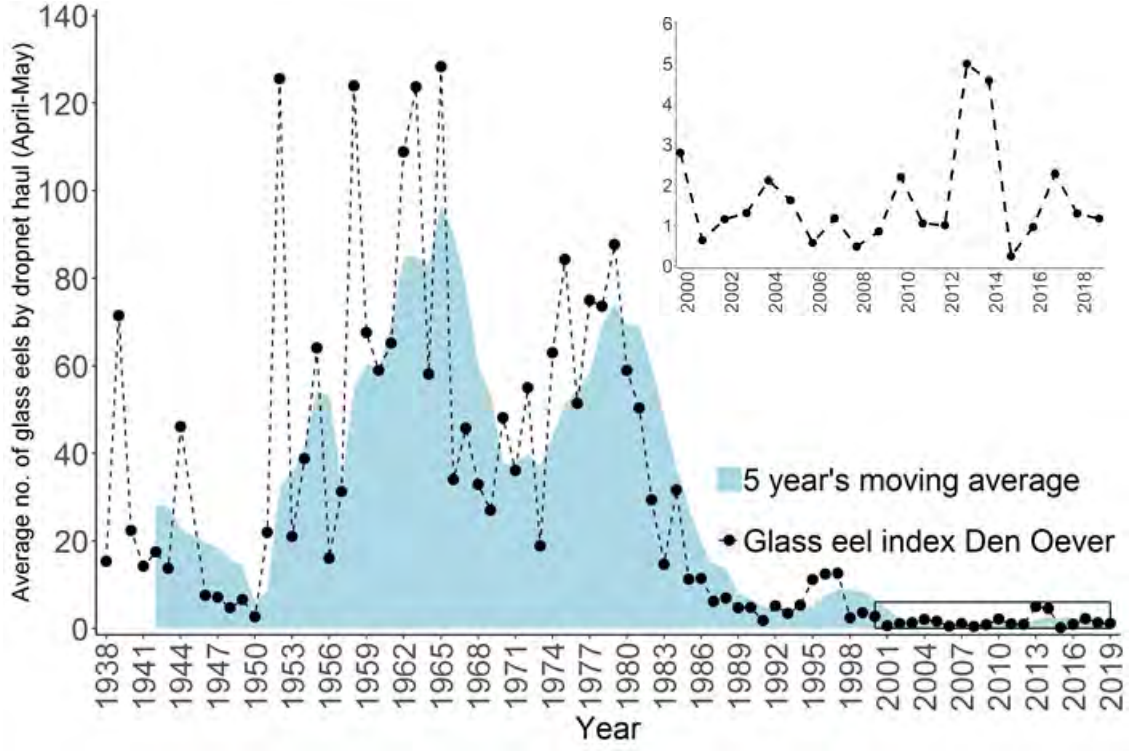

Figure 3. Trend indices (mean number per haul in April and May) of glass eel recruitment at Den Oever (1938–2019).

Table 2. Average number of glass eel caught per lift net haul at the sluices in Den Oever in the period April–May.

Decade Year	1930	1940	1950	1960	1970	1980	1990	2000	2010
0		22.4	2.7	58.9	48.1	59.0	4.9	2.8	2.2
1		14.3	21.9	65.2	36.1	50.4	1.8	0.6	1.1
2		17.5	125.6	108.9	55.0	29.4	5.2	1.2	1.0
3		13.7	21.1	123.7	18.8	14.7	3.5	1.3	4.9
4		46.1	38.8	58.1	63.0	31.6	5.4	2.1	4.6
5		NA	64.1	128.3	84.3	11.2	11.1	1.6	0.2
6		7.5	16.1	34.0	51.4	11.4	12.5	0.6	1.0
7		7.2	31.3	45.8	75.0	6.2	12.6	1.2	2.3
8	15.3	4.8	124.0	32.9	73.6	7.0	2.5	0.5	1.3
9	71.5	6.6	67.6	27.1	87.7	4.8	3.7	0.9	1.2

Table 3. Average number of glass eel caught by liftnet hauls after sunset, before sunrise in the period April–May at 12 sites in the Netherlands (1979–2019). If less than six hauls were carried out, data are not presented. Data are visualised in Figure 4. The locations in light grey are used in the ICES assessment.

YEAR	Schelde_Bath_BATH	Maas_Bergsche-Diep_BDSL	Maas_Krammer-sluizen_KRAS	Maas_Stellendam_STGS	Rijn_DenOever_DOSP	Rijn_Harlingen_HTHS	Rijn_IJmuiden_IJMS	Rijn_Katwijk_KATW	Rijn_Lauwersmeer_LAUS	Eems_NieuwStat-enzijl_NSZS	Eems_Termunter-zijl_TMZS
1979					87.7		222.3		100.4		
1980					59.0						
1981					50.4		188.7		75.9		
1982					29.4				21.6		
1983					14.7				15.8		
1984					31.6		8.1		9.5		
1985					11.2		0.6		25.2		
1986					11.4		3.3		1.3		
1987					6.2		7.7				
1988				13.8	7.0		4.0		1.0		
1989				4.4	4.8		1.5		14.3		
1990			0.3	10.9	4.9		3.2		6.0		
1991		1.3	0.2	3.1	1.8		3.6	5.1	6.6		0.5
1992	14.5	2.2	0.4	16.9	5.2	16.7	5.8	8.1	12.1		0.6
1993	22.7		0.4	10.1	3.5		3.3	13.5	33.2		1.2
1994	14.2		0.5	4.0	5.4	16.0	4.0	15.1	31.0		2.8
1995	17.8		0.4	3.3	11.1	6.6	2.0	29.7	16.9		3.7
1996	35.3		0.7	0.5	12.5	34.2	4.5	25.3	49.4	27.5	7.7
1997	41.6		0.6	2.8	12.6	14.0	1.8	12.3	27.8	30.0	15.6
1998	28.2		0.6	1.0	2.5	18.3	2.0	38.8	14.4	21.8	1.4
1999	29.7		0.5	1.2	3.7	19.1	1.9	122.7	31.7	13.5	10.1
2000	10.2	3.8	1.0	7.1	2.8	2.9	0.7	11.6	7.2	38.8	8.7
2001		0.1	0.1	1.0	0.6	2.3	0.5	14.1	2.4	39.7	1.1
2002	1.9		0.2	4.2	1.2	3.2	0.1	12.3	5.5	36.4	1.6

YEAR	Schelde_Bath_BATH	Maas_Bergsche-Diep_BDSL	Maas_Krammer-sluizen_KRAS	Maas_Stellendam_STGS	Rijn_DenOever_DOSP	Rijn_Harlingen_HTHS	Rijn_IJmuiden_IJMS	Rijn_Katwijk_KATW	Rijn_Lauwersmeer_LAUS	Eems_NieuwStat-enzijl_NSZS	Eems_Termunter-zijl_TMZS
2003	7.5		0.1	0.3	1.3	5.1	0.0	12.7	1.7	23.6	0.8
2004	16.4		0.0	0.3	2.1	14.3	0.1	4.5	2.3	28.1	1.9
2005	14.6		0.6	0.2	1.6	6.8	0.0	5.6	1.4	21.1	1.8
2006	12.0		0.2	0.0	0.6	0.6	0.0	1.4	1.7	8.3	1.3
2007	40.5	0.4	0.1	0.1	1.2	1.7	0.1	24.8	0.9	21.7	4.0
2008	13.2	2.3	0.0	0.0	0.5	1.1	0.1	4.1	2.8	15.9	1.3
2009	9.1	1.1	0.0	0.4	0.9	0.7	0.1	3.5	0.6	13.6	1.2
2010	28.4	1.7	0.0	0.2	2.2	1.0	0.0		1.1	13.0	1.2
2011	39.2	1.3	0.1	0.3	1.1	3.1	0.0		1.4	11.6	1.4
2012	25.8	0.8	0.2	0.1	1.0	1.1	0.1	1.6	2.9	27.6	1.3
2013	69.5	16.7	0.0	0.2	5.0	4.8	0.0	1.4	9.1	60.5	1.9
2014	96.3	6.3	0.0	0.5	4.6	5.8	0.0	0.4	16.2	72.0	2.1
2015	24.2	2.2		0.2	0.2	1.0	0.1	0.6		3.0	0.4
2016	22.8	4.7	0.0	1.0	1.0	1.5	0.0	0.7		31.1	0.8
2017	12.2	0.5		0.1	2.3		0.0	0.4	2.3	7.6	1.4
2018				0.2	1.3		0.7	0.8	1.2		
2019				0.3	1.2		0.0	2.4	0.8		

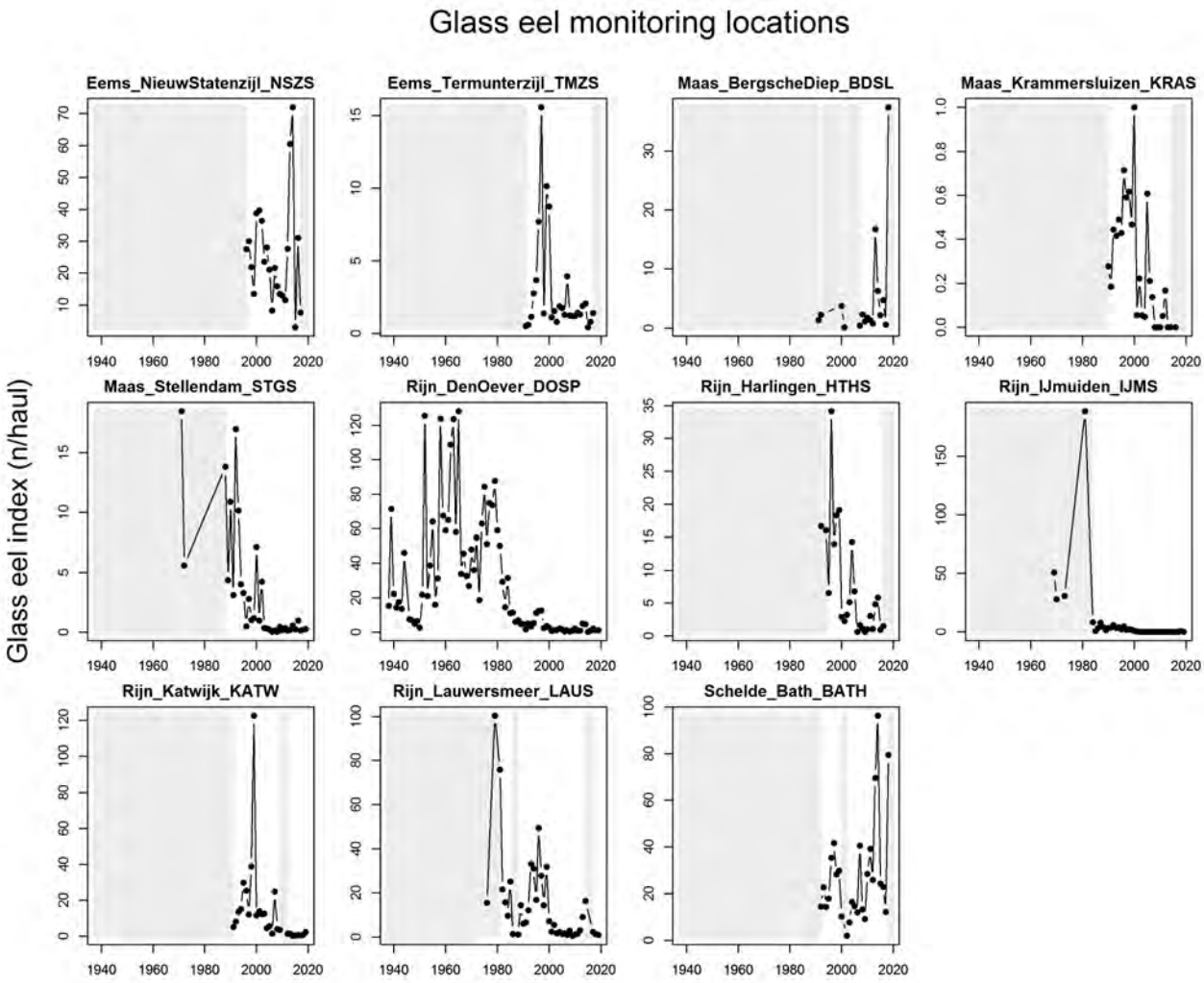

Figure 4. Time-series of the glass eel indices (data of Table 3). Grey = not sampled (data Wageningen Marine Research).

2 Overview of the national stock and its management

2.1 Describe the eel stock and its management

2.1.1 Eel Management Units and Eel Management Plans

The Netherlands consists of one EMU coded 'NL_Neth' and there is one Eel Management Plan (EMP)[1] that was implemented in July 2009 and revised in 2011.

2.1.2 Management authorities

The Dutch Ministry of Agriculture, Nature and Food Quality (PO Box 20401, 2500 EK Den Haag, The Netherlands) is responsible for the conservation of stocks and for the management of all anthropogenic impacts, as well as for the delivery of the Eel Management Plan (EMP).

2.1.3 Fisheries

Fisheries on eel in the Netherlands is regulated by the Dutch Fisheries Act, while protection of eel is regulated under the Dutch Flora and Fauna Act. In summary, the following regulations apply: the minimum catch size is 28 cm, the fisheries are closed in the period 1 September–30 November (apart from the province of Friesland), all eel caught between 1 September and 30 November have to be released, including Recreational catches. In addition, since 2011 the main large rivers are closed for fisheries due to pollution (dioxins, Figure 5)[2].

Figure 5. Overview of the areas closed for eel fishery as of 1 April 2011 (Source: Ministry of Agriculture, Nature and Food Quality).

1 https://archief06.archiefweb.eu/archives/archiefweb/20180227041226/https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2012/07/10/aalbeheerplan-april-2011/aalbeheerplan-april-2011.pdf
2 http://www.sportvisserijnederland.nl/vispas/visserijwet-en-regels/binnenwater/paling.html

2.1.4 Management actions

The management measures taken in the Netherlands in the framework of the EMP are listed in Table 4. Overview of all the measures described in the Dutch Eel Management Plan to be implement to reach the 40% escapement objective (source: van de Wolfshaar *et al.*, 2018).

Table 4. Overview of all the measures described in the Dutch Eel Management Plan to be implement to reach the 40% escapement objective (source: Van de Wolfshaar *et al*., 2018).

No	Foreseen Measure	Planned implementation	Realised implementation
1	Reduction of eel mortality at pumping stations and other water works.	2015–2027	2015–2027[a]
2	Reduction of eel mortality at hydro-electric stations with at least 35%	2009	November 2011[b]
3	The establishment of fishery-free zones in areas that are important for eel migration	2010	1 April 2011[c]
4	Release of eel caught (a) at sea and (b) at inland waters by anglers	2009	1 October 2009
5	Ban on recreational fishery in coastal areas using professional gear	2011	1 January 2011[d]
6	Annual closed season from 1 September to 1 December	2009	1 October 2009
7	Stop the issue of licences for eel snigglers by the minister of LNV in state owned waters	2009	1 May 2009
8	Restocking of glass eel and pre-grown eel from aquaculture	2009	Early 2010
9	Research into the artificial propagation of eel	ongoing	EU-project started
10	Closure eel fishery in contaminated (PCBs, dioxins) areas (Unforeseen Measure)		1 April 2011

[a]In agreement with the European Commission changes have been made to the original schedule of solving migration barriers.

[b]Due to technical difficulties the maximum achievable reduction in mortality by adjusted turbine management is 24%.

[c]The vast majority of the contaminated areas that were closed for commercial fisheries on 1/4/2011 are the main rivers.

[d]The use of fykes and long-lines by recreational fishers has been banned in nearly all marine and inland waters waters.

2.2 Significant changes since last report

There have not been significant changes in the status of the eel across The Netherlands since the Country Report of 2018 (van Rijssel and van der Hammen, 2018).

3 Impacts on the national stock

Table 5. Overview of the assessed impacts per habitat type. Barriers include habitat loss; indirect impacts are anthropogenic impacts on the ecosystem, but only indirectly on eel (e.g. eutrophication). A = assessed, MI = not assessed, minor, MA = not assessed, major, AB = impact absent, NP = not present.

EMU code	Habitat	Fish com	Fish rec	Hydro & pumps	Barriers	Restocking	Predators	Indirect impacts
NL_Neth	Riv	A	A	A	A	MI/MA	MI/MA	MI/MA
	Lak	A	A	A	A	MI/MA	MI/MA	MI/MA
	Est	MI	MI	NP	NP	MI	MI/MA	MI/MA
	Lag	NP	NP	NP	NP	NP	NP	NP
	Coa	MI	A	AB	AB	AB	AB	MI

Table 6. Loss of eel (kg) for each impact per developmental stage. A = assessed, MI = not assessed, minor; MA = not assessed, major; AB = impact absent. All eel caught recreationally were assumed to be yellow eel.

EMU code	Stage	Fish com	Fish rec	Hydro & pumps	Barriers	Restocking	Predators	Indirect impacts
NL_Neth	Glass	AB	AB	MI/MA	MI/MA	AB	MI/MA	MI/MA
NL_Neth	Yellow	A	A	MI/MA	MI/MA	AB	MI/MA	MI/MA
NL_Neth	Silver	A	AB[1]	A	MI/MA	AB	MI/MA	MI/MA

3.1 Fisheries

3.1.1 General information

Eel fisheries in the Netherlands occur in coastal waters, estuaries, larger and smaller lakes, rivers, polders, etc. Management of eel stock and fisheries has been an integral part of the long tradition in manipulating water courses (polder construction, river straightening, ditches and canals, etc.). Governmental control of the fishery is restricted to, on the one hand a set of general rules (gear restrictions, size restrictions, for course (silver) fish (such as carp, roach and bream): closed seasons), and on the other hand site-specific licensing. Since 1/1/2010 there is a general registration of landings. Until 2013, licencees in state-owned waters were obliged to participate in so-called Fish Stock Management Committees [‘Visstand Beheer Commissies’ VBC][3], in which commercial fisheries, sports fisheries and water managers are represented. The VBC was responsible for the development of a regional Fish Stock Management Plan. The Management Plans are currently not subject to general objectives or quality criteria. The future of VBC and their role in fish stock management is still under debate and only a few VBCs are still active.

Until April 2011, the total Dutch freshwater fishery on eel involved approximately 200 companies, with an estimated total catch of nearly 442 tonnes of eel in 2010. However, on 1 April 2011

[3] http://www.visstandbeheercommissie.nl/

a large part of the fishery was closed due to high PCB-levels (Figure 5). This closure affected about 50 fishing companies catching 170 tonnes of eel in 2010.

3.1.2 Spatial subdivision of the territory

The fishing areas in the Netherlands can be categorised into five groups:

1. The Wadden Sea; 53ºN 5ºE; 2591 km². The Wadden Sea is an estuarine-like area, shielded from the North Sea by a series of islands. The inflow of seawater at the western side mainly consists of the outflow of the river Rhine, which explains the estuarine character of the Wadden Sea. The fishery in the Wadden Sea is permitted to licence holders and assigns specific fishing sites to individual licencees. Fishing gears include fykenets and poundnets; the traditional use of eel pots is in rapid decline. The fishery in the Wadden Sea is obliged to apply standard EU fishing logbooks. Landings statistics are therefore available from 1995 onwards. In 2016 and 2017, there is a sudden increase from ~5 to ~11 tons (Figure 6, Table 7). In 2018, catches decline again to similar quantities as before 2016 (5.5 t).
2. Lake IJsselmeer; 52º40'N 5º25'E; now 1820 km². Lake IJsselmeer is a shallow, eutrophic freshwater lake, which was reclaimed from the Wadden Sea in 1932 by a dyke (Afsluitdijk), substituting the estuarine area known before as the Zuiderzee. The surface of the lake was reduced stepwise by land reclamation, from an original 3470 km² in 1932, to 1820 km² since 1967. In preparation for further land reclamation, a dam was built in 1976, dividing the lake into two compartments of 1200 and 620 km², respectively, but no further reclamation has actually taken place. In managing the fisheries, the two lake compartments have been treated as a single management unit. The discharge of the river IJssel into the larger compartment (at 52º35'N 5º50'E, average 7 km³ per annum, coming from the River Rhine) is sluiced through the Afsluitdijk into the Wadden Sea at low tide, by passive fall. Fishing gears include standard and summer fykenets, eel boxes and longlines; trawling was banned in 1970. Licensed fishermen are not spatially restricted within the lake, but the number of gears is controlled by a gear-tagging system. The registered landings at the auctions are assumed to cover the actual total. There are, however, differences in estimated landings reported by the fisheries organisation (PO IJsselmeer), the Fish Board (PVIS) and catch registration system of the Ministry of Agriculture, Nature and Food quality (LNV).
3. Main rivers; 180 km² of water surface. The Rivers Rhine and Meuse flow from Germany and Belgium respectively, and in the Netherlands constitute a network of dividing and joining river branches. Traditional eel fisheries in the rivers have declined tremendously during the 20th century, but following water rehabilitation measures in the last decades, is now slowly increasing. The traditional fishery used stownets for silver eel, but fykenet fisheries for yellow and silver eel now dominates. Individual fishermen are licensed for specific river stretches, where they execute the sole fishing right. Since 1 April 2011 the eel fishery on the main rivers has been closed due to high levels of pollutants in eel.
4. Zeeland; 965 km². In the Southwest, the Rivers Rhine, Meuse and Scheldt (Belgium) discharge into the North Sea in a complicated network of river branches, lagoon-like waters and estuaries. Following a major storm catastrophe in 1953, most of these waters have been (partially) closed off from the North Sea, sometimes turning them into fresh waterbodies. Fishing is licensed to individual fishermen, mostly spatially restricted. Fishing gears are dominated by fykenets. Management is partially based on marine, partly on freshwater legislation. This area has also been affected by the ban on eel fishery due to high pollution levels.
5. Remaining waters; inland 1340 km². This comprises 636 km² of lakes (average surface: 12.5 km²); 386 km² of canals (>6 m wide, 27 590 km total length); 289 km² of ditches (<6 m

wide, 144 605 km total length); and 28 km² of smaller rivers (all estimates based on areas less than 1 m above sea level, 55% of the total surface; see Tien and Dekker 2004 for details). Traditional fisheries are based on fykenetting, and hook and line. Individual licences permit fisheries in spatially restricted areas, usually comprising a few lakes or canal sections, and the joining ditches. Only the spatial limitation is registered.

Table 7. Marine fisheries landings in the Netherlands from Dutch vessels in ICES areas 4.a, 4.b, 4.c, 7.a, 7.d and 8.b). Landings with unknown ('UNK') location are assumed to be from one of these locations.

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Landings(tonnes)	35535	27725	24129	18395	21906	19488	34973	28205	17951	31153	18155	17414
YEAR	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Landings (tonnes)	9131	6909	3960	4971	3684	4338	5797	4241	4297	11177	11081	5529

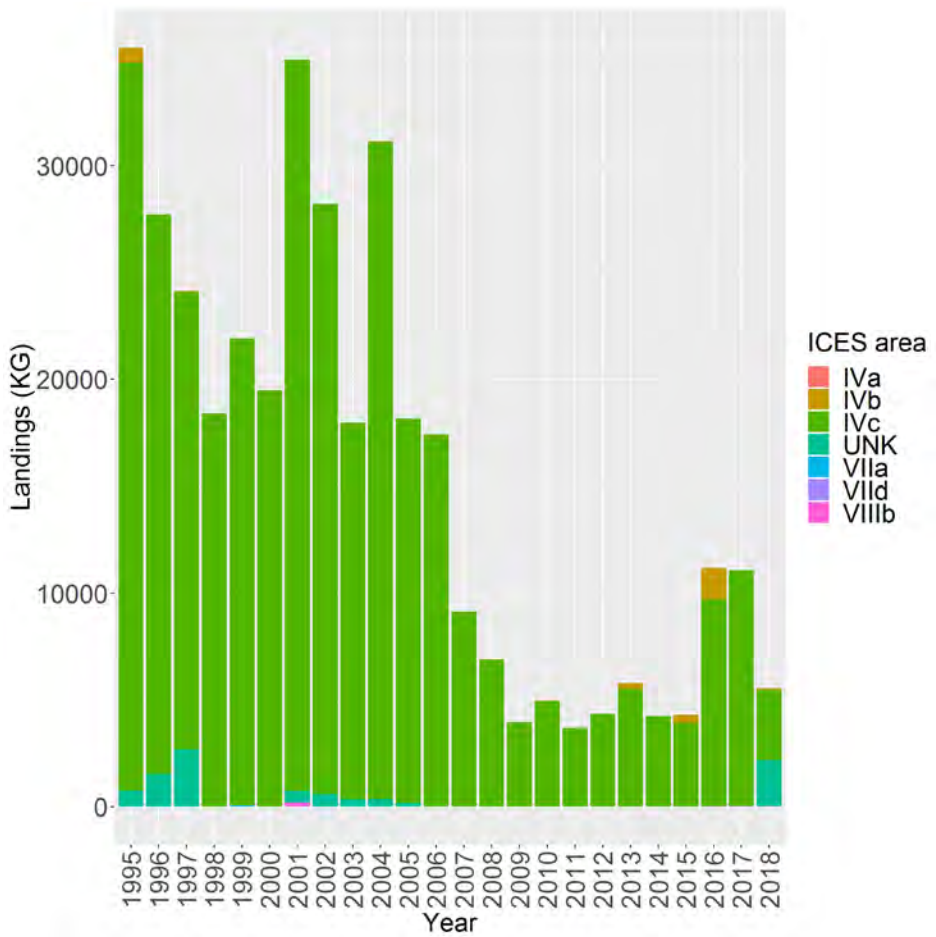

Figure 6. Marine fisheries landings (kg per country) in the Netherlands from ICES areas 4.a, 4.b, 4.c, 7.a, 7.d and 8.b). Landings with unknown ('UNK') location are assumed to be from one of these locations.

The Water Framework Directive subdivides the Netherlands into four separate River Basin District (RBD), all of which extend beyond our borders. These are:

1. the River Ems (Eems), 53º20'N 7º10'E (=river mouth), shared with Germany. This RBD includes the northeastern Province Groningen, and the eastern part of Province Drenthe. Drainage area: 18 000 km², of which 2400 km² are in the Netherlands.

2. the River Rhine (Rijn), 52º00'N 4º10'E, shared with Germany, Luxemburg, France, Switzerland, Austria, Liechtenstein. Drainage area: 185 000 km², of which 25 000 km² are in the Netherlands, which is the major part of the country.
3. the River Meuse (Maas), 51º55'N 4º00'E, shared with Belgium, Luxemburg, France and Germany. Drainage area: 35 000 km² , of which 8000 km² in the Netherlands.
4. the River Scheldt (Schelde), 51º30'N 3º25'E, shared with Belgium and France. Most of the southwestern Province Zeeland used to belong to this RBD, but water reclamation has changed the situation dramatically. Drainage area: 22 000 km², of which 1860 km² in the Netherlands.

Within the Netherlands, all rivers tend to intertwine and confluent. Rivers Rhine and Meuse have a complete anastomosis at several places, whereas a large part of the outflow of the River Meuse is now redirected through former outlets of the River Scheldt. Additionally, the coastal areas in front of the different RBDs constitute a confluent zone. Consequently, sharp boundaries between the RBDs cannot be made – neither on a practical nor on a juridical basis. This report will subdivide the national data on a pragmatic basis.

In this report, we will subdivide the national data on eel stock and fisheries by drainage area on a preliminary assumption that water surfaces and fishing companies are approximately equally distributed over the total surface, and thus, totals can be split up over RBDs proportionally to surface areas.

3.1.3 Fishing capacity

Capacity is defined as the potential fishery usage (i.e. number of licences issued). For marine waters and Lake Ijsselmeer, a register of ships is kept, but for the other waters no central registration of the ships being used is available. Registration of the number of gears owned or employed was lacking until recently.

For Lake IJsselmeer/Markermeer, an estimate of the number of gears actually used is available for the years 1970–1988 (Dekker, 1991). In the mid-1980s, the total number of fykenets was capped, and reduced by 40% in 1989. In 1992 the number of eel boxes was counted, and capped. Subsequently, the caps have been lowered further in several steps, the latest being a buy-out in 2006. Since the number of companies has reduced at the same time, the nominal fishing effort per company has not reduced at the same rate, and underutilisation of the nominal effort probably still exists. The effort in the longline fishery is not restricted, other than by the number of licences.

The ministry (LNV-RVO) provides permits that give the right to fish with certain gears. The numbers of gears and rights differ per permit holder. Insight in the use of the permits is provided by the weekly catch reports that fishermen are obliged to hand in. When fishermen fish with a certain gear, they have to mark it with a label ('merkje'). Permits can also be reserved temporarily, e.g. when there is no vessel available. In that case, there are no rights to fish (source: pers. comm. RVO, Ministry of Agriculture, Nature and Food quality, 2017). In 2019, the total number of gears allowed was; 1579 fixed fykes, 3192 (one less than last year) train fykes (one fyke = two eel units), 7415 eel boxes. These numbers have hardly changed in the past few years.

3.1.4 Glass eel fisheries

There is no fishing on glass eel.

3.1.5 Yellow eel fisheries

3.1.5.1 Commercial

No reliable long-term time-series of yellow eel landing exist; total landings of yellow and silver eel combined were reported.

Statistics from the auctions around Lake IJsselmeer were kept by the Ministry of LNV until 1994; since then and until 2012 statistics were kept by the Fish Board (PVis; Figure 7). These statistics are broken down by species, month, harbour and main fishing gear. The quality of this information deteriorated considerably over the past decades, due to misclassification of gears, and the trading of eel from areas other than Lake IJsselmeer and Lake Markermeer at the auctions around the lakes. In the data from auctions around Lake IJsselmeer yellow and silver eel were reported separately, but data from recent decades (from early 1990s onwards) is unreliable: yellow eel from eel boxes and silver eel from all gears have been combined.

In addition, the fishers organisation (PO IJsselmeer) has kept records of the catches of their associated fishers (>90% of the fishers active in the IJsselmeer area) from 2001 onwards (Figure 7).

An obligatory catch registration system was introduced in the Netherlands in January 2010 by the Ministry of LNV. Weekly catches of eel have been reported, but yellow eel and silver eel catches are combined in this program. Since 2012, also information on effort are reported, however the completeness of the effort data is unclear until now. We regard the landings data from 2010 onwards as the best representative of the amount of eels actually caught and landed in The Netherlands (Table 8, Figure 7).

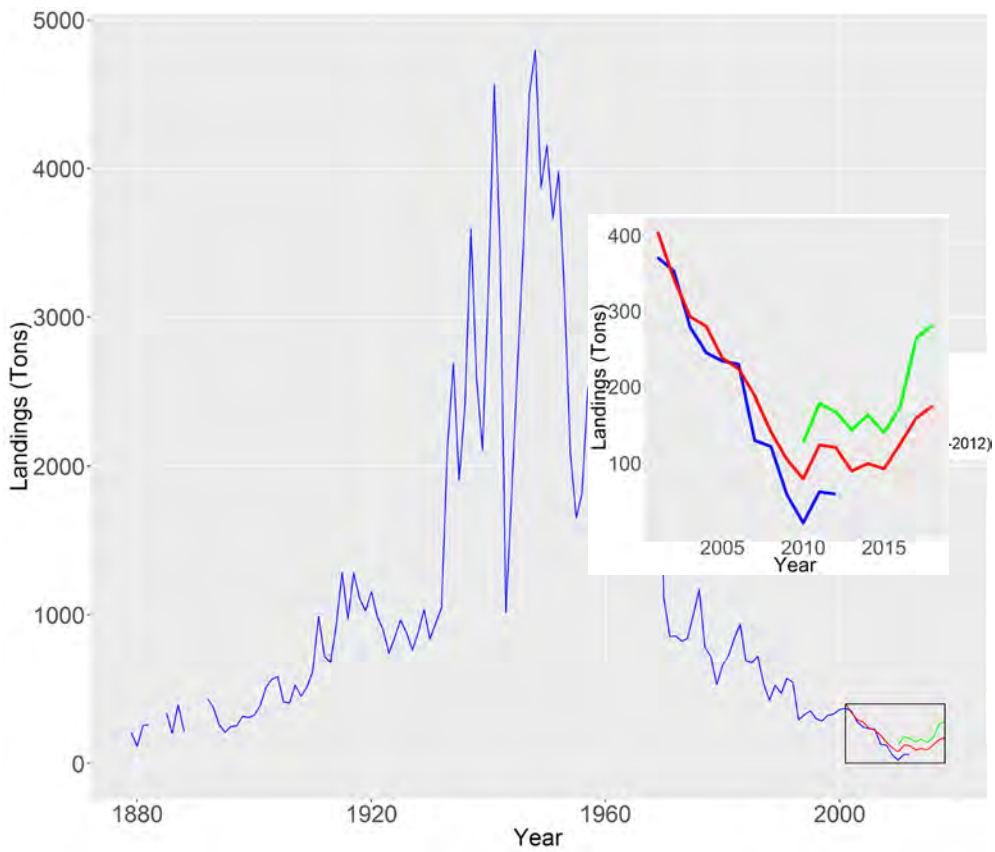

Figure 7. Time-series of landings of yellow eel, silver eel and yellow plus silver eel combined from Lake IJsselmeer/Markermeer at auctions. Source data: LNV, Productschap Vis and PO IJsselmeer.

Table 8. Landings in lake IJsselmeer and Markermeer (yellow eel and silver eel combined). Source: Ministry of Agriculture, Nature and Food quality (LNV).

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018
Landings (tonnes)	127.6	178.5	168	144	163.8	140.5	174.3	264.5	281.1

In addition to landings of Lake IJsselmeer, the Ministry of LNV collects also eel landing data from all other waters through the catch registration system since 2010 (Figure 8). The steep drop in landings in 2011 is due to the closure of eel fishery in contaminated (PCBs, dioxins) areas. Since this closure, the landings of Lake IJsselmeer exceed those of all other inland waters. Just as in Lake IJsselmeer and Lake Markermeer, landings have gone up again in 2017 and 2018.

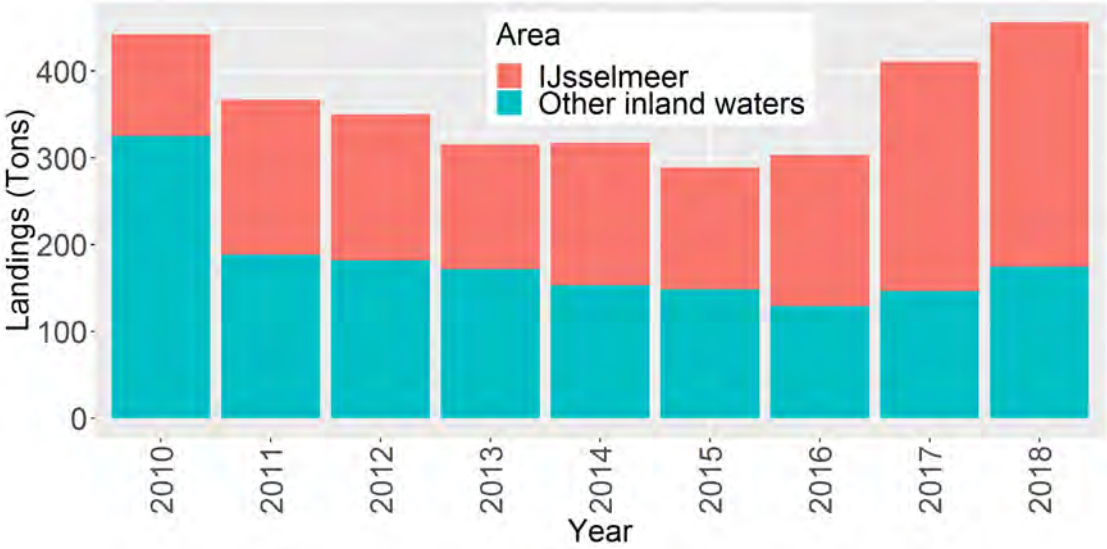

Figure 8. Time-series of landings of yellow plus silver eel combined from all inland waters based on the catch registration system. Source data: LNV.

3.1.5.2 Recreational Fishery

In 2009, an extensive Recreation Fisheries Program was started in the Netherlands, which was repeated every other year. In December 2009, 2011, 2013, 2015 and 2017, ~50 000 households were approached during a screening survey to determine the total number of recreational fishermen in the Netherlands. In the following year (2010, 2012, 2014, 2016 and 2018), 2000–2500 recreational fishermen were selected for a 12-month logbook programme. The number and weight of eel caught by recreational anglers was estimated from the logbook data (van der Hammen, 2019).

From 2010 to 2016, the estimated number of retained eel decreased from 111 tonnes to 24 tonnes. In the latest estimation only few eels were reported during the logbook survey which makes the estimates only approximate (low precision).

Table 9. Recreational Fisheries: retained and released catches of eel in numbers (and biomass when available) in the Netherlands in inland and marine areas. Only estimated numbers from angling were available (van der Hammen, 2019).

		Number (thousands)				Biomass (tonnes)			
		2010	2012	2014	2016	2010	2012	2014	2016
Retained	Marine	172	**91**	193	**55**	36	**18**	40	**14**
	Fresh water	294	313	220	**48**	75	41	30	**10**
	Sum	466	**404**	413	**103**	111	**59**	70	**24**
Released	Marine	114	**67**	247	76				
	Fresh water	862	1,517	1,936	166				
	Sum	967	**1,584**	2,183	242				
	% retained	33%	20%	16%	30%				

3.1.6 Silver eel fisheries

3.1.6.1 Commercial

There are no reliable historical data on silver eel landings available (see also paragraph 3.1.5 on yellow eel fisheries). Silver eel and yellow eel landings have therefore been combined.

Since the closed season from 1 September to 1 December (October 2009 onwards), which is during the migration period of silver eel, it is expected that the amount of silver eel landings have declined.

Since 2011, Frisian inland fishers, associated through the Frisian association of inland fishers (Friese Bond van Binnenvissers), have been experimenting with fishing quotas for eel. This approach is also known as 'decentralised eel management' (Dutch: decentraal aalbeheer). This quota is in lieu of the statutory eel fisheries system, which includes a three-month period in which no eel may be fished, which means silver eels can and will be caught by these Frisian inland fishers. In April 2018, a change in the eel management plan was accepted by the European Commission and the decentralised eel management in Friesland was added to the management plan. Frisian fishers are allowed to catch 36.6 ton annually regardless of the season.

3.2 Restocking

3.2.1 Reconstructed time-series on Stocking

No (historical) data are available with regards to origin and whether or not stocked eels were quarantined. After the implementation of the eel management plan (2009), the amount of restocked glass eels and yellow eels has been increasing (Figure 9).

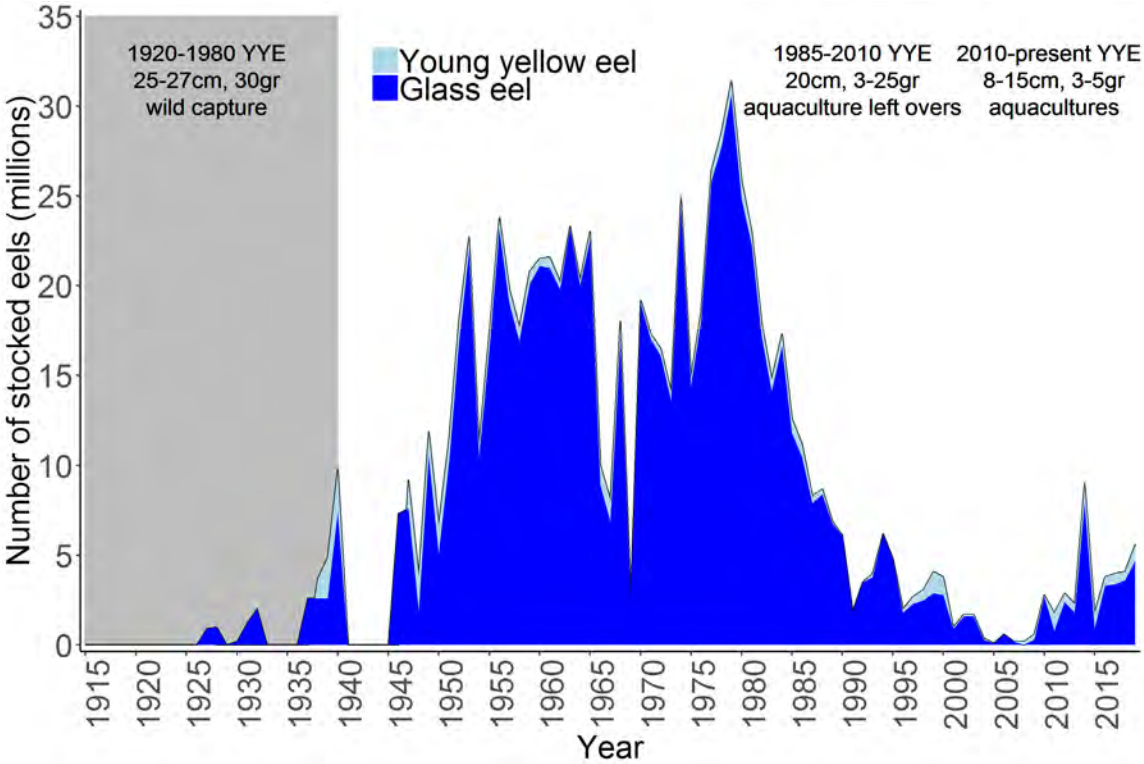

Figure 9. Overview of stocking of glass eel and young yellow eel in the Netherlands (1920–2019). Note that the average weight of stocked young yellow eel decreased from ~30g to ~3 g between 1920 and 2010. YYE = Young Yellow Eel.

3.2.2 Amount stocked

The locations and numbers of eels stocked in 2019 in the Netherlands can be found in Table 10.

Table 10. Overview of glass eel and young yellow eel stocked in the Netherlands in 2019 (Source DUPAN).

	Date	Stocking location	Origin	kg	N	N/kg
N	GLASS EEL					
1	21-03-2019	Vechtboezem	France	31	104639	3375
2	21-03-2019	Zwartemeer/ Zwartewater	France	187	627835	3357
3	21-03-2019	Markermeer	France	362	1213814	3353
4	21-03-2019	Vollenhovermeer	France	25	83711	3348
5	06-03-2019	Veluwe Randmeren	France	467	1399927	2998
6	06-03-2019	Zuidelijke Randmeren	France	313	937492	2995
7	06-03-2019	Lage Oude Veer	France	19**	60000	3238**
8	2019	Kudelstaart***	France	25	80947*	3238*
9	2019	Noordeinde***	France	15	48568*	3238*
10	2019	Giethoorn***	France	15	48568*	3238*
11	2019	Nederhors den Berg***	France	17	55044*	3238*
12	2019	Nieuwekerk aan den IJssel***	France	5	16189*	3238*
	TOTAL Glass eel			1481	4676735	
	YOUNG YELLOW EEL					
13	17-05-2019	Friesland	Glass eel from France (aquaculture in NL)	1368	450342	329
14	23-05-2019	Grevelingen	Glass eel from France (aquaculture in NL)	1024	360450	352
15	18-05-2019	Kampen (Ganzediep, Zwarte water, IJssel)	Glass eel from France (aquaculture in NL)	118**	40000	341**
	TOTAL young yellow eel			2510	850792	
	TOTAL glass eel+yellow eel			3990	5527527	

***Only KG are known, numbers and N/KG are based on averages of the other stockings.**
****Only numbers are known, KG and N/KG are based on averages of the other stockings.**
*****Locations of fishermen that bought glass eels, restocking waterbody unknown.**

3.3 Aquaculture

3.3.1 Seed supply

Table 11. Origin of glass eel used for aquaculture in the Netherlands since 2010. Numbers are rough estimates (Source DUPAN).

Year	France	Spain	England	Total (kg)
2010	4725	1890	135	6750
2011	5325	1350	100	6775
2012	5500	650	550	6700
2013	3400	250	1250	4900
2014	4400	500	300	5200
2015	5200		Few hundred*	5500
2016	5300	800	150	6250
2017	4690	900	300	5890
2018	5730	0	550	6280
2019	4340	0	1000	5340

***assuming 'a few hundred' to be 300 kg.**

3.3.1.1 Production

The production of eels through aquaculture remains relatively stable over the past decade (Figure 10).

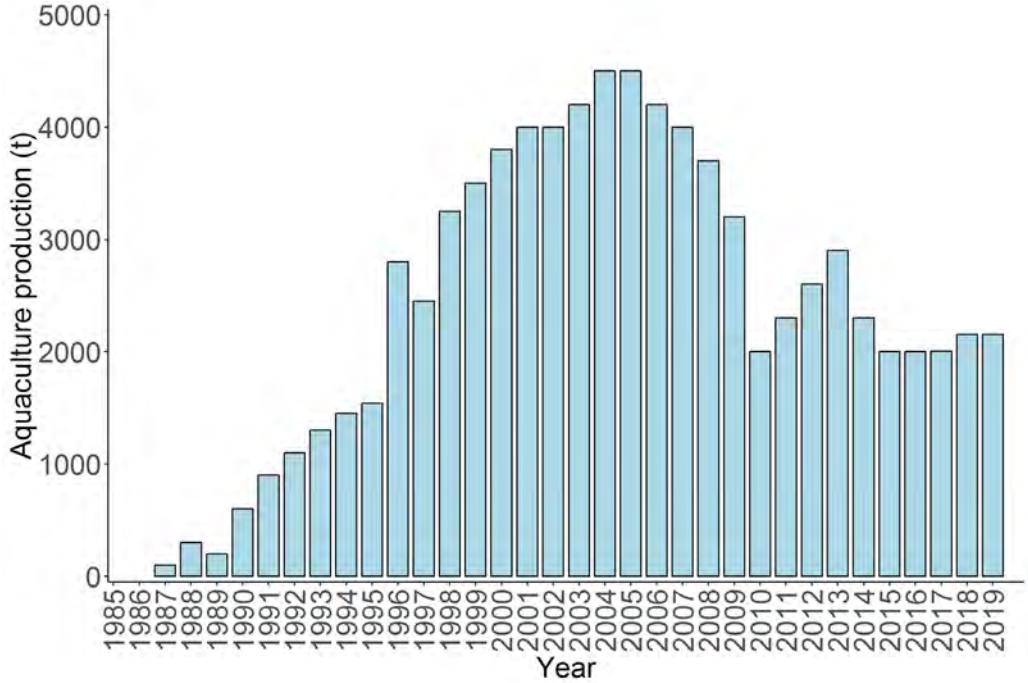

Figure 10. Trend in aquaculture production of yellow eel for consumption in the Netherlands. In 2019, the production was ~2155 t (rough estimate) (Source DUPAN).

3.4 Entrainment

A summary of the methods to estimate entrainment is given below, more information can be found in van de Wolfshaar *et al*. (2018).

A conceptual model for silver eel migration was built, based on a hierarchy of waterbodies, which may provide a reasonable description of silver eel migration in The Netherlands. In this conceptual model, silver eels are split into three groups of starting origin, according to waterbody type. These three main waterbody types correspond to the three main hierarchy levels of waterbodies in The Netherlands:

1. 1st hierarchy (termed **'polder' waterbodies**): waterbodies which are below sea level and serviced by a large number of small pumping stations with often high levels of mortality during passage. In the model, each polder is serviced by a single pumping station (i.e. no multiple pumping stations in sequence). Pumping stations of coastal polders can pump water directly into the sea, in which case the silver eels that survive the passage of these sites are directly contributing to the silver eel 'escapement' out of the Netherlands. However, for most polders, pumping stations would discharge water into a waterbody of the 2nd hierarchy in our model ('boezem' waterbodies);
2. 2nd hierarchy (termed **'boezem' waterbodies**): waterbodies such as canals, small inland lakes (such as the Frysian lakes), but also smaller streams and rivers which are either connected directly to the sea or to large nationally managed waterbodies (the 3rd hierarchy of waterbody in the model; see below) via larger pumping stations and/or sluices;
3. 3rd hierarchy (termed **'national' waterbodies**): large nationally managed waterbodies such as sections of the main rivers and large lakes. Silver eels have been found to experience low levels of mortalities during passage of most of the barriers (because these are mainly discharge sluice complexes) in these large waterbodies. The exception are the passages of hydropower plants by eels that start their migration from upstream sections of the main rivers Rhine and Meuse. Both these sections hold a substantial biomass of silver eel (van de Wolfshaar *et al*., 2018).

A key assumption in this model is that barriers within a hierarchical class, for example within polder waters, are never in sequence. Instead, sequential barrier mortality only occurs when silver eels are transferred from one hierarchical class to another, for example from polder to boezem. This approach is thought to hold true in the majority of cases. However, there are some polder waters with two boezem layers, in which polder waters are pumped into an 'inner boezem' and subsequently pumped into an 'outer boezem' (which would be the second hierarchy in the model presented here).

Given the assessed mortality and transition rates, the percentage of silver eels (out of the total starting biomass) that is estimated to die during migration is dependent only on the proportional distribution of silver eel biomass over the different hierarchies of waterbodies. Instead, the biomass of silver eels that is estimated to die during migration will be dependent on the absolute biomass of all starting silver eel.

For the parameterisation of the barrier mortality model, we use "net mortality rates" for barriers: the proportion of silver eels that ends up in front of that barrier multiplied by the proportion that dies during passage. If there is only one route available in passing a barrier, the mortality rate of this barrier can be multiplied by the number of silver eels that end up in front of the barrier. In our approach, we consider blockage (i.e. silver eels that end up at barriers but are not passing), the same as mortality, since in both cases these silver eels do not contribute to the 'escapement' of silver eel to sea. In case an alternative route for migration trough a pumping station or hydropower plant is available, such as a ship lock, sluice of fish pass, estimates of net mortality rates are typically lower than the proportion of silver eels that suffer mortality attempting to pass the pumping station or hydropower plant.

3.4.1 Mortality rates and transition from polder to boezem or the sea

Silver eel migrating from the polders to the boezem waters will encounter pumping stations. There are direct and indirect effects of pumping stations on silver eel migration. In the first place, pumping stations can cause damage and direct or delayed mortality in eel when passing through a pump. Secondly, a pumping station may function as a barrier for eel, both during upstream and downstream migration.

Pumping stations can roughly be divided into three groups: 1) water wheels, 2) Archimedes screws, and 3) pumps [centrifugal pumps (radial water flow); propeller-centrifugal pumps (radial/axial water flow), propeller pumps (axial water flow)]. Based on literature, mainly studies conducted in the Netherlands and Belgium, propeller pumps have the highest mortality (Table 12), these type of propeller pumps are the most common type used to regulate water levels.

For the 1st hierarchy 'polder waters', average densities per polder area and an overall estimate of mortality rate based on the national distribution of types of pumping stations and estimated mortality rates were used to provide an overall estimate of escapement from polders to sea, and to the 2nd hierarchy of boezem waters. From polder waters to boezem waters or to the sea: a best guess estimate of 35% mortality was used. Regionally, the starting biomass and mortality rates will be different from the average, but for the purpose of estimating a national mortality rate, this generic approach for the 1st hierarchy will largely level out.

Transition rates between the three hierarchies of waterbodies (and the sections of river upstream of the hydropower plants) are needed to complete the model. The majority of polders (except some coastal polders) are thought to have pumping stations that discharge water into the boezem rather than to the sea. We estimated (best guess) that 20% of the eel in polder waters is transferred directly from polder to sea, whereas the remainder (80%) is transferred to boezem waters where additional mortality due to barrier passage might occur.

Table 12. Calculation of the average pumping station mortality used to estimate silver eel mortality during migration.

Pump type	Proportion	Average mortality* (%)	Weighted Mortality (%)
Water wheel	0.002	0	0
Archimedes screw	0.27	12	3.2
Centrifugal pump	0.14	12	1.8
Propeller-centrifugal pump	0.05	9	0.4
Propeller pump	0.55	56	29.3
Pump Mortality (estimate used in Yellow Eel Model)			~35%

*** Mortality is % dead + 0.5 % damaged.**

3.4.2 Mortality rates from boezem waterbodies to national waterbodies, and hydropower stations

The mortality estimates for silver eel migrating from boezem to national waters are based on an inventory of the main migration barriers for silver eel migrating from the Netherlands (Winter *et al*., 2013a and 2013b), which was updated for changes and input from water boards during 2013–2017 for this evaluation study.

Given the mortalities of barriers weighted by the amount of silver eel per barrier relative to the total amount of silver eel, the overall estimated mortality is 6% for passage to the sea and 14% for passage to national waters.

3.4.3 Mortality rates from national waterbodies to sea, and hydropower stations

The approach for barrier mortality estimation for national waters is also based on the inventory of Winter *et al*. (2013a, 2013b) and updated for the period 2013–2017 as described above for the barriers in boezem waters.

Given the mortalities of barriers weighted by the amount of silver eel per barrier relative to the total amount of silver eel, the overall estimated mortality from national waters to the sea (excluding hydropower stations) is 0.5%.

3.4.4 Migration mortality

Based on the distribution and mortality estimates reported above, the model scheme can be filled with a best guess mortality scenario Figure 11.

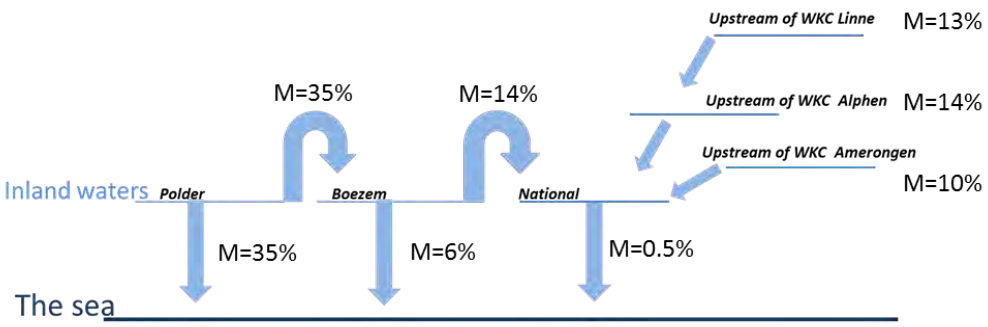

Figure 11. Migration mortality scheme, used to estimate overall migration mortality of silver eel. 'WKC' = hydropower station (Dutch: 'waterkrachtcentrale').

3.5 Habitat Quantity and Quality

General information on habitat quantity is mentioned in paragraph 3.1.2 and in Van de Wolfshaar *et al*. (2018). A summary of the impact of entrainment in the different habitats can be found in Table 5.

3.6 Other impacts

3.6.1 Assisted migration of silver eel

Since 2011, several (pilot)projects have started at migration barriers (pumping stations) to assist the migration of silver eel (programme 'Paling Over De Dijk', PODD). In 2011, 540 kg silver eel was caught and released again past barriers at four sites ('assisted migration'). In 2018, about 11 900 kg was caught and released, which is the highest amount since the start of the project (Figure 12).

However, the mortality rate of silver eel passing the selected barriers has been assessed at moderate to low (Bierman *et al.*, 2012; Winter *et al.*, 2013a). Thus, the net amount of eels saved by the assisted migration is much lower than the amount caught and released. In 2013, the barriers for silver eel were prioritised (Winter *et al.*, 2013a) to improve the selection and efficiency of assisted migration initiatives. Applying location-specific mortality rates, the net amount of 'saved' eels in 2018 was 3800 kg (Figure 12). Rates of 50% mortality were used for unknown locations (van de Wolfshaar *et al*., 2018).

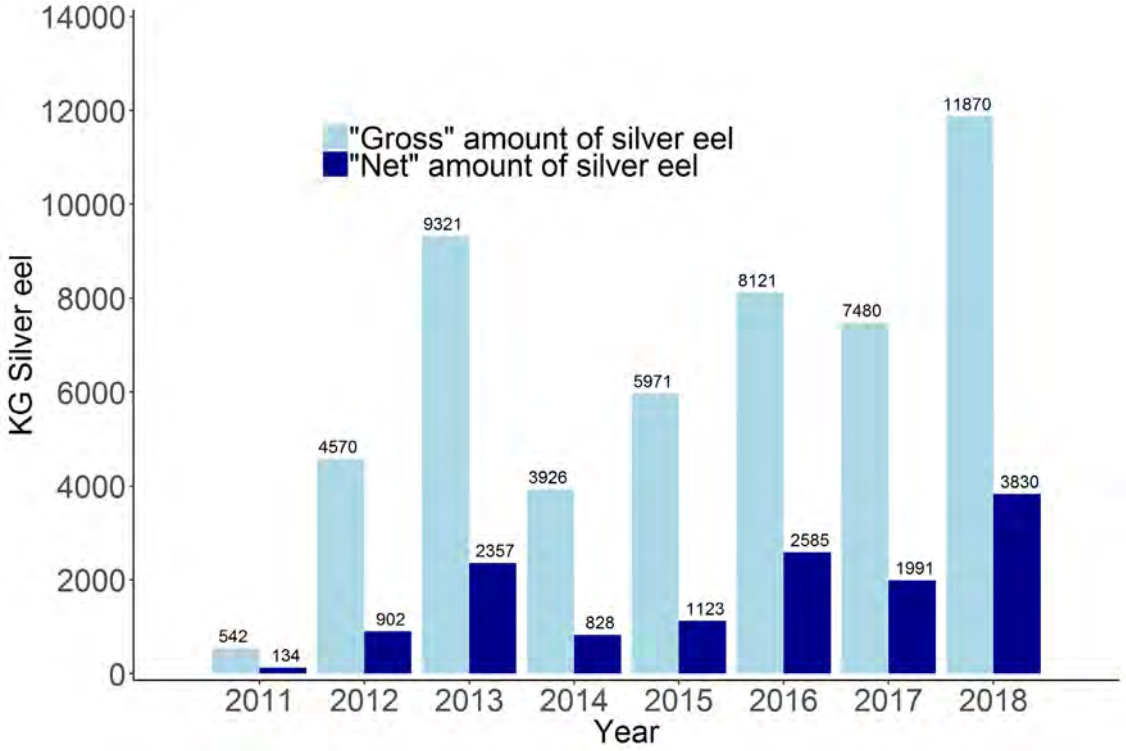

Figure 12. Overview of the "gross" and "net" amount of silver eel assisted over migration barriers in the Netherlands (2011–2018).

3.6.2 Illegal, unreported and unregulated (IUU) fishing

The task of adherence to rules and regulations pertaining to eel fishery is carried out by the Netherlands Food and Consumer Product Safety Authority (NVWA). Following indication of illegal eel fishing in 2012, they intensified their monitoring in 2013. In 2015 in total 202 fishing gears associated with illegal eel fishing were seized, this number decreased in 2016 to 80 and to 24 in 2017 (Table 13). The NVWA does not record weights of illegal catches. At the time of writing this report, the numbers of 2018 are not delivered to us by the NVWA yet.

Table 13. Overview of suspected causes of illegal fishing activities in the Netherlands (2017). Number of cases per cause per area. Weights of illegal catches are not known (Source: NVWA).

	IJsselmeer	Markermeer	Zuid-HolLand	Noord-HolLand	Friesland	Zeeland	TOTAL
1. Fishing out of the season				1			1
2. Fishing without licence	4	1	1	1			7
3. Fishing using illegal gears	2	5		1	1	7	16
4. Retention of eel below size limit							
5. Illegal selling of catches							
6. Fishing in closed areas							
TOTAL							24

4 National stock assessment

4.1 Description of Method

Methods are described in Van de Wolfshaar *et al.* (2018) and in Van der Sluis *et al*. (2016). The status of the Dutch eel population in the framework of the Dutch Eel Management Plan is assessed every three years. The latest report is Van de Wolfshaar *et al.* (2018) that describes the stock based on the years 2014–2016.

4.1.1 Data collection

Glass eel monitoring 2018				
Gear	Location	Frequency	Time	Period
liftnet (1x1 m; mesh 1x1 mm)	Den Oever	daily	8 hauls, one every hour between 22:00–5:00	~March–May
Liftnet (1x1 m; mesh 1x1 mm)	7 other locations along the coast	~weekly	~3 hauls at night time	~March–May
Glass eel detector	5 location along the coast	continuous	Continuous, emptying ~2 times a week	~March–June

Silver eel monitoring 2018				
Gear	Location	Frequency	Time	Period
Fykes (7 sites)	Rhine, Den Oever, Kornwerderzand, Noordzeekanaal, Nieuwe waterweg, Haringvliet, Maas	continuous	weekly	September–November Haringvliet in uneven years also in December, Kornwerderzand in even years also in December
Fykes (4 sites)	Waal, IJssel, Meuse, Lek	every three years (2018, 2021,2014)	weekly	September–November

Passive monitoring program: Main rivers and Lake IJsselmeer 2018			
Gear	Location	Frequency	Period
Fykes (4) (stretched mesh 18–20 mm)	Veerse Meer, Haringvliet (North Sea)	continuous	December–August
Fykes (number depends on location. (stretched mesh 18–20 mm)	7 locations in main rivers, estuaries and lakes Rhine, Den Oever, Kornwerderzand, Noordzeekanaal, Nieuwe waterweg, Haringvliet, Maas	continuous	March–May
Fykes (number depends on location. (stretched mesh 18–20 mm)	Waal, IJssel, Meuse Lek	every three years	March–May

Due to closure of the eel fishery in polluted areas, this program, which started in the 1990s, has been interrupted. Almost two thirds of the sampling locations were located in the polluted areas and sampling ceased on 1 April 2011. Only the locations Veerse Meer and Haringvliet remained. An alternative program to study diadromous fish started in 2012.

Active monitoring program: Main rivers 2018			
Gear	Location	Frequency	Period
Bottom trawl (channel; 3 m beam; 15 mm stretched mesh)	~26 waterbodies (rivers, lakes and estuaries)	10 min trawl, ~1000 m transect	spring and/or fall
Electrofishing (shore area)	22 waterbodies (rivers, lakes and estuaries	20 min, 600 m transect	spring and/or fall

4.1.1.1 Sampling commercial catches 2018

Area	Sampling frequency	No. of fishers sampled	Gear
Fryslan	Twice	2	Fykes
Hollands Noorderkwartier	Twice	2	Fykes
Rijnland	Twice	1	Fykes
Veluwe Randmeren	Twice	1	Train fyke
Noorderzijlvest	Twice	1	Fykes
Brabantse Delta	Twice	1	Train fyke
Hunze en Aa's	Twice	1	Fykes
Zuiderzeeland	Twice	1	Fykes
Stichtse Rijnlanden	Once	1	Fykes
Lake IJsselmeer	Twice	1	Train fyke
Lake IJsselmeer	Once	2	Train fyke
Lake IJsselmeer	Twice	2	Large fyke
Lake IJsselmeer	Once	3	Large fyke
Lake IJsselmeer	Twice	2	Longlines
Lake IJsselmeer	Once	1	Longlines
Lake Markermeer	Twice	1	Large fyke
Parameter		Sample details	
No. eels for length-frequency		maximum 150 eels per sample	
No. eels for biology (sex, life stage, parasites)		< 50 cm: 4 eels per 10 cm size class ≥ 50 cm: 2 eels per 10 cm size class	
Period		May–August	

4.1.2 Analysis

The national stock assessment methodology is described in Van de Wolfshaar *et al*. (2018).

4.1.2.1 Age and growth increment analysis

Since 2010, age readings have been obtained annually, which were collected from eels in different areas of the Netherlands. From 2014 onwards, ~50 otoliths were send to the Swedish University of Agricultural Sciences (SLU) in Sweden annually. The number of annuli were counted to determine the age of individuals ("crack and burn" method). Furthermore, distances between consecutive annuli were measured using image analysis software to determine growth increments.

4.1.2.2 Life stages

Life stages (yellow, silvering, silver) are visually determined based on colouration of body and fins and eye diameter. Criteria for life stages are at present not formally described.

4.1.2.3 Sex determinations

Sex is determined by macroscopic examination of the gonads.

4.1.3 Reporting

Van de Wolfshaar *et al.* (2018) report on the status of the eel population in 2005–2016.

4.1.4 Data quality issues and how they are being addressed

A summary of the data quality issues is given below, for more details see van de Wolfshaar *et al*. (2018).

4.1.4.1 Pristine silver eel biomass (B_0)

The B_0 value for inland waters in the Netherlands is set at 10 400 t. However, the value has a wide range (6500–20 250 t, inland waters B_0 = 10 400 t, range 5200–16 200 t). In addition, this range has been subject to discussion. Initially the pristine silver eel biomass (B_0) in the Netherlands, was set at 10 000–15 000 t (Klein Breteler, 2008). In a review, it was concluded that B_0 was between 6500–20 250 t (Eijsackers *et al*., 2009). However, ICES (review of the national eel management plans; ICES, 2010) did not accept all arguments of Eijsackers *et al*. (2009) and set B_0 at 13 000 t. A second review of B_0 values for the Netherlands concluded that the method to calculate B_0 was fundamentally of good quality with respect to adhering to the guidelines set by the Eel Regulation (Rabbinge *et al*., 2013).

4.1.4.2 Anthropogenic mortality (B_{best}, $B_{current}$ and *LAM*)

The estimates for lifetime anthropogenic mortality (*LAM*) is set by the values of B_{best} and $B_{current}$. These values are uncertain due to the following main assumptions that influence $B_{current}$:

- the efficiency of the electrofishing gear;
- distribution of eel over the surface of a waterbody in the static spatial population model;
- assumptions of *F* when estimating eel populations using the demographic population model for some of the larger lakes.

4.1.4.3 Unquantified sources of anthropogenic mortality

The estimated lifetime anthropogenic mortality is most likely an *underestimate* of the true anthropogenic mortality because some sources of mortality have not been quantified:

- Poaching;
- yellow eel mortality in hydropower plants and pumping stations;
- impact of (human-induced) viruses, parasites and pollution.

4.2 Trends in Assessment results

Current biomass of escaping silver eel ($B_{current}$)

Between 2005–2007 and 2008–2013, there was a modest decrease in the biomass of escaping silver eel while between 2008–2013 and 2014–2016 there was a modest increase ($B_{current}$, Table 14). Large differences between years in biomass were not expected as current silver eel escapement has largely been determined by processes (recruitment, anthropogenic mortality) that occurred in

the previous 5–15 years. Furthermore, an increase in glass eel recruitment will, at the earliest, result in an increase of silver eel after 5–15 years, and glass eel recruitment has not significantly increased after the implementation of the EMP in 2009. Moreover, the total silver eel biomass depends not only on the status of the Dutch part of the eel stock, but also on the stock status in the other Member States.

Current best possible biomass (B_{best})

The current best possible biomass decreases between 2005–2007 and 2008–2013, while between 2008–2013 and 2014–2016 there was a modest increase (B_{best}, Table 14).

Lifetime Anthropogenic Mortality (LAM)

A reduction in Lifetime Anthropogenic Mortality (LAM) can be achieved by reducing fishing mortality and barrier mortality. A reduction in anthropogenic mortality is therefore the direct result of the measures taken by a Member State. In the Netherlands, the implementation of the EMP has resulted in a reduction in LAM between 2005 and 2016 from 81% to 48%. In each three-year period, a reduction was achieved (Table 14). This reduction was mainly the result of a decrease in fishery mortality, both commercial and recreational: retained catches (landings) of both commercial and recreational fishery strongly decreased between 2005–2007 and 2014–2016.

Table 14. Stock indicators used to evaluate the impact of the EMP on the biomass of escaping silver eel (horizontal axis modified precautionary diagram) and anthropogenic mortality (vertical axis modified precautionary diagram).

Stock Indicator	2005–2007	2008–2010	2011–2013	2014–2016
B_0^*	10400 t	10400 t	10400 t	10400 t
$B_{current}$	1049 t	816 t	867 t	1365 t
B_{best}	5619 t	2445 t	2123 t	2547 t
% escaping Silver Eel *(100* $B_{current}/B_0$)*	10%	8%	8%	13%
LAM	81%	67%	59%	48%

* **Excluding coastal waters (2600 t).**

5 Other data collection for eel

5.1 Yellow eel abundance surveys

5.1.1 Recreational

No data available.

5.1.2 Fishery-independent

One of the few long time-series for eel is the fyke monitoring at NIOZ (Den Burg, Texel; van der Meer *et al.*, 2011) (Figure 13). This dataset shows a familiar pattern of a steep decline in abundance since the 1980s.

In the past, almost all catches were yellow eel, based on their length. More recently, the catches also comprise silver eel (source: NIOZ). In 2018, four eels were caught within a period of 119 fyke days.

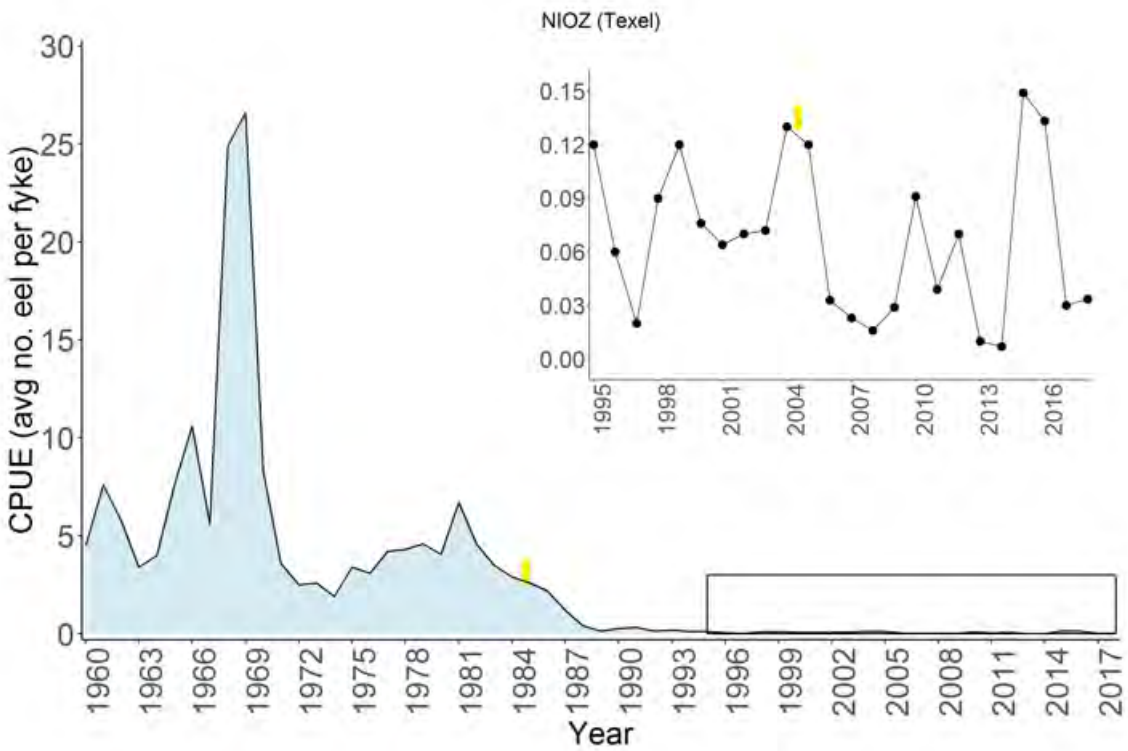

Figure 13. Time-series of the mean catch per fyke (numbers) of yellow eel at NIOZ 1960-2018 (data Van der Meer *et al.*, 2011 and NIOZ).

5.1.2.1 Lake IJsselmeer/Markermeer (active gear)

Figure 14 presents the trends in CPUE for the annual (yellow) eel surveys in Lake IJsselmeer (25 sites) and Lake Markermeer (15 sites), using the electrified trawl. Weight of the eel catches in in 2017 and 2018 are relatively high compared to the previous decade. The number of eels however, shows a slight increase but remains low, indicating an increase of (larger) females in the lakes.

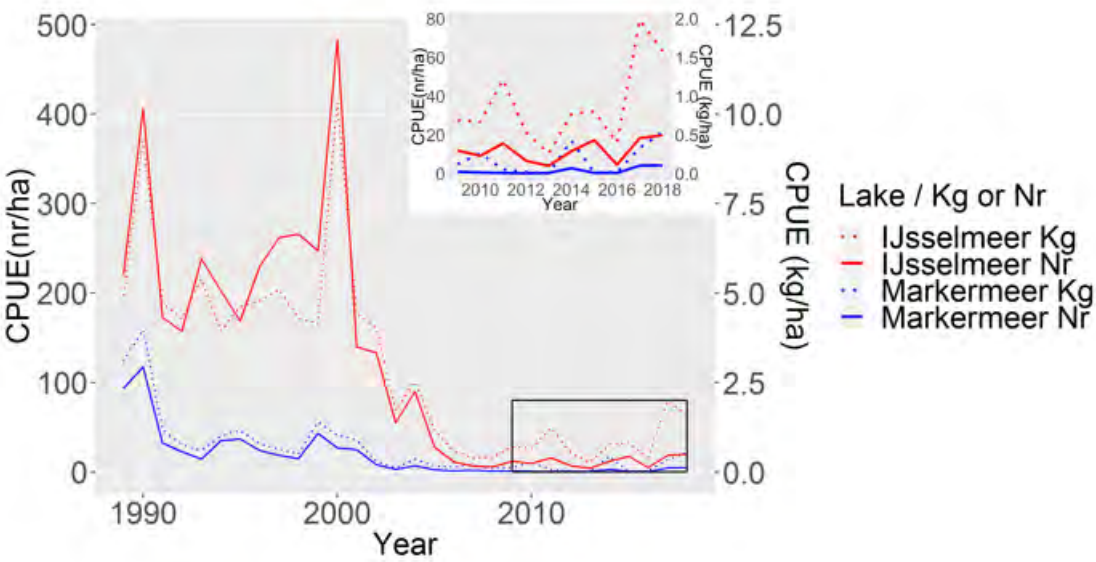

Figure 14. CPUE trends in Lake IJsselmeer stock surveys (N/ha and kg/ha), using the electrified trawl. Note: The northern and southern compartments (IJsselmeer and Markermeer resp.) have been separated by a dyke since 1976 (data: Wageningen Marine Research).

5.1.2.2 Main rivers (active gear)

A selection of data collected from 1999–2017 was made over five so-called "VBC-areas" (Figure 15). VBC areas were selected when annual monitoring data was collected for 12 years or more. Figure 16 shows the trends in CPUE for the annual (yellow) eel surveys in these five VBC areas collected by electrofishing. CPUEs tend to fluctuate strongly over the past two decades. All VBC areas show an increase either in 2015, 2016 or in 2017 after which all VBC areas show a sharp decrease in catches in 2018.

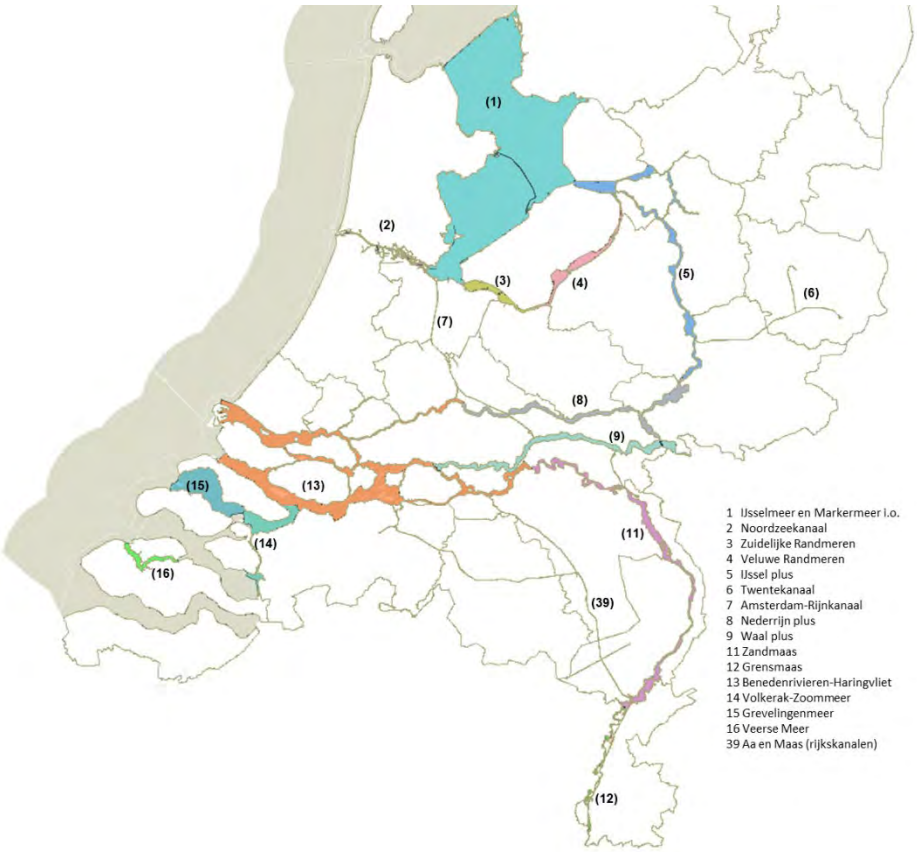

Figure 15. Map of VBC areas in the Netherlands.

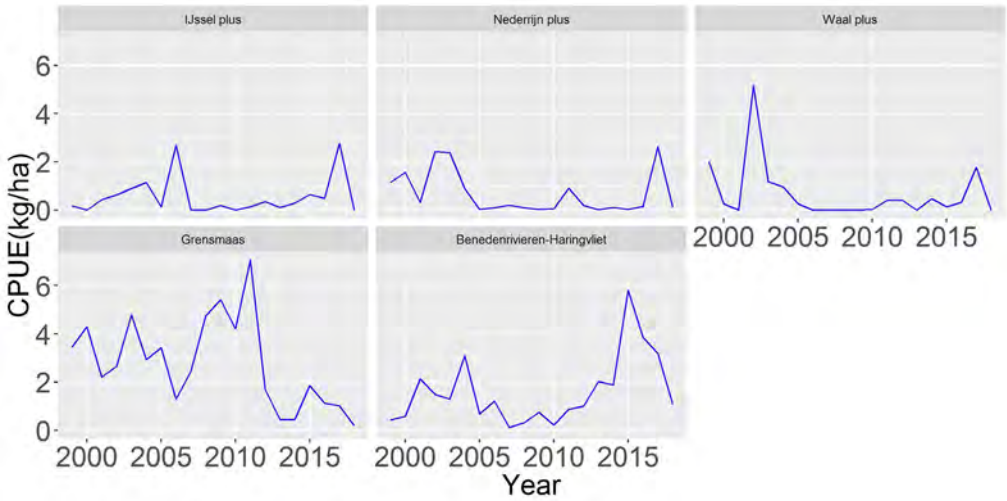

Figure 16. CPUE trends in five VBC areas (kg/ha), sampled by electrofishing (data: Wageningen Marine Research).

5.1.2.3 Main rivers (passive gear)

The Silver Eel Index in the Netherlands is calculated by using a survey programme that started in 2012. In cooperation with commercial fishermen the abundance of migrating silver eel is monitored on five exit points (Kornwerderzand sluices, Den Oever sluices, North Sea Canal, New Waterway channel, Haringvliet-West inlet) and two entry points for migratory fish (River Rhine and River Meuse) during spring and autumn. In 2015 and 2018, four extra locations were monitored but not shown in Figure 17. Figure 17 shows that both eel biomass and numbers fluctuate strongly on a yearly basis. Most eels are caught at the Kornwerderzand sluices. In the last three years, the numbers have increased at this location while the biomass decreased, indicating a

larger number of smaller individuals. At the other locations, however, increased and decreases of biomass and number are in the same direction.

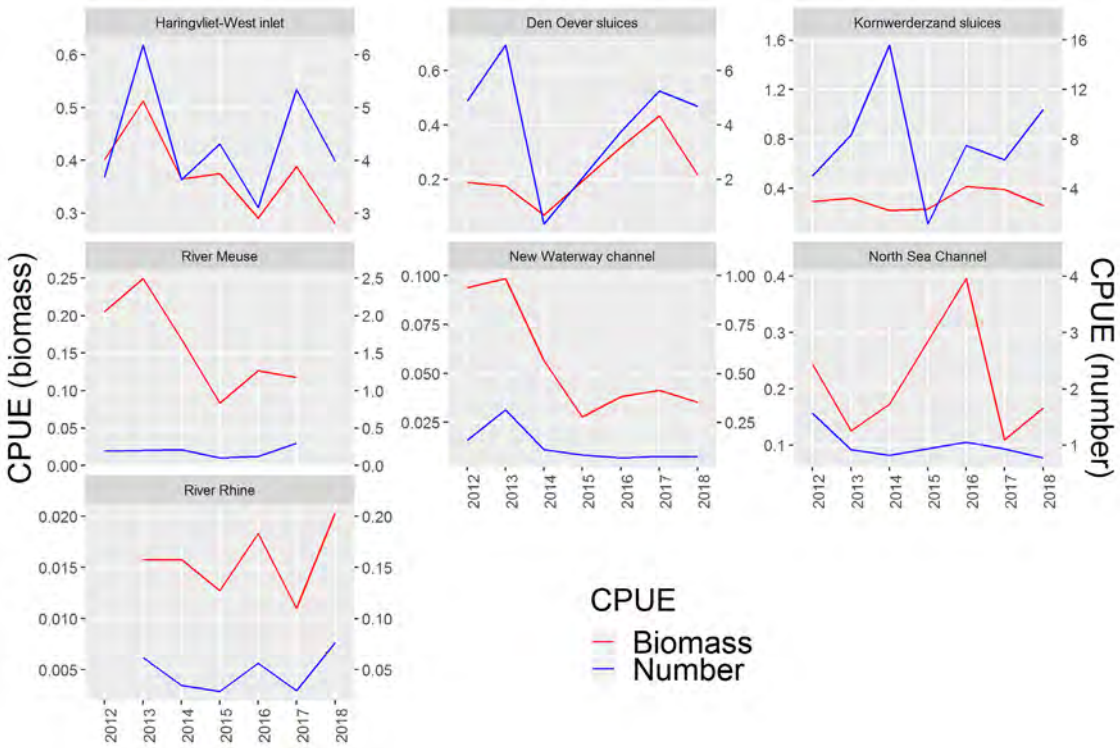

Figure 17. CPUE of eel (biomass and number per fyke day) caught during the diadromous fish monitoring per catch location. Data is missing for the River Rhine in 2012, for the North Sea Channel in 2015 and for the River Meuse in 2018.

5.1.2.4 Coastal waters (active gear)

The number of eels caught in a coastal survey (Demersal Young Fish Survey) is presented in Figure 18. Until the mid-1980s, considerable catches of eel were observed, after which a gradual decrease was observed. A more elaborate statistical analysis of the abundance and length composition of the eel stock in coastal waters is presented in Dekker (2009). Only a few eels are caught in the Wadden Sea in the past few years.

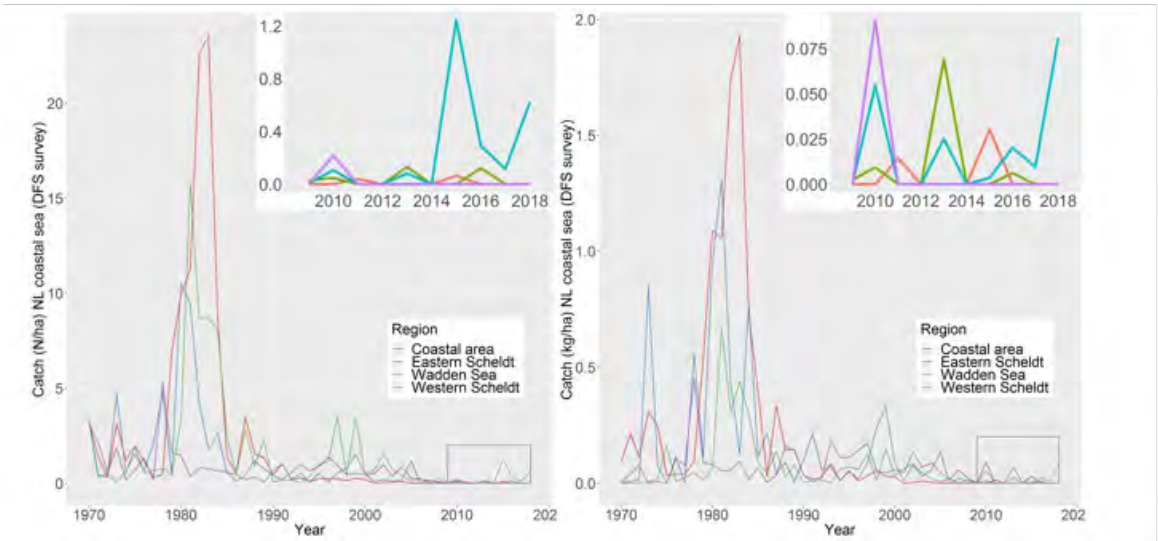

Figure 18. Trends in coastal survey catch 1970–2018. Left graph: n/ha; right graph: kg/ha. Most of the Wadden Sea belongs to RBD Rhine; Eastern Scheldt is mixed RBD Scheldt and Meuse; Western Scheldt belongs to RBD Scheldt (with an extra inflow from Meuse), the coastal area belongs to RBD Rhine (data: Wageningen Marine Research).

5.2 Silver eel escapement surveys

See Section 5.1.2.3

5.3 Life-history parameters

See van de Wolfshaar *et al*., 2018.

5.4 Diseases, Parasites and Pathogens or Contaminants

The swimbladder nematode *Anguillicoloides crassus* was introduced from Southeast Asia in wild stocks of European eel in The Netherlands in the early 1980s. The market sampling for Lake IJsselmeer collects information on eels showing *Anguillicoloides crassus* infection based on inspection of the swimbladder by the naked eye. We scored an infection as 'present' when either we observed one or more *Anguillicoloides crassus* or a thickened swimbladder. As part of the extended market sampling program in 2009, data on *Anguillicoloides* infection rates have since also been collected in two other areas (Friesland and Rivers), and since 2011 the market sampling was conducted in most of the Netherlands.

Following the initial breakout in the late 1980s, infection rates in Lake IJsselmeer have been stable around 50%. Over the past years, infection rates appear to decrease for all areas, but strongly fluctuates per year with an increase in 2018 for all areas except Friesland (the area that showed an increase in 2017, Table 15, Figure 19).

Table 15. Infection rates of eels (2010–2018) with 'Anguillicoloides crassus', in the Netherlands. Median infection rates of all sampled locations.

	Fryslan		Lake Jsselmeer		Lake Markermeer		Rest NL	
	N eels	N infected (% infected)	N eels	N infected (% infected)	N eels	N infected (% infected)	N eels	N infected (% infected)
2010	509	232(46%)	375	188(50%)	225	108(48%)	511	258(50%)
2011	107	40(37%)	293	127(43%)	104	35(34%)	583	231(40%)
2012	133	44(33%)	320	170(53%)	253	95(38%)	517	186(36%)
2013	17	8(47%)	159	88(55%)	93	41(44%)	283	106(37%)
2014	49	31(63%)	202	100(50%)	46	12(26%)	321	127(40%)
2015	61	24(39%)	267	111(42%)	nc	nc	297	112(38%)
2016	65	14(22%)	260	89(34%)	77	27(35%)	240	70(29%)
2017	74	34(46%)	149	31(21%)	151	25(17%)	272	70(26%)
2018	85	22(26%)	244	78(32%)	49	17(35%)	285	84(29%)

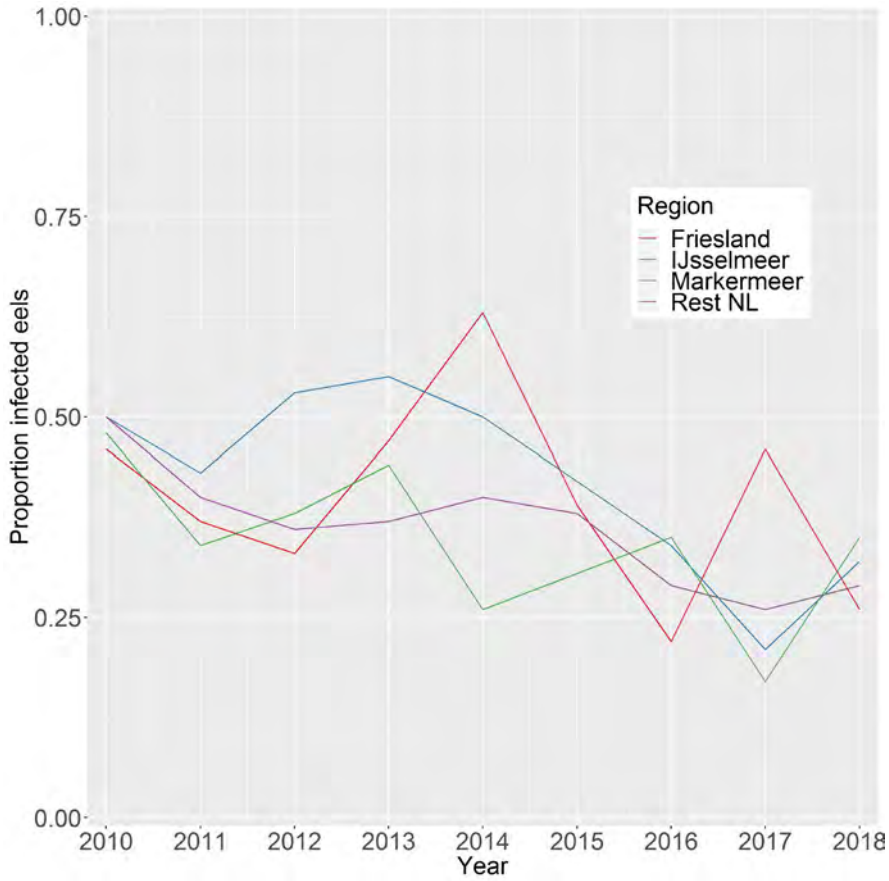

Figure 19. Proportion eels infected with *Anguillicoloides crassus* per region in the Netherlands.

5.5 Contaminants

In 2018, 20 locations were sampled to assess contaminant levels (sum TEQ and sum non-dioxin-like PCBs) in eel (Table 16). TEQ=Toxic Equivalent: sum of dioxines, furanes and dioxine-like PCBs. Eel samples of length class 30–40 cm consisted of about 25 individuals and eel samples of the predefined length class 53–75 cm consisted of approximately 15 individuals. Filets of the small eels were pooled (same mass per eel); for the large eels, the mass of filet per eel used is determined by the size of the eel. In this way, the pooled sample is a proper representation of the eel composition in the Dutch waters (determined by monitoring the eel catch of fishers).

Contaminant concentrations are always higher in larger eel than in smaller eel from the same locations. As in previous years, several samples had contaminant levels above the revised regulatory limits of 2012 set by the European Commission (10 pg/g sum TEQ and 350 ng/g sum Non-dioxin-like PCBs[4], plus 10% uncertainty, Table 16). All locations that did have eels with a concentration of Sum TEQ or Sum Non-dioxin-like PCBs above the regulatory levels were fed (directly or indirectly) by the rivers Rhine (IJssel, Lek) and Meuse.

Since 1978/1979, several locations have been monitored annually for PCBs. The levels for PCB 153 are shown in Figure 20. Concentrations in 2018 were about similar to those in previous years for Hollandsch Diep and Lake IJsselmeer (no data for other rivers within the 30–40 cm size class). Decrease of PCB-contamination occurs very slowly, if any. As the number of small eels is very low on some of the trend locations, the number of locations with data for small eels decreases. Therefore, large eels (53–76 cm) are monitored on a yearly basis at eight different locations since

[4] Sum of 6 PCBs including PCB153. These are non-toxic indicator PCBs that can be measured easily.

2016. Figure 21 shows the sum TEQ, sum non-dioxin-like PCBs and PCB153 of these larger eels from 2016 onwards. After an increase in both sum TEQ and non-dioxin-like PCBs in 2017, concentrations in 2018 are similar to those of 2016.

Table 16. Sum-TEQ, sum Non-dioxin-like PCBs, and PBC-153 in eel (2018) (data: Wageningen Marine Research and RIKILT). PCB-153 is plotted in Figure 20. Values of Sum-TEQ above the regulatory limit of 11 pg/g (10+10%*10) and of Sum-ndl-PCB above the regulatory limit of 330 ng/g (300+10%*300) are indicated in bold and grey.

Nr	Location	Size (cm)	Lipid level (%)	Sum-TEQ	Sum-ndl-PCB	PCB 153
1	Hollands Diep	>53	22.3	23.0	914	438
	Hollands Diep	30–40	6.1	6.1	274	130
2	IJssel, Olst	>53	16.3	18.8	538	231
3	Lek, Culemborg	>53	19.5	19.6	654	278
4	Maas, Eijsden	>53	12.5	12.4	976	396
5	Rijn, Lobith	>53	19.1	24.1	735	308
6	Waal, Tiel	>53	20.3	18.4	561	235
7	Volkerak, Volkeraksluizen	>53	17.2	12.5	312	140
	Volkerak, Volkeraksluizen	30–40	4.5	3.2	114	52.9
8	Volkerak, Steenbergen	>53	18.6	7.1	164	79.3
9	Twentekanaal, Goor	>53	16.5	5.6	118	50.7
10	Lauwersmeer	>53	15.4	3.5	54.2	26.9
11	Ketelmeer, IJsseloog	>53	20.2	21.3	830	424
12	IJsselmeer, 500–1000 meter from Ketelmeer	>53	21.7	14.5	399	174
13	IJsselmeer, Enkhuizen	>53	16.1	6.6	78.2	36.9
14	IJsselmeer, Lemmer	>53	19.7	3.6	54.7	25.4
15	IJsselmeer, Makkum	>53	16.7	3.2	38.2	18.2
16	IJsselmeer, Medemblik	>53	16.7	3.6	48.2	23
	IJsselmeer, Medemblik	30–40	5.5	2.0	27.0	12.9
17	IJmeer, Durgerdam	>53	16.6	2.7	44.5	19.6
18	Zoommeer	>53	16.7	4.6	75.3	37.4
19	Zwarte meer	>53	16.4	4.0	82.1	37.4
20	Ramsgeul, east of Ramspolbrug	>53	11.3	7.6	191	86.4

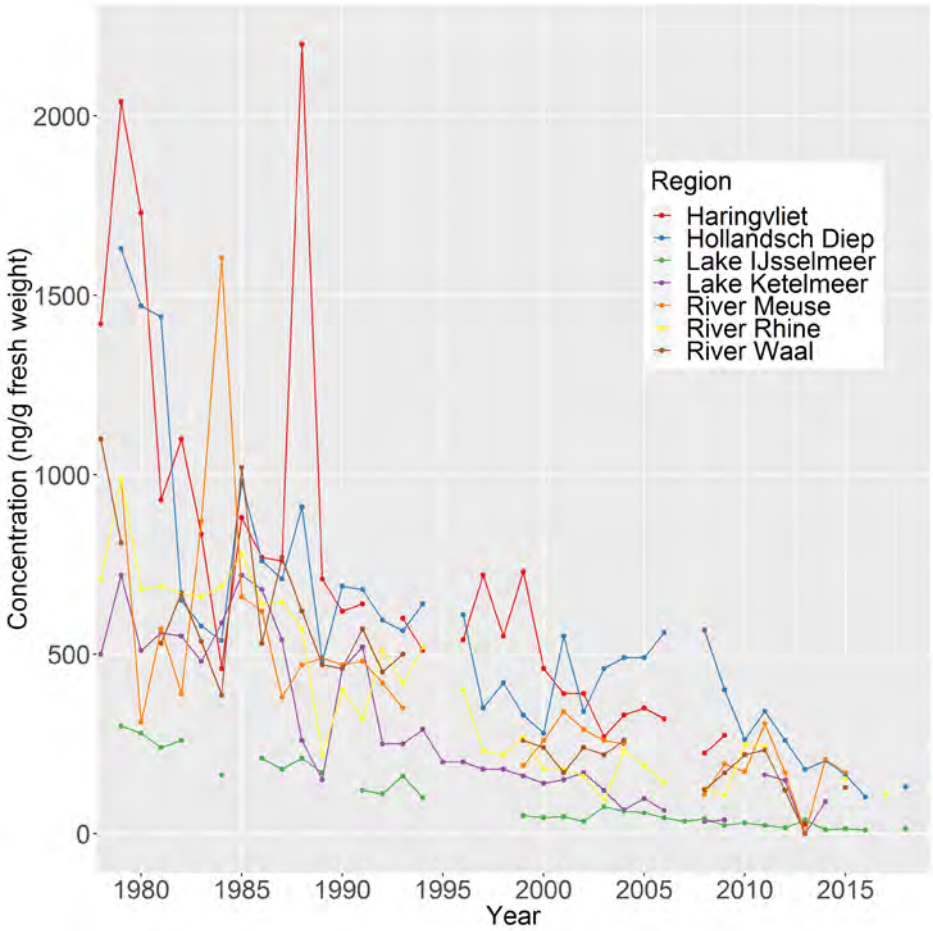

Figure 20. Trend in PBC-153 in 30–40 cm eel (1978–2018). Only data for two locations for this size class are available for 2018 (Hollandsch Diep and Lake IJsselmeer), see Table 16. Only consecutive years are connected with a line (data: Wageningen Marine Research and Wageningen Food Safety Research).

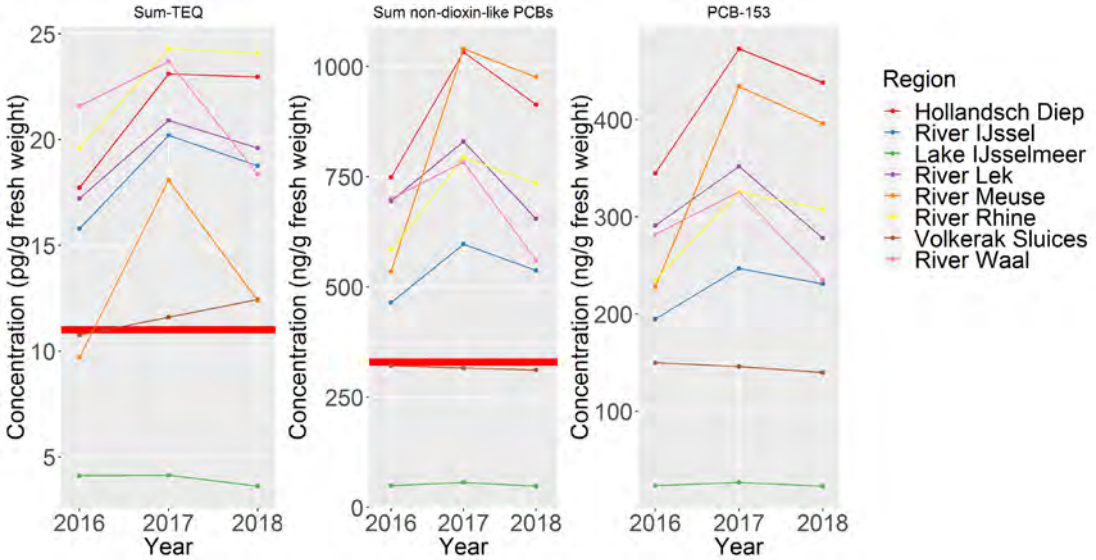

Figure 21. Trends in sum TEQ, sum non-dioxin-like PCBs and PCB153 of eels between 53–76 cm. The red horizontal lines indicate the regulatory limits including 10% uncertainty (11 for Sum-TEQ and 330 for sum non-dioxin-like PCBs). Data: Wageningen Marine Research and Wageningen Food Safety Research.

5.6 Predators

Predation of eel by cormorants (*Phalacrocorax carbo*) is much disputed amongst eel fishermen and bird protectors. The number of cormorant breeding pairs increased rapidly until the early 1990s, then stabilised and even decreased in recent years (Figure 22, Figure 23). For Lake IJsselmeer, food consumption has been well quantified (van Rijn and van Eerden, 2001; van Rijn, 2004); eel constitutes a minor fraction of the diet of cormorants. In other waters, neither the abundance, nor the food consumption is accurately known.

Figure 22. Natura 2000 areas with cormorant breeding colonies adjacent to the IJsselmeer and Markermeer: (72) IJsselmeer (73) Markermeer & IJmeer (78) Oostvaarderplassen (79) Lepelaarsplassen (94) Naardermeer.

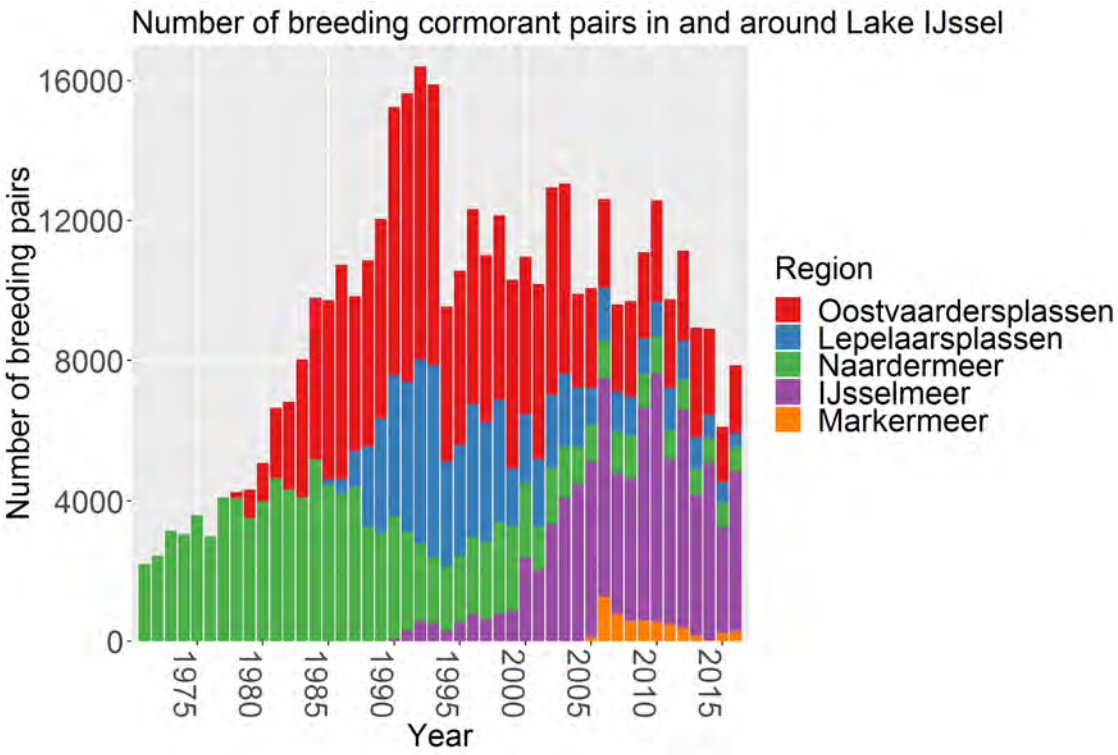

Figure 23. Trends in the number of breeding pairs of cormorants (*Phalacrocorax carbo*) in and around Lake IJsselmeer/Markermeer (Source: Netwerk Ecologische Monitoring, Sovon & CBS) (1980–2017).

6 New Information

Glass eel detectors

Due to the low catchability of glass eels with lift nets and because it is difficult to find volunteers to do the sampling, sampling with glass eel detectors has been carried out at the ICES locations (Den Oever, Katwijk, Stellendam, Lauwersoog and IJmuiden). Monitoring with glass eel detectors is continuous, so the effort is the same at all locations. In addition, much more glass eels are caught compared to the lift net sampling, which gives a higher precision. The lift net sampling must run for at least three years at the same time as the new sampling in order to properly calibrate the new sampling. The new sampling with glass eel detectors will be evaluated and it will be examined whether this can replace the regular lift net sampling. It is expected that, after a few overlapping years, the lift net sampling will no longer be necessary. The 2019 data from the glass eel detectors have not been analysed yet.

Two major improvements in terms of eel migration possibilities have been/will be implemented.

The Haringvliet sluices separate the North Sea and the freshwater inlet "Haringvliet" since 1970. The Haringvliet is an important estuary of the Rhine-Meuse delta. In order to improve the ecological situation in the rivers Meuse and Rhine, several sluices are officially opened on 15th November 2018. This allows the return of brackish water and will partly restore the main route for migrating fish (especially salmonids). In addition, migrating (glass) eels might benefit from this opening as well. Because of the drought in the summer of 2018, only one sluice was actually opened, which occurred on 16th January 2019. The sluices will be closed during the period of low river discharges (September–October) which is concurrent with the silver eel migration to the sea, indicating that this measure might be more beneficial to glass eel than silver eel migration. In addition, Winter and Bierman (2010) have shown that silver eels usually make use of the lock at the Haringvliet sluices for migrating to the sea (Griffioen *et al*., 2018).

The Afsluitdijk is a hard barrier (dyke) between the salty Wadden Sea and the fresh IJsselmeer. There are two openings: the Stevin locks at Den Oever and the Lorentz locks at Kornwerderzand. However, these locks only allow large amounts of fresh water from the IJsselmeer into the Wadden Sea and not the other way around. In addition, the current is much too strong for most species of migratory fish to swim against. As a solution, a "Fish Migration River" (an opening in the Afsluitdijk) will be constructed in 2020–2023 so that migratory fish can swim from fresh to salt water and vice versa. Especially glass eels might benefit from the tide current created by the Fish Migration River.

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Report on the eel stock, fishery and other impacts in Norway, 2018–2019

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Martin Ohldieck, Institute of Marine Research

1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

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
2017	NO_ToT	24600	No data	276600	279800	No data	0.014	No data	No data
2018	NO_TOT	24600	No data	302000	304000	No data	0.006	No data	No data

Key:
EMU_code = Eel Management Unit code (see Table 2 for list of codes); 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.

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.

The only available time-series of elvers is from a trap at the mouth of the River Imsa in south-western Norway (58°50′ N, 5°58′ E) (Figures 1 and 2, Tables 1, 2 and 3). Staff at the Norwegian Institute for Nature Research (NINA) Research Station at Ims have been trapping and recording upstream migration of elvers annually since 1975. There is a wolf trap across the river at this site, collecting all downstream migrating fish as well. A few elvers may be able to migrate upstream at this site without being trapped, but probably not in large numbers. Larger elvers (>3 mm diameter) are counted, whereas smaller ones are measured in litres, with the assumption that there are 2000 elvers per litre. This assumption should have been checked. There should also have been a control check of the historical data, but still, the quality of the dataseries seems good. It should be noted that in Imsa, recruits migrating upstream are not true glass eel, but have already achieved a brown colour, and are here therefore termed elvers (true transparent glass eels do occur in Norway and were collected in 2014 for a population genetics study).

Figure 1. Map of Norway showing the location of the eel monitoring sites River Imsa and Skagerrak coast.

2 Overview of the national stock and its management

2.1 Describe the eel stock and its management

Durif and Skiftesvik, 2018 (in Norwegian) summarizes the monitoring program started in 2017.

2.2 Significant changes since last report

No changes.

3 Impacts on the national stock

3.1 Fisheries

3.1.1 Glass eel fisheries

No glass eel fisheries.

3.1.2 Yellow eel fisheries

Data are in the data spreadsheet.

3.1.3 Silver eel fisheries

There are no silver eel fisheries.

3.2 Restocking

There is no restocking.

3.3 Aquaculture

There is no aquaculture.

3.4 Entrainment

Approximately one third of the water covered areas are influenced by hydropower development. There are between 600 and 700 hydropower stations with an installed effect larger than 1 MW in operation. Effects by hydropower development on eel and eel distribution have not been studied or quantified.

3.5 Habitat Quantity and Quality

Norway has abundant rivers and lakes, and 6% of the total area of 323 802 km^2 is covered by freshwater. There are 144 river systems with a catchment area ≥200 km^2.

Eels is present everywhere along the Norwegian coastline. It's also been registered inland, in every one of Norway's administrative regions (Thorstad *et al.*, 2010). Eel fisheries were traditionally located in southern Norway (Skagerrak coast). However, there have also been eel fishers in the western and central part of Norway. These fishers operate in saltwater but mostly in fjords and wind protected areas.

The analysis of telemetry data obtained on 11 eels in the sea in southern Norway (Arendal) shows that eels residing in the marine area occupy move at depths between 2 and 6 meters. Their home range varied between 2 to 5.6 km^2 (Durif *et al.*, in preparation).

In Norway, the landscape is quickly elevated when leaving the coast. This limits the ascension of eels high up into the watersheds. That is, 63% of the eels were registered less than 10 km from the coastline. 50% of the lakes where eel is documented are located 50 meters above sea level.

Overall, the eel density and carrying capacity of habitats in fresh- and saltwater in Norway is poorly known.

3.6 Other impacts

Acidification has caused the loss or reduction of many Atlantic salmon (*Salmo salar* L.) populations in southern Norway, and some rivers are still severely affected by chronic or episodic acid water. The areas affected by acidification have likely been among the most important areas for eel in Norway. Based on surveys in 13 rivers that are now limed, it seems that occurrence and density of eel was reduced due to acidification (Thorstad *et al*., 2010; Larsen *et al*., 2014). Densities of eel increased more than four-fold after liming when compared with pre-liming levels.

4 National stock assessment

4.1 Description of Method

Durif and Skiftesvik 2018 (in Norwegian) summarizes the monitoring program started in 2017.

4.1.1 Data collection

Eel densities (in number of eels per length of coastline) are based on mark–recapture experiments in two locations (western and southern Norway). Available habitat is calculated by GIS taking the whole coastline.

4.1.2 Analysis

Methods are described in Durif and Skiftesvik, 2018.

4.1.3 Reporting

The results are reported to the Norwegian Directorate of Fisheries (last year in 2019).

4.1.4 Data quality issues and how they are being addressed

No available data.

4.2 Trends in Assessment results

We only have stock indicators for two consecutive years (2017–2018).

5 Other data collection for eel

5.1 Yellow eel abundance surveys

The Skagerrak beach seine surveys data from Norway constitute the longest non-fishery dependent set of data. It is also the only potential time-series on the subpopulation of marine eels. This unique monitoring programm was initiated at the Norwegian Skagerrak coast (southern Norway).

The first hauls of the Skagerrak monitoring programm were conducted in 1904, and during the following years, new sampling stations were added, and a standard routine for the hauls was developed. Approximately 130 stations are sampled in 20 different areas. All hauls are taken at the same season (autumn) and always during daytime. Based on the initial results from these hauls, the monitoring program was established and reached its present form in 1919. The catching method is not ideal for eels (close to the shore, in daylight) and the number of eels caught per year is less than 100. Yet, the time-series definitely shows a reliable trend, which is much like the other trends in the rest of Europe (Durif *et al*., 2011). For each year, we calculate the number of eels per number of hauls.

Some of the eels have been measured since 1993, but not very precisely. The stage is not determined but it is mostly yellow eels.

5.2 Silver eel escapement surveys

No available data.

5.3 Life-history parameters

Age and silvering stage available for around 1000 eels. Most of the data are from Imsa.

Silver stage is evaluated using Durif *et al*. (2005) wherever eye and fin measurements are available.

5.4 Diseases, Parasites and Pathogens or Contaminants

Eels caught with fyke nets were sampled in southern Norway (Flødevigen and Grimstad).

year	Number of eels without Anguillicola	Number of eels with Anguillicola	% of eels with Anguillicola
2016	101	22	18%
2017	86	20	19%
2018			
Freshwater	28	27	49%
Saltwater	74	3	4%

6 New Information

Nothing to report.

7 References

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Report on the eel stock, fishery and other impacts, in Poland

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Reporting Period: This report was completed in August 2019, and contains data up to 2018.

1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

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
2011	PL_Oder	253400	1426000	87000	150000	15	1.07	0.51	1.58
2011	PL_Vist	184000	1386000	59000	125000	11	1.55	0.8	2.35
2012	PL_Oder	253400	1426000	75000	150000	13	0.94	0.51	1.46
2012	PL_Vist	184000	1386000	46000	125000	8	1.74	0.8	2.54
2013	PL_Oder	253400	1426000	60000	150000	11	1.4	0.51	1.91
2013	PL_Vist	184000	1386000	38000	125000	7	1.62	0.8	2.42
2014	PL_Oder	253400	1426000	51000	150000	9	1.15	0.51	1.66
2014	PL_Vist	184000	1386000	24000	125000	4	1.46	0.8	2.26
2015	PL_Oder	253400	1426000	71000	150000	12	1.12	0.51	1.63
2015	PL_Vist	184000	1386000	25000	125000	4	1.23	0.8	2.03
2016	PL_Oder	253400	1426000	52000	150000	9	1.17	0.51	1.69
2016	PL_Vist	184000	1386000	23000	125000	4	1.39	0.8	2.19
2017	PL_Oder	253400	1426000	41000	150000	7	1.23	0.51	1.74
2017	PL_Vist	184000	1386000	18000	125000	3	1.21	0.8	2.00

Key:

EMU_code = Eel Management Unit code (see Table 2 for list of codes); 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.

1.2 Recruitment time-series

Data from Polish rivers are not used by WGEEL to determine the level of natural recruitment. The decreasing number of glass eel reaching Europe and intense catches of them suggest that currently far fewer fish are ascending the rivers of the southern Baltic than did so in the past. Additionally, their further migration in rivers is significantly hampered by river degradation and barriers. The vast majority of lakes in Poland that are primary eel production areas are inaccessible to ascending eels.

Since 2012, Poland has been monitoring ascending eels on selected rivers. The data obtained from the traps permit determining if, when, and which eel arrive at trap locations. However, they do not permit determining the absolute number of ascending eel and provide only highly speculative estimates, but they can provide location-specific indicators of migration intensity.

Figure 1. Eel trap located on the Slupia river.

2 Overview of the national stock and its management

2.1 Describe the eel stock and its management

Eel fisheries in Poland is conducted in lakes, rivers, coastal open waters, and two brackish water basins; the Szczecin and Vistula lagoons. Part of the Szczecin Lagoon belongs to Germany, while part of the Vistula Lagoon belongs to Russia. Inland and coastal fisheries target silver and yellow eel, but no data on the shares of these forms in the catches are available. The total area of inland lakes and reservoirs exceeding 50 ha is 2293 km^2. Dams in the Vistula and Oder rivers and in many of their tributaries prevent migrations of eel and other fish species.

Eel fisheries has a long tradition in Poland. Prior to World War II it was conducted mainly in inland waters because the short length of coastline within Polish borders did not provide enough access to conduct sea fisheries. Following the war, the length of the Polish coastline increased considerably to over 500 km. With this broader access to the Baltic Sea, Polish coastal eel fisheries developed and landings were as much as 388 tons annually. Inland eel fisheries also expanded to a substantially larger number of lakes, and landings were as much as 1500 tons annually. In the 1974–1994 period, inland catches comprised up to 75% of the total annual Polish eel catch. Since the end of this period, catches have declined considerably, and the two types of eel fisheries together currently land about 200 tons annually.

Until the late 1950s, Polish eel fisheries were based almost exclusively on natural recruitment. Later, extensive stocking programmes that released mainly glass eel were conducted in many lakes and in both lagoons. Changes in fishery management and the high price of glass eel put a near stop to these programmes by the late 1990s. This, in turn, resulted in very serious decrease in eel catches, mainly in inland fisheries

The first version of Polish EMP was submitted to the EU in December 2008, and was updated by the document submitted in June 2009. The EU officially accepted the Polish EMP in January 2010. Regulations for protecting eel, such as designated minimum length and closed seasons, were introduced into Polish law in 2010, and stocking started in August 2011. In June 2015, Poland submitted Joint Polish/Russian Transboundary Eel Management Plan in Pregola RBD and Vistula Lagoon. The Plan has not been revised yet.

For the needs of the Eel Management Plan, in consideration of the availability of data essential to estimating the population size and the potential escapement of silver eel and in consultation with countries that share transboundary river basins, the territory of Poland was divided into two Eel Management Units.

These EMUs include the following river basins, running waters, and maritime waters: Oder (Odra) EMU and Vistula EMU.

Figure 2.1.1. EMUs in Poland according to the Polish EMP.

The major elements and measures of the Polish EMP are as follows:

stocking – 6 million glass eels annually in the Oder River basin and 7 million in the Vistula River basin, or 1.2 and 1.4 million ongrown eels <20 cm, respectively;

make migration routes passable – removing barriers, building passes, closing hydroelectric facilities periodically during eel escapement, technical modifications;

designate closed seasons – to achieve the principles of the plan and reduce fishing mortality by 25% there must be a month-long closed fishing season from June 15 to July 15 throughout Poland;

unify minimum length – the optimum protected size for European eel in Polish waters should be 50.0 cm *L.t.* regardless of weight;

improve fishing gear selectivity – the selectivity of the most commonly used trap gear can be increased by installing selective sieves or by increasing the mesh size in the chamber to 20 mm (bar length);

limit daily rod catches to two eel – Polish regulations do not limit daily rod catches; doing so will counteract the increased mortality caused by recreational catches above that foreseen in the population model applied;

limit great cormorant pressure (predation);

limit IUU;

include protected areas in the eel protection process (national parks).

2.2 Significant changes since last report

No significant changes.

3 Impacts on the national stock

3.1 Fisheries

3.1.1 Glass eel fisheries

Not applicable.

3.1.2 Yellow eel fisheries

No distinction has been made between yellow and silver eel in statistics. The data on inland catches were obtained by surveying selected fisheries facilities, then extrapolating the results for the entire river basin. These data are thus approximated. The data from the lagoons were drawn from official catch statistics (logbooks). These might also be incomplete because of poor statistics, the quality of which declined notably following 1990. Data are presented as total landings.

Table 3.1.2. Commercial catches (kg) of eel fin Poland reported from 2005 to 2018.

Year	PL_ODER	PL_VIST
2005	90338	129572
2006	73797	110651
2007	74900	105800
2008	68400	91300
2009	74400	86200
2010	76100	97100
2011	54800	64000
2012	51300	68000
2013	67400	70000
2014	45700	71100
2015	35432	66991
2016	45749	92645
2017	64459	108159
2018	70851	75639

3.1.3 Silver eel fisheries

Data are presented as total landings (see above).

3.2 Restocking

Eel stocking was initiated in regions within current Polish borders as early as at the beginning of the 20th century, and it produced good results (Sakowicz, 1930). This was done mainly in rivers within the Vistula River basin and in the Vistula Lagoon. The stocking material of the day originated from the coasts of Great Britain (glass eel), although the Vistula Lagoon was also stocked with eel inhabiting the River Elbe (20–30 cm total length; Roehler, 1942). In the 1950s, great demand developed in Western Europe for live eel, and this fuelled efforts to stock all appropriate waters with this species. The restocking programme collapsed after the socio-economic changes of 1989 transformed the former state fisheries enterprises into private ones. The Stocking Fund, which had been a department of the central government budget office, was also discontinued at this time. Private fisheries enterprises leased waters in which stocking had once been performed, and the import of eel recommenced in the mid-1990s. Because of economic concerns and the increasing price of glass eel, these were mostly fingerlings. Stocking did not recommence in either lagoon until 2005 as part of the stocking plan for Polish Marine Areas. The intensity of European eel stocking in inland and marine waters in 2011–2017 was determined using data obtained from the users of fisheries districts and from Inland Fisheries Institute database.

Table 3.2. Restocking (indiv.) of ongrown eels x reported from 2005 to 2017.

Year	PL_ODER	PL_VIST
2005	220000	520000
2006	354000	563900
2007	475604	919281
2008	530107	988611
2009	462070	938142
2010	426148	865210
2011	1098671	1574303
2012	753458	993975
2013	1308936	2170066
2014	1511058	783554
2015	401475	3225676
2016	761125	745611
2017	842045	967905

3.3 Aquaculture

No data available.

3.4 Entrainment

On Polish rivers, there are tens of thousands of barriers of varying kinds. Their influence on eel migration is highly varied: practically every one of them to some degree makes it difficult for eel to move upstream; not all, however, constitute a hindrance for eel moving downstream. The barriers' influence depends on a range of factors, the main one of which is the purpose of the construction, and, in particular, whether water is used to produce electricity, for irrigation, in water supply, for ponds, etc. whether the water is used in its entirety, or whether it is possible for the eel to avoid machinery (turbines, pumps, etc.) which, in turn, depends on individual configurations of technology. The influence also depends on whether - if the eel can avoid the machinery - they are exposed to the risk of injury from falls, changes in pressure, etc. The worst, in this respect, are without doubt water-powered electricity generating facilities. In Poland there are around 600 of them, and their number has grown in recent years. Mortality among eel navigating the barrier of an electricity generating facility depends on the possibility for the eel of avoiding the turbines, on the size of the eel themselves, on the type and size of a given turbine, and the height of a given barrage. Mortality rises with the size of the eel; it is greater in Francis turbines than in Kaplan ones; and it is greater in smaller turbines. Smaller electricity generating facilities often have Francis turbines; however, it seems that eel have more chance of voiding a turbine in larger electricity generating facilities. It is also worth recalling that when passing through turbines eel are subject to much more serious injuries than, for example, salmon smelt. At the same time, it is only from 24% of the surfaces of lakes, which are the basic environment and site of natural eel production that eel can swim to the sea without encountering a water-powered generating station. From as much as 63% of those surfaces they have to deal with at least two power stations. Based on results A variable, often significant, part of the eel after release does not swim downstream, but quite the reverse swims upstream (up the facility's reservoir). This was observed both in spring and in fall experiments. On the Narew River (Zegrzyński Reservoir) in 2012, of 30 eel 20 swam upstream, including nine that went as far as the reservoir backwater. Twelve of them (40% of all eel) did not pass the dam up to the end of the experiment, which is over a period of two and a half months. In 2013, the percentage of such eel was 32%. On the Słupia in Słupsk this was 18%, in Kondradowo 96%, in Krzynia 23%, on the Drawa in Kamienna 16%, and on the Radunia in Rutki 100%. Partly this may be a result of stress induced by capture, transport, marking, and release. At several places the eel are too big to get through the grates protecting the turbine inflows. Many eel, however, do not go near the inflow, but immediately swim upstream, several reaching the river above the reservoir. This phenomenon is described in the literature: barriers and reservoirs can prevent eel migration, sometimes forever. It is difficult to assess to what degree this is attributable to the eel natural impulse, and to what degree to the method employed in the research. Certainly, however, the limit on downstream movement placed on silver eel by barriers is not restricted to the injuries eel may suffer in passing through the turbines of a power station.

The Polish Eel Management Plan (PEMP) assumes an improvement in the conditions of downstream migration, and makes the success of the plan dependent on such improvement, and designates it as a fundamental course of action.

3.5 Habitat Quantity and Quality

No new data available.

3.6 Other impacts

No new data available.

4 National stock assessment

4.1 Description of Method

The stock dynamics of eel in both RBDs were estimated using a version of the CAGEAN model (Deriso *et al*., 1985). The model was originally fitted to data covering the period of 1960–2011. There were many gaps in the age-structure data and for some data only approximate or assumed values were available, so the model was fitted using simplified assumptions. The available data included:

- fishery and recreational catches covering whole period;
- stocking numbers covering whole period;
- age structure and weight-at-age for several years, but in most years these data were not available and the best age and weight data are from 2006;
- cormorant eel predation.

In the CAGEAN model fishing, mortality (F) was separated into year effect (fishing mortality at reference age in a year) and age effect (selection). Until 2005, data for estimating year effect in F were too scarce, the F is presented as a time-dependent polynomial of the 7th degree, and coefficients of this polynomial were estimated in the model. Since 2006, F can be calculated for each year as age data are available. Cormorant predation mortality was included, but it appeared to be low (usually well below 0.1). Recruitment to the model was assumed as proportional to recruitment indices estimated using GLM by WGEEL (ICES, 2017) and the coefficient of proportionality (Ralfa) was estimated in the model. Selection was estimated at ages 3–6, at others it was assumed at one. Another parameter was Zini, which was total mortality used to estimate initial stock numbers (in 1960) from average recruitment at the beginning of the simulation period.

The model was fitted by minimizing the sum of squared residuals between observed and modelled catches and observed and modelled catch-at-age in those years in which age distribution was available. The residuals were determined from logged values. Details of the model were presented in the 2008 Polish eel management plan. The inverse of variance weighting was applied to weight terms of the total sum of squared residuals. Estimated fishing mortality and Ralfa were inversely correlated, and there was relatively little information in the data for selecting the most representative estimate of Ralfa. Thus, the model was run for series of Ralfa values, and as a representative for eel dynamics the Ralfa selected was that at which the minimized sum of squared residuals showed low changes, while the total mortality was relatively close to the mortality estimates from the catch curve. Otherwise, the minimizing procedure tended to select high Ralfa and produced unrealistically low fishing mortality.

Changes in the data and model fit in 2017 compared with previous fit were as follows:

- new recruitment indices provided by GLM estimates presented in the WGEEL Report in 2017 were used, and they differed only slightly from previous estimates;
- new data on catches, stocking, and the age structure of catches in 2015–2017 were included in the analysis;
- historical data on catches and stocking were updated for a few years;
- age data from ages older than 14 were combined into a plus group and included in the analysis for the six most recent years, previously the abundance of fish at age >14 was so low (practically zero), so it was omitted.

4.1.1 Data collection

During 2015–2016, the eel monitoring was conducted exclusively in marine and transitional waters, based on the requirements of Council Regulation (EC) No 199/2008. The monitoring programme was based on the collection of catch and biological data, such as length, age, weight, and state of gonads.

Since 2010, WGEEL has been indicating the need of an assessment of biomass and mortality indicators in management as well as scientific reference points to ultimately result in a scientific advice framework that works in line with the ICES precautionary approach (RCM Baltic 2016). The sampling design had to provide relevant data for biomass assessment to WGEEL to perform the approach for international stock assessment.

As required by Commission Implementing Decision (EU) 2016/1251 of 12 July 2016, data collection for two Polish EMUs (Oder and Vistula) from 2017 onwards must consist of:

- catch quantities derived from inland and marine commercial fisheries (logbooks and official statistical questionnaires) biological variables; age, length, weight, sex, and life stage.
- abundance of recruits – catch data obtained on eel ladders set in Pomeranian rivers, data on stocking from statistical questionnaires and resellers.
- abundance of the standing stock – calculated by mathematical modelling, supplemented by data from scientific non selective fykenets set in lagoons and electrofishing in lakes.
- number of emigrating silver eels will be calculated by mathematical modelling.

The stock dynamics of eel for both EMUs is estimated using a version of CAGEAN model (Deriso *et al*., 1985), described in the Polish Eel Management Plan. Data was delivered to WGEEL annually.

4.1.2 Analysis

Eel Model is described in paragraph 4.1.

4.1.3 Reporting

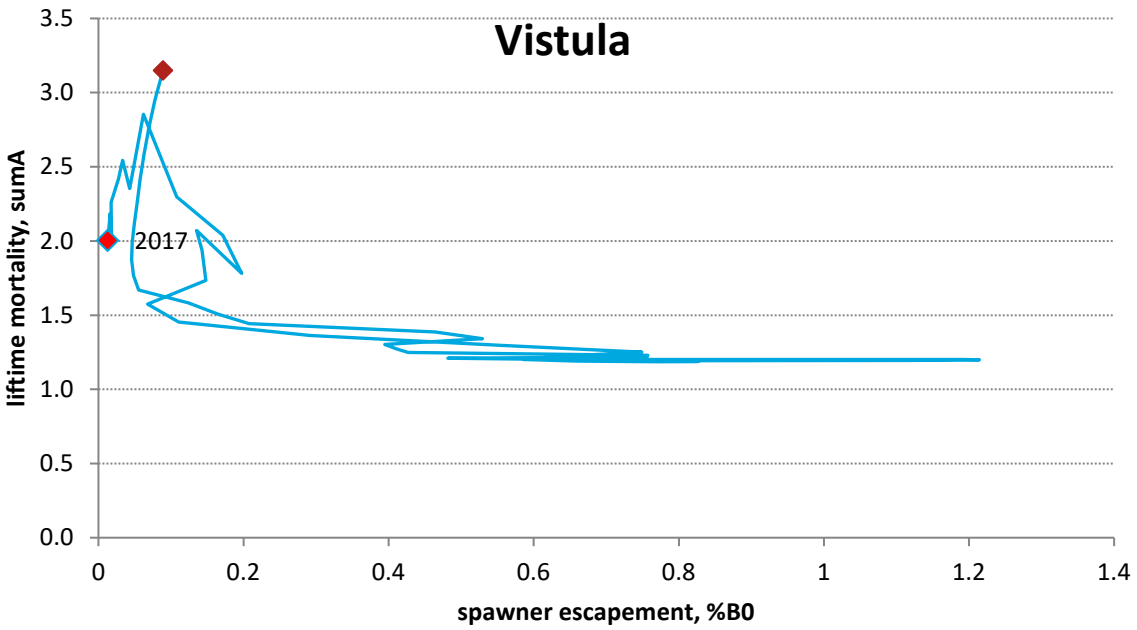
Results of DCF sampling are stored in the international database - FishFrame. Data needed by WGEEL were sent to stock coordinator.

4.1.4 Data quality issues and how they are being addressed

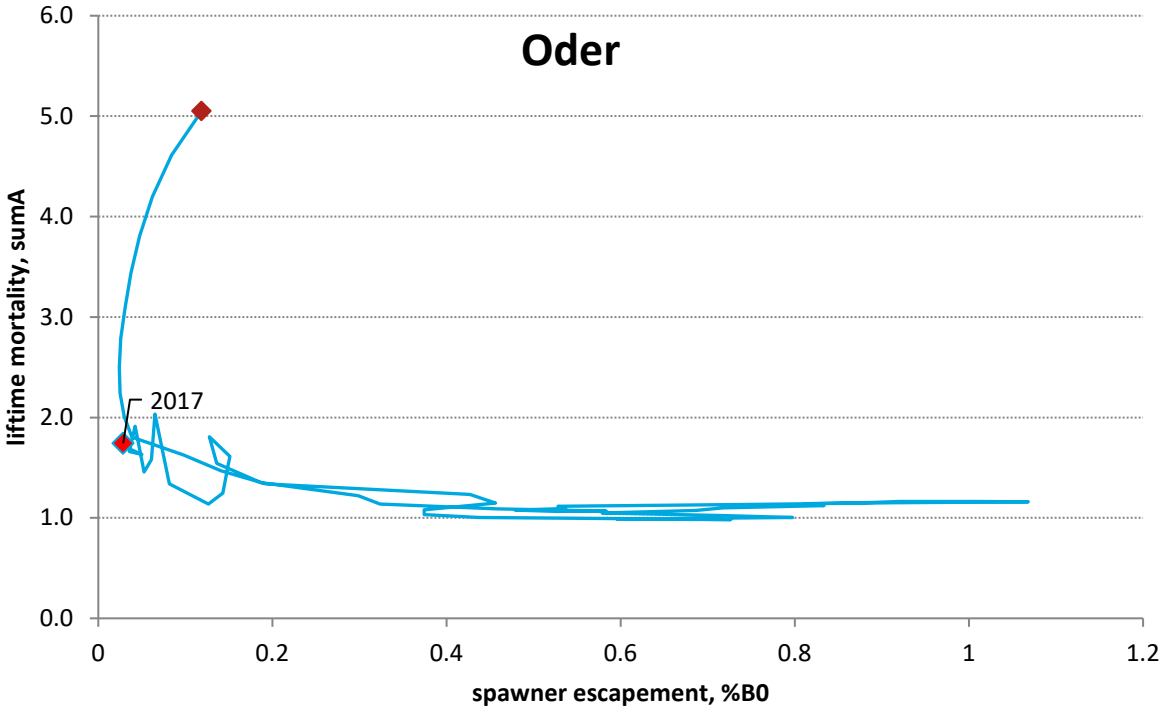
Data collection in coastal and transitional waters meets quality requirements of the DCF. From 2019 onwards, NMFRI and IFI will put more effort into quality aspects including better spatial coverage of freshwater samples, cross reading of otoliths, incorporating new data into the eel model.

4.2 Trends in Assessment results

Figure 4.2.1. Stock dynamics in Vistula RBD (A) and Oder RBD (B) presented as a $B_{current}$ in 2011–2017.



A



B

Figure 4.2.2. Lifetime mortality (sumF+sumH) plotted against spawner escapement (fraction of B_0) for 1960–2017 (A= Vistula river basin district, B= Oder river basin district).

5 Other data collection for eel

5.1 Yellow eel abundance surveys

Routine electrofishing surveys are conducted every year in Pomeranian rivers to estimate abundance of salmon and see trout. Every ten years each of lake and rivers owners must investigate structure and abundance of fish fauna on their own. Some data are available, but quality and usefulness of this dataset is considered to be low. In the new EU – MAP Work Plan Poland inserted abundance survey. The 2018 results showed that electrofishing is not effective in lakes due to the low eel abundance. For this reason, non-selective scientific fykenets have also been used to estimate CPUE trend.

Research on the Vistula Lagoon has been conducted in the period from May 1 to October 30. A total of 285 eels were caught with a total weight of 105 kg. The distribution of the length of the eel caught is presented in the figure

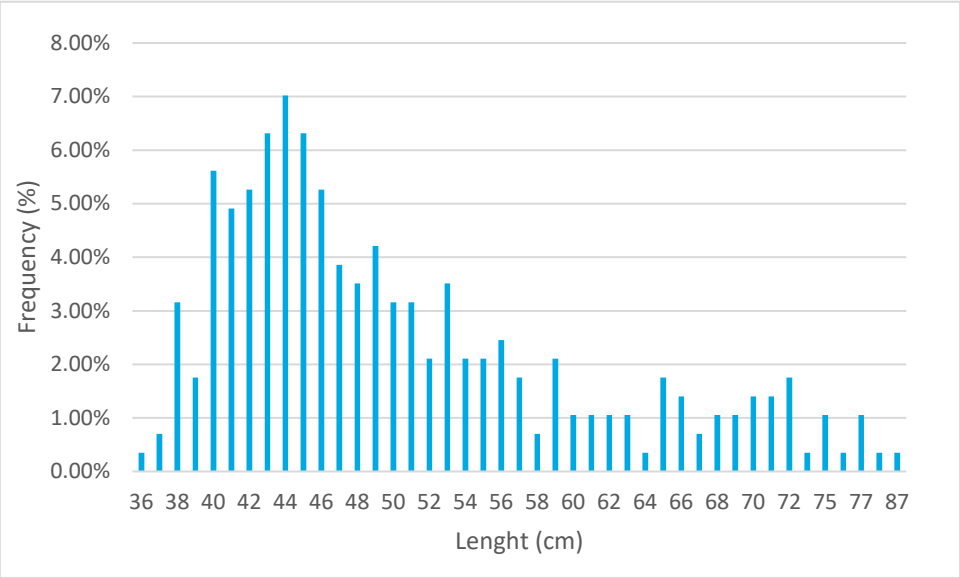


Figure 5.1. Length distribution of eels caught in the Vistula Lagoon in non-selective fykenet.

More than half eels (58%) were individuals below the protective size (50 cm). The presence of eels of this size and their significant number is the result of restocking carried out in the years 2011–2015. Compared to 2017 (1.5 individuals/day/fyke), CPUE dropped to 0.79 individuals/day. The reason may be the systematic removal of fish by commercial/recreational fishery.

5.2 Silver eel escapement surveys

Tagging if silver eel by NMFRI from the waters situated on Polish territory started in September 2011 and continued in subsequent years. The fish originated from the Szczecin Lagoon and the Pomeranian lakes of Koszalin region. Eels were tagged with PIT (Personal Identification Tag) and Floy Tags. Eels were released directly into the sea. From 2011 more than 1500 eels were released. Returns has already been noted in the following years after tagging. Overall, from 2012 onwards it has been noted more than 40 tag returns, mostly from fishermen operating in the eastern part of Germany, coast of southern Sweden and Denmark in the eastern part of the island of Zealand in the Copenhagen. Tags were also found by consumers during standard processing.

Currently no silver eels surveys is being performed. The number of emigrating silver eels is calculated using mathematical models.

5.3 Life-history parameters

Data are collected according to EU–MAP requirements and includes standard analysis of length, age (from sectioned otoliths), and maturity stage (silvering index). During 2015–2018, more than 2000 eel from commercial fisheries were collected and analysed. On the basis of biological analyses, the age structure of eel was identified, and then it was used in a mathematical model that permitted calculating biomass and mortality indicators. In 2018, age data from inland waters were also included.

In inland waters, age groups ranging from six to 26 in the Oder EMU, and from four to 33 in the Vistula EMU were identified. The most abundant fish were from age groups 12–14 in the Oder EMU (30% of the total frequency) and from age groups 16–18 in the Vistula EMU (30% of the frequency). Both EMUs were characterized by quite numerous individuals from age groups 14+, for which 100% silvering was assumed.

The age structure in transitional waters differed and age groups 4–8 dominated. The biomass in these basins is supplemented regularly by intense stocking, the eel have good living conditions, and the growth rate is higher than in inland waters.

5.4 Diseases, Parasites and Pathogens or Contaminants

The cormorant daily food ration and annual food requirement in 2015–2017 were estimated assuming the following:

- the cormorant breeding population in Poland was approximately 30 000 pairs;
- the population of non-nesting cormorants accounted for 20% of the breeding population, or approximately 12 000 birds;
- adult cormorants consume approximately 400 g of fish daily;
- cormorants roost in Poland for 150 days;
- chicks are fed from May to July (90 days) and their dietary requirement is approximately 250 g/ individual.;
- cormorant breeding success is 2.2 chicks/nest;
- weight share (%) of eel in the cormorant diet was 0.14%.

The estimate of the mean number of cormorants in Poland was based on data from the literature. In 2015–2017 the number of cormorants was approximately 130 000 individuals. Assuming that a cormorant individual consumes approximately 0.4 kg of fish per day, the cormorant population that migrates to Poland annually consumes approximately 576 000 tons of fish annually. The share of eels in the cormorant diet, which was estimated based on studies from 2012–2014, is 0.14%, which means that the great cormorant population of approximately 130 000 individuals consumes approximately 80 tons of eel in Poland annually. Considering the location of the largest colonies of this bird (in 2017, 50% of the cormorant population inhabited coastal waters, then approximately 40 tons of eels consumed by cormorants are from inland waters and approximately 40 tons are from coastal waters.

6 New Information

No data available.

7 References

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Report on the eel stock, fishery and other impacts, in Portugal

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Reporting Period: This report, completed in August 2019, contains data up to 2018 and some provisional data for 2019.

Acknowledgments:

Capitania do Porto de Caminha

DGRM (General Directorate of Natural Resources, Maritime Safety and Services)

ICNF (Institute of Conservation of Nature and Forests)

1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

The stock indicators of silver eel escapement biomass, mortality rates, and assessed habitat area, are shown in Table 1.1. These are the most recent indicators, which have been calculated to report the progress of two EMUs to the European Commission, in accordance with Article 9 of the Eel Regulation - Regulation (EC) Nº 1100/2007. These EMUs are: PT_Port, that includes all the country, except the river Minho, which has been included in a transboundary EMU, ES_Minh, shared between Spain and Portugal.

The pristine escapement (B_0) estimates (Table 1.1) have been improved compared to the estimates presented in the Portuguese EMP (PT_Port EMU) submitted to the EC in 2008. These data have been submitted to the ICES Data Call in 2018.

Table 1. Stock indicators of silver eel escapement, biomass and mortality rates, and assessed habitat area for the two EMUs, PT_Port and ES_Minh, reported by Portugal.

Year	EMU_code	Assessed Area (ha)	B_0 (kg)	B_{curr} (kg)	B_{best} (kg)	Bcurr/B_0 (%)	∑F	∑H	∑A
2018	PT_Port	135487	1364571	698826	1026094	51.21	0.38	0.00	0.38
2018	ES_Minh	1823,69	36474	4278	36474	11.7	2.73	0.00	2.73

Key: EMU_code = Eel Management Unit code.
B0 = the amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the stock (kg).
Bcurr = The amount of silver eel biomass that currently escapes to the sea to spawn (in the assessment year) (kg).
Bbest = 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).

1.2 Recruitment time-series

The Portuguese recruitment time-series that has been used by the WGEEL to analyse the trends in recruitment is the commercial fishery from River Minho. There have been some changes in the number of licences throughout time as well as in the extension of the fishing season (number of days) and the fishing area.

Since 2017, within the framework of DCF, two new fishery-independent recruitment series have been set: one in the Minho River and the other in the Mondego River. These river systems were chosen to compare current recruitment with data collected in the late 1980s, when recruitment began to decline. These data are not yet used by the WGEEL as recruitment "time-series" in the estimates of the recruitment indices, due to their recent collection, but they may contribute to calculate these indices in the future.

2 Overview of the national stock and its management

2.1 Describe the eel stock and its management

2.1.1 EMUs, EMPs

In compliance with Regulation EC 1100/2007, Portugal has considered **two EMUs** in accordance with Article 2 of the Eel Regulation: one that includes the entire territory (mainland), and the other that includes the International River Minho. Therefore, Portugal submitted **two EMPs**: one **national EMP** and a **transboundary EMP**, shared with Spain, for the River Minho.

The Portuguese Eel Management Plan was submitted in December 2008. This EMP was approved by the European Commission on the 5th April 2011, following the delivery of the last revised version on the 19th November 2010.

Despite the existence of five river basins extending beyond Portugal (Minho, Lima, Douro, Tagus, and Guadiana) (Figure 2.1a), and included in three different River Basin Districts (Figure 2.1b), it was agreed between both countries that the only Transboundary Eel Management Plan that should be considered was for River Minho, as it is the only international river where the river mouth is shared by both countries and there is a strong interest on the glass eel fishing. As coordination between the two countries was delayed, it was not possible to consider it in December 2008, when submitting the Portuguese Eel Management Plan.

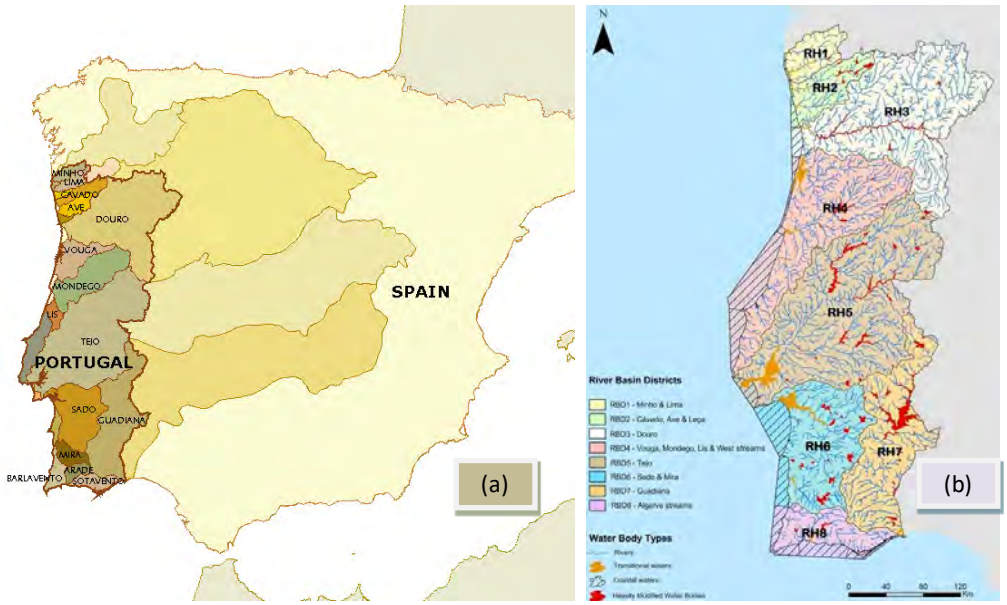

Figure 2.1. Map showing Portuguese River basins including the catchment area extending to Spain (a), and limits of the 8 Portuguese River Basin Districts defined according to the Directive 2000/60/EC (b). RBD is labeled as RH in the map.

A first version of the Transboundary EMP, for River Minho, was sent to the European Commission in June 2011 followed by a revised version in November of the same year. The Transboundary EMP was approved by the European Commission on the 21st May 2012.

Because the EMP for the River Minho was not delivered in time, Portugal had to reduce the fisheries effort until the implementation of the EMP in that river. Hence, several measures were taken to comply with the provisions of Article 4, number 4 *i.e.* to reduce fishing effort by at least 50% relative to the average effort deployed from 2004 to 2006. Those measures included reducing

the number of fishing licences to fish glass eels, shrinking the authorized fishing zone for glass eels, shortening the fishing period, and banning the fishery for eels.

2.1.2 Management authorities

Eel fishery is managed by **DGRM** (General Directorate of Natural Resources, Maritime Safety and Services) with responsibility in coastal waters, and **ICNF** (Institute of Conservation of Nature and Forests) with responsibility in inland waters. These institutions are under two ministries: Ministry of Sea and Ministry of Agriculture, Forestry and Rural Development respectively. The exception is River Minho because as an international river with a common stretch bordering both countries, there is a Commission (**Standing Transboundary Commission of the River Minho**) that includes representatives from both countries setting specific rules that are applied to the fishery conducted in the international section of that river basin. Licences to fish in inland waters are issued by ICNF, whereas licences to fish in transitional and coastal waters are issued by DGRM. Licences for Portuguese fishermen to fish for glass eels in the Minho River are issued by **Capitania do Porto de Caminha.**

The management of waterbodies is the responsibility of **APA** (Portuguese Environment Agency) and five regional administration authorities for inland waters, which are under the Ministry of Environment. These authorities are responsible for the implementation of Water Framework Directive and therefore for obstacles in water basins.

Finally, ICNF is also the **National Authority for the CITES** convention, which implies they also have a role in the implementation of the EMPs.

2.1.3 Fishery Regulations

Glass eel fishery is forbidden in all river basins since 2000 (*Decreto Regulamentar* nº 7/2000), except for the international River Minho where it is still permitted (*Decreto Lei nº 316, artº 55 of 26/11/81*).

Yellow eel fishery is ruled by 11 specific byelaws applied to 11 fishing areas in coastal waters (estuaries and coastal lagoons) and nine other byelaws that are applied to specific fishing areas called ZPPs (Zonas de Pesca Profissional / Professional Fishing Zones) (See Figure 2.2a), which are the only areas where professional eel fishery is allowed in inland waters. These laws set the rules for types and characteristics of fishing gears and in most cases, limit the maximum number of gears per fishing licence. Fishing effort is not recorded. In inland waters, professional fishery is ruled by Law 112/2017 (6 September 2017) in the stretches represented in green, whereas in the sections represented in yellow it is ruled by the byelaws (Figure 2.2b).

Fisheries managed by DGRM have mandatory landing reports because eels are sold at fish auctions, while in inland waters, there are no auctions. In 2012, in line with the implementation of the EMP, professional fishermen have become obliged to report catches annually to be able to renew their fishing licences. Minimum legal size is 22 cm in both areas of jurisdiction. The yellow fishery is permitted from January 1st until September 30th.

It is forbidden to catch **silver eels**, which implies it is mandatory to release them if they are caught. Besides, a closed season of three months (October, November and December) has been set to increase escapement of silver eels. This prohibition was first set in 2010 for waters within the jurisdiction of DGRM, *i.e.* estuaries and coastal lagoons (*Portaria nº 928/2010, from 20 September*) and in 2012 for waters under the jurisdiction of ICNF, *i.e.* inland waters (*Portaria nº 180/2012, from 6th June*). In River Minho the yellow and silver eel fishery is forbidden since the fishing season 2011–2012.

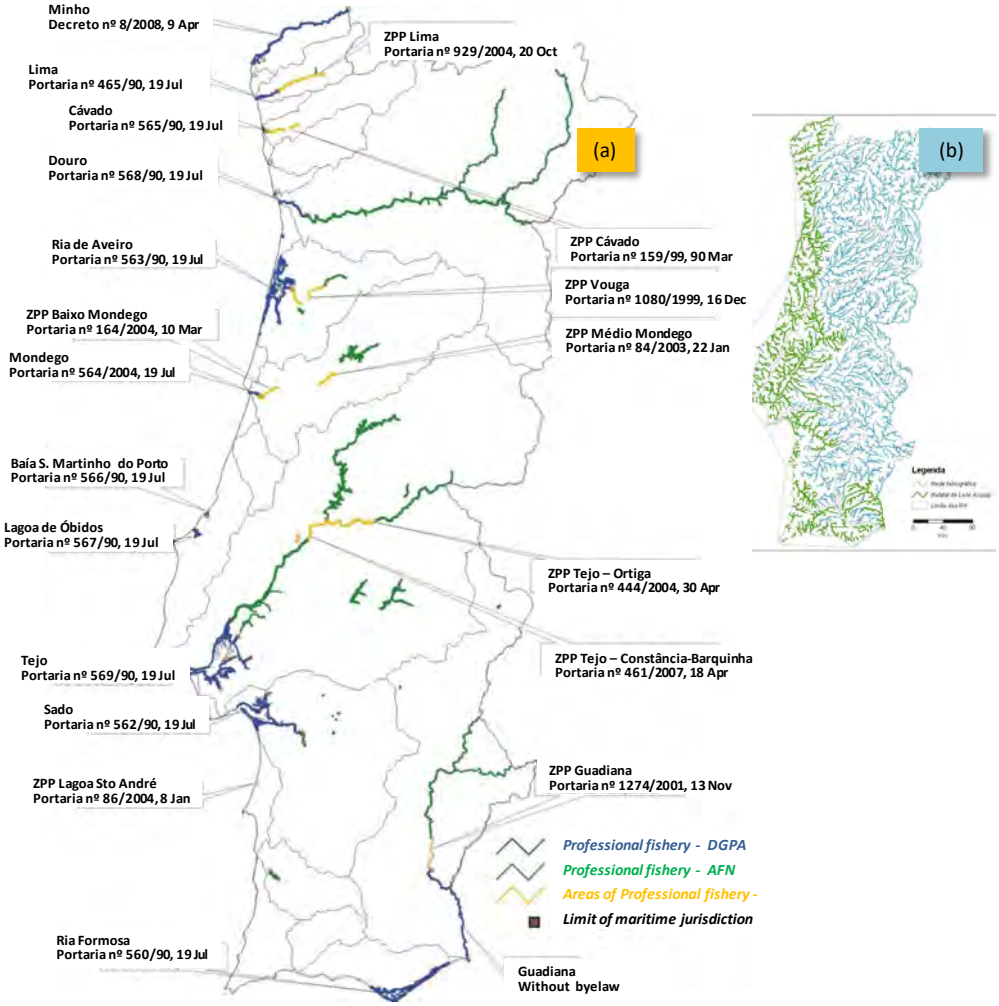

Figure 2.2. Map showing areas where professional fisheries can be conducted both in estuaries and coastal lagoons (jurisdiction of DGRM) and in inland waters (jurisdiction of ICNF) (a). The limit of maritime jurisdiction and the byelaws that rule the fisheries at each area are presented in the map (a). (Source: ICNF). The habitat that is accessible for the eel is also represented in green (b).

2.1.4 Management actions

The main objective of the Portuguese Eel Management Plan, which considered the entire country as one management unit, was to establish a series of measures to be applied at the national level that could contribute to reduce mortality and increase silver eel escapement as requested by Regulation 1100/2007. These measures can be classified into four categories:

- Fisheries restrictions;
- Mitigation of obstacles to upstream migration;
- Reinforcing police control on glass eel poaching;
- Data collection (Habitat/stock assessment).

An overview of the measures foreseen can be seen in Table 2.1. In general, all measures related to the fisheries have now been implemented. These measures focused on reducing the fishing capacity and effort but also on setting a ban on the fishery during the most intensive period of silver eel migration. Besides, to control the eel fishery in freshwater and reduce fishing effort, if needed, a special licence for the eel fishery was implemented in 2018, under the designation of species of relevant interest for the professional fishery.

Table 2.1. List of the management measures foreseen within the scope of the Portuguese EMP and state of implementation. ☺ - Fully implemented; 😐 - Partially implemented.

Action Type	Action	Life Stage	Planned	Outcome
Com. Fish	Prohibit the eel fishery outside the professional fishing areas in freshwater jurisdiction	Y	After 2011	☺
	Set maximum number of fishing gears and licences per professional fishing area, in freshwater	Y	After 2011	☺
	Introduce obligation to report catches in freshwater to obtain a licence the following year	Y	After 2011	☺
	Introduce a specific annual licence for eel fishery in freshwater jurisdiction	Y	After 2011	☺
	Introduce closed fishing season (1st October to 31st December) in freshwater jurisdiction	S	After 2011	Portaria nº 180/2012 ☺
	Introduce closed fishing season (1st October to 31st December) in marine jurisdiction	S	until 2012	Portaria nº 928/2010 ☺
	Reduce the number of licences for marine water jurisdiction	Y	2009-	☺
Rec. Fish	Prohibit recreational eel fishery in marine (M) jurisdiction	Y/S	After 2011	Portaria nº 14/2014 ☺
	Prohibit recreational eel fishery in freshwater (F) jurisdiction		After 2011	Portaria nº 108/2018 ☺
Hydropower & Pumps	Mitigate the impact of existing obstacles (upstream migration)	G/Y	After 2011	😐
Restocking	0	na	na	Na
Other	Collect data and conduct studies on the stock (Recruitment/Production/Escapement)	All	Until 2012	DCF 2017–2019 ☺
	Monitoring and control of glass eel poaching	G	2009-	☺

Reinforcement of actions to reduce the poaching was carried out when the Portuguese EMP was approved, either in the aquatic systems where the fishery was taking place or on land when catches were being transported. Several actions have been undertaken by the authorities both in the marine jurisdiction (Maritime Police) and freshwater jurisdiction (SEPNA, a special unit from GNR, the National Republican Guard). These authorities have been making a huge effort to control the situation; however, the nets seized are rapidly substituted by new ones. SEPNA has among other competences, the obligation to monitor the illegal activities of fishing and can act on land. However, another special unit from GNR, the UCC acts close to the coast and has also been involved in these actions.

More recently, in 2017 and 2018, with the pressure on international illegal trade generated by the listing of *Anguilla anguilla* in CITES, the Portuguese Food and Economic Security Authority (ASAE) together with the CITES authority have been involved in joint actions that resulted in the seizure of glass eels at several Portuguese airports, on various occasions. Cooperation with the Spanish authorities, Europol and Interpol, have also been improved within the scope of the

illegal trade on glass eels. The Sargasso operation, which ended in March 2018, resulted in the seizure of 600 kg of glass eels as well as all the material used for storage and transport. (Press release from ASAE can be consulted at http://www.asae.gov.pt/espaco-publico/noticias/comunicados-de-imprensa/asae-faz-a-maior-apreensao-de-meixao-de-sempre-em-portugal-e-desmantela-rede-de-trafico-de-meixao.aspx). In the fishing season 2018/2019, the control force from GNR, has been involved in the "Freshwater Operation", that resulted in the seizure of 518 kg of glass eels, as well as material used in the fishing operation and transport (More information about the operation at https://sudoang.eu/wp-content/uploads/2019/07/Workshopcontrol-GNR.pdf and also at https://www.dn.pt/edicao-do-dia/01-jul-2019/interior/do-atlantico-aos-pratos-na-asia-trafico-de-enguias-bebes-da-milhoes-e-passa-por-portugal-11059967.html).

The most difficult measures to implement are related to restoring longitudinal connectivity for fish migration because there are numerous obstacles and their impact has not been evaluated. As for the need to collect data on the stock (recruitment/production and escapement), vital to accomplish the objectives set by the Eel Regulation, it was finally started in 2017, under the EU MAP obligations.

The implementation of the Transboundary EMP for the River Minho has been more successful, mostly because it includes a smaller area and the measures were all focused on the fishing activity, which is easier to implement. The results can be consulted in Table 2.2.

Table 2.2. List of the management measures foreseen within the scope of the Transboundary Eel Management Plan for the River Minho and state of implementation. ☺ - Fully implemented.

Action Type	Action	Life Stage	Planned	Outcome
Com Fish	Prohibit the eel fishery	Y/S	EMP	☺
	Reduce fishing effort	G	EMP	☺
	Introduce obligation to fill in logbooks	G	After approval	☺
Rec Fish	Prohibit the eel fishery in marine jurisdiction	Y/S	EMP	☺
Hydropower & Pumps	0	na	na	na
Restocking	0	na	na	na
Other	0	na	na	na

2.2 Significant changes since last report

No significant changes since last report. The stock indicators have been provided for the first time both for the ICES data call 2018 and the 2018 EMPs Progress Reports.

The collection of information about the stock as well as biological sampling are being conducted since 2017, within the framework of DCF, following the Commission Implementing Decision (EU) 2016/1251 - Multiannual Programme for the collection, management and use of data in the fisheries and aquaculture sectors for the period 2017–2019.

3 Impacts on the national stock

3.1 Fisheries

3.1.1 Glass eel fisheries

The glass eel fishery is prohibited in all rivers of Portugal (*Decreto Regulamentar* nº 7/2000 of May 30), except in the River Minho (Decreto-Lei 316 artº 55 of 26/11/81). It was after the fishing season 2000/2001 that the fishery became prohibited in all other Portuguese rivers, except for aquaculture and restocking programmes. The official Portuguese fishery statistics from Minho are kept by the responsible local Authority - Capitania do Porto de Caminha. Total annual statistics have been recorded since 1974 (Figure 3.1).

There have been some changes in the number of licences throughout time (Figure 3.1), as well as in the extension of the fishing season and the fishing area.

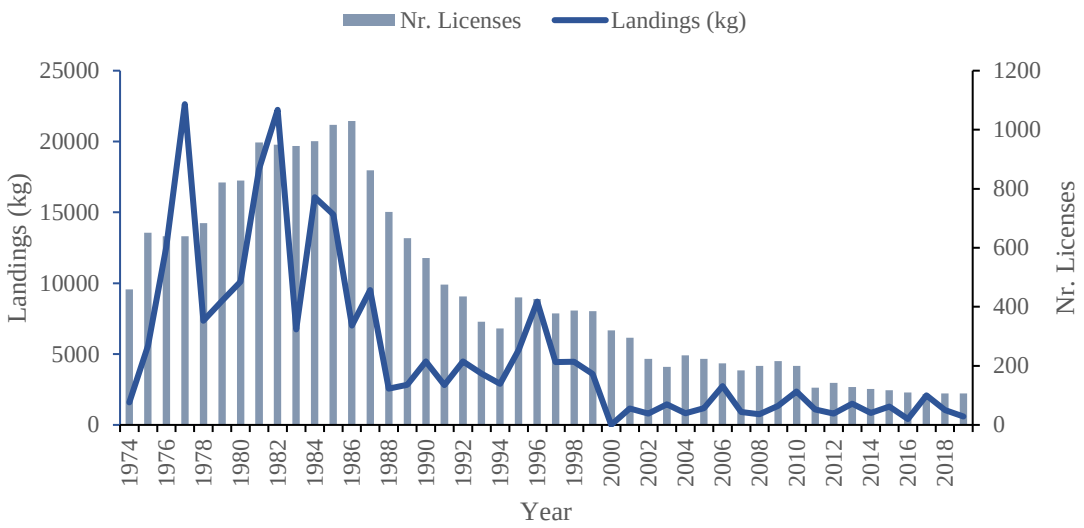

Figure 3.1. Glass eel recruitment and number of licences issued to Portuguese fishermen in the River Minho from 1974 to 2019 (Source: Capitania do Porto de Caminha).

In order to reduce fishing pressure, the Standing Transboundary Commission of the River Minho decided that from the 2010/2011 fishing season onwards, the maximum number of fishing licences to be issued by each country would be 200, and that the fishing area of the glass eel fishery would decrease 25 km in the river length. In the same year, a new change was introduced in the licensing process, and licences started to be issued to the owners of the boats and not to fishermen, implying that the drop to 126 licences in 2011 is a consequence of these changes rather than a real reduction in fishing pressure. The number of fishermen is however, generally the same, as there are two men per boat.

Glass eel fishery in the River Minho was permitted between November and April for many years, but after the fishing season 2005/2006, mostly due to the eel population decline and the high fishing pressure, an agreement between the Portuguese and Spanish authorities, started to gradually reduce the fishing period. The fishing season is currently defined, to include four New Moons (the most profitable period), but the fishery can only occur eight days before and eight days after each New Moon, in a total of ≅ 60 fishing days. In the last fishing season (2018/2019)

fishing occurred between the 1st November and the 28th February, with two weeks of fishing around each new moon.

3.1.2 Yellow eel fisheries

Fishing capacity in freshwater is not known, and under the present legislation, it is not possible to estimate the number of fishermen and eel fishing gears they owe/use. Professional fishermen must obtain a licence issued by ICNF to fish in these waters and they are obliged to report their catches. The professional fishery is ruled by nine byelaws, which define the river sections where fishermen can fish, establish the number of fishermen for each fishing season and the rules for fishing (fishing gears and mesh size, size limit of the species, hour restrictions and species restriction).

The fishing licences issued by DGRM for local fishery in estuarine and coastal waters are linked to fishing boats. The same fishing boat can be licenced to fish with more than one type of fishing gear. In some areas within the DGRM jurisdiction, there is a policy on maximum number of fishing gears permitted by licence. That does not imply fishermen use them all, but the number they use is unknown. The type, number and characteristics of eel fishing gears vary according to fishing area. There are 11 specific byelaws that set the rules for eleven fishing areas. However, for certain areas and/or fishing gears there is no restriction on the number permitted for each licence. These different rules and the lack of record on the actual number of fishing gears fishermen use, contribute as extra difficulties to estimate fishing capacity.

The use of fykenets in the River Minho was banned by Decree 8/2008 (April 9th) and its application started on the fishing season 2008/2009. However, longlines are still permitted in the international part of the river (80 Km) and eels are caught as bycatch (maximum 10% allowed) of other fisheries.

Landings from coastal fisheries (estuaries and coastal lagoons) in the EMU PT_Port, are shown in Table 3.2. There was a decline in catches after 2010, which continues today. However, it should be noted that a ban of three months (October, November and December), implemented in 2010 (Portaria nº 928/2010, from 20 September), might account for the decline observed. The changes in fishery regulations, derived from the implementation of the EMP, add as extra difficulties to evaluate the trend on the stock, based on landings.

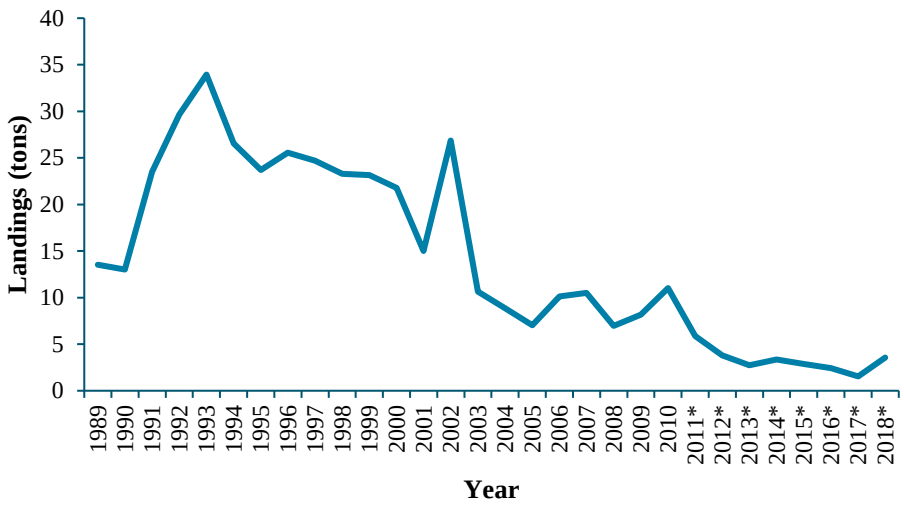

Figure 3.2. Annual landings of yellow eel fishery in coastal waters (estuaries and coastal lagoons), from 1989 to 2018 in the PT_Port EMU. (Source: DGRM). (*) In 2011, an eel fishing ban was set between October and December to increase silver eel escapement, which is still in force.

3.1.3 Silver eel fisheries

It is forbidden to fish silver eels. With the implementation of the EMP, the eel fishery was closed during the most important period of spawning migration, *i.e.* from the 1st October to 31st December in both marine (Portaria nº 928/2010) and freshwater (Portaria nº 180/2012) jurisdictions. Besides, in the freshwater jurisdiction, if fishermen catch silver eels outside the ban period, they are obliged to return them to the water.

3.2 Restocking

There is no stocking of eels in Portugal.

3.3 Aquaculture

Aquaculture production of European eel is not significant in Portugal because there have been no units of eel aquaculture in Portugal. In brackish water systems, production of eels is a by-product in aquaculture systems directed towards extensive and semi-intensive seabass (*Dicentrarchus labrax*) and seabream (*Sparus aurata*) farming. The production of eels in these systems is presented in Table 3.1.

Table 3.1. Aquaculture production of eels (tons) between 2010 and 2017 (Source: DGRM).

YEAR	PRODUCTION (KG)
2010	285
2011	562
2012	886
2013	1383
2014	917
2015	890
2016	1060
2017	32 963

The increase in the aquaculture production in 2017, results from a new aquaculture unit for eel production installed in central Portugal (Figueira da Foz). This facility has however, closed at time of writing this report.

3.4 Entrainment

Anthropogenic impacts identified in the two Eel Management Plans (PT_Port and the Transboundary EMP for the Minho, ES_Minh) submitted by Portugal were mainly related to fisheries and obstacles to migration that have reduced available habitat to grow. Although turbine activity is usually a major mortality factor especially for silver eels, in Portugal there is no passage for eels in the hydroelectric dams, which implies there is no mortality associated with turbines. Besides, because these EMPs do not include stocking of upriver sections that are inaccessible for the eel, there is not a problem for silver eels escaping from continental waters to spawn. As for pumps or diversions, they may become a problem especially for glass eels that might easily be entrained by the pumps, but that impact has not been considered and is not being assessed.

3.5 Habitat Quantity and Quality

Habitat quality and quantity have been considered in the Portuguese EMP as measures to increase the quality and quantity of silver eels escaping to the sea. The improvement of water quality was a measure set in the Portuguese EMP to be achieved by the implementation of WFD. However, because there are many obstacles in the water courses, the quantity of habitat available for eels to grow, required a list of needs to be implemented in the short, medium and long run.

The quantity of habitat free of obstacles has also increased in River Mondego. A project entitled "Rehabilitation of habitats for diadromous fish in the River Mondego" funded by Programa Operacional Pesca 2007–2013 (PROMAR) (Reference 31-03-02-FEP-5), which aimed to remove obstacles allowed to install an eel pass in the first dam that was hampering the colonization of the watershed. The result was an effective increase of 30 km of river completely free of obstacles. The monitoring of the eel pass is under course.

In River Minho, the presence of the Frieira dam impedes eels from migrating upstream. As such, there is a high concentration of juvenile eels (elvers) just below this obstacle, which has driven

the authorities to release these individuals in tributaries located below the dam to reduce mortality derived from high densities. In total, there was a redistribution of 3.7 tonnes of eels between 2011 and 2018 (Table 3.2).

Table 3.2. Quantity of eels (kg) captured below the Frieira dam both in the salmonid ladder and the ramp. (Source: Estación de Frieira dam).

YEAR	Ramp	Ladder	Total
2011	187.52		187.52
2012	243.18		243.18
2013	98.86	658.45	757.31
2014	136.01	426.65	562.66
2015	103.75	652.3	756.05
2016	70.76	104.28	175.05
2017	82.7	915.44	998.145
2018	0	0	0
TOTAL	922.78	2757.12	3679.915

3.6 Other impacts

Nothing to report.

4 National stock assessment

4.1 Description of Method

4.1.1 Data collection

Surveys are currently done under the DCF (Period 2017–2019). A combination of methods including the commercial fishery and independent surveys are used as a proxy to estimate stock indicators. Wherever there is a fishery, it is monitored, but in the absence of a fishery, experimental fishing is carried out.

The river basin chosen to represent the PT_Port EMU was River Mondego (estuary and freshwater) to compare with data from the 1990s but because this EMU is the whole country and the production of eels is affected by the type of aquatic system, a coastal lagoon (Santo André Lagoon) was also included in the data collection to represent the variety of aquatic systems (river + estuary + coastal lagoon). These surveys include experimental fishing for recruitment estimates (monthly from November to April) and surveys on yellow and silver eels in the Mondego River. Moreover, still within the framework of DFC biological sampling is also being conducted. A sample of eels is collected each year for length, weight, sex and age determination.

As for the other EMU, ES_Minh, the same surveys and biological sampling are being conducted under DCF. The yellow eel fishery is prohibited, which implies biological sampling is done by experimental fishing.

4.1.2 Analysis

Estimates of the silver eel biomass were improved compared to the estimated biomass provided in the Portuguese EMP presented in 2008, in which calculations were done by extrapolating data from watersheds of France. The biomass estimates herein presented are based on the densities of yellow eel surveys conducted in the Mondego River, using electric fishing. Additionally, sampling of yellow and silver eels that has been conducted between 2014 and 2016 within the framework of the Project "Rehabilitation of habitats for diadromous fish in the River Mondego" funded by PROMAR, provided data to determine the mean silvering age, the mean weight (yellow and silver eels), and the silvering rate. Data from scientific surveys conducted in 1988–1990 (Domingos, unpublished data) was used to improve estimates of the pristine biomass of silver eels.

The stock indicators were calculated for the PT_Port EMU, extrapolating the silver eel production obtained in the river Mondego, according to the following expressions:

$$B_0 = [[(\text{YE densities 1988})*(\text{silvering rate})]*\text{mean SE weight}] * \text{wetted area}$$

$$B_{current} = [[(\text{YE densities 2017})*(\text{silvering rate})]*\text{mean SE weight}] * \text{wetted area}$$

$$B_{best} = B_{current} + \text{Anthropogenic mortality in Silver Eel Equivalents (SEE)}$$

The silvering rate and mean silver eel weight were obtained by conducting surveys in the river Mondego during the autumn period when silver eels can be distinguished morphologically. The silvering rate was estimated calculating the ratio between these individuals and the non-migrating ones (Durif *et al.*, 2009), being 2.8%, and the mean weight considered was 109 g.

The wetted area is the natural habitat of eel in the PT_Port EMU, which was considered unchanged since 1988, because all the anthropogenic obstacles present in 2017 already existed in

1988. Therefore, the pristine habitat (referred to the period 1988) in the EMU is the same as the current habitat and amounts to a total of 135 487 ha (see Table 1.1).

The anthropogenic mortality in SEE was calculated using the method proposed by the WGEEL and considering a five-year generation time, based on the age determined for silver eels from the Mondego. The catches of glass and yellow eel (silver eel fishery is forbidden), from five and three years ago, respectively, were used, and an 80% mortality in glass eel settlement and annual mortality of 0.138 were considered (Dekker, 2000); we assumed yellow eel average weight of 23.6 g and silver eel average weight of 109.0 g (Table 4.1).

Since glass eel catches are forbidden in the PT_Port EMU, the catches from the Minho river (fishery allowed) were used to estimate the illegal catches in the EMU by extrapolation. It was therefore considered that the main river basins (Lima, Cávado, Ave, Douro, Vouga, Mondego, Tejo, Sado, Mira, Guadiana) from the PT_Port EMU had the same amount of illegal fishing as the legal fishing that occurs in the Minho river, and the total of illegal catches estimated by this method was considered to represent illegal catches of glass eel throughout the whole EMU.

Table 4.1. Data used to estimate the anthropogenic mortality in SEE for the PT_Port EMU.

Glass eel mean weight (g)	Yellow eel mean weight (g)	Silver eel mean weight (g)	Yellow eel mean age	Silver eel mean age	Glass eel settlement mortality	Eel natural mortality
0.28	23.6	109.0	3	5	80%	0.138

The only anthropogenic mortality considered was the mortality derived from the fisheries, which was estimated using the following expression:

$$SumF= -\ln (B_{current}/(B_{current}+kg\ SEE)).$$

4.1.3 Reporting

The stock indicators shown in Table 1.1, were calculated to include in the 2018 EMPs progress reports (PT EMU and PT Minho EMU) to deliver to the EC, as required by the EC Eel Regulation (1100/2007). They were also provided for the ICES Data Call 2018.

The data, which started to be recently obtained in the frame of the DCF (period 2017-2019), are regularly reported to the EC, and is used/included in the ICES data call and contributed to estimate the indicators and to improve the stock assessment.

4.1.4 Data quality issues and how they are being addressed

The following quality issues must be addressed in a near future:

- Anthropogenic mortality indices are still missing in the EMU, namely glass eel illegal fishing.
- Coastal waters were considered to have the same eel densities as the freshwater zone for the present estimated biomasses. DCF data from the Mondego estuary and Santo André coastal lagoon will be used to improve production estimates in estuaries and coastal lagoons all over the EMU.
- The silver eel biomass indicators represent the EMU total production and not the real silver eel escapement.

4.2 Trends in Assessment results

The assessment results presented in chapter 1 were the first stock indicators estimated since the submission of the EMPs. Therefore, it is not possible to report any changes over time.

5 Other data collection for eel

Sampling of yellow and silver eels has been conducted between 2014 and 2016, within the framework of two Projects "Rehabilitation of habitats for diadromous fish in the River Mondego" and "Sustainable Management of the Eel Fisheries in Santo André Lagoon", both funded by PROMAR. Biological aspects to be studied included sex ratio, age, *Anguillicola crassus* infection, and silvering rate. Ecological aspects include size distribution, abundance, influence of obstacles and escapement.

In the River Minho, the project "Migra Miño-Minho", funded by INTERREG – POCTEP (2017–2020), aims to improve river connectivity for diadromous species including the eel.

An ongoing project (LIFE16 ENV/PT/000411) entitled "Conservation and management actions for migratory fish in the Vouga river basin" aims to improve habitat accessibility for migratory species. The European eel will also benefit from this project that ends in 2022 (1st August 2017 to 31st July 2022).

5.1 Yellow eel abundance surveys

There have been surveys on yellow eels in the Mondego River and in Santo André Lagoon, under the framework of two projects funded by PROMAR. These data have contributed to improve the quality of estimates of production in coastal lagoons and rivers presented in the EMP. These surveys continue within the framework of DCF and will be analysed by the end of 2019.

5.2 Silver eel escapement surveys

Scientific surveys on silver eel escapement have been conducted within the scope of two projects funded by PROMAR: one in the River Mondego and the other in Santo André Lagoon. In both cases, receivers were installed along the water course in the two aquatic systems studied, from the upper sections until the river mouth (Mondego River) and in the coastal area close to the opening of the lagoon (Santo André Lagoon) to measure escapement. The results obtained for the Mondego River will be compared with new data from the SUDOANG project (SOE2/P5/E0617), funded by Interreg, in which acoustic transmitters were once again used to measure real escapement aiming at calibrating a model for escapement in the SUDOE area. The data collected are not yet available.

5.3 Life-history parameters

Biological parameters are being collected under DCF since 2017 according to the Commission Implementing Decision (EU) 2016/1251 of 12 July 2016 adopting a multiannual Union programme for the collection, management and use of data in the fisheries and aquaculture sectors for the period 2017–2019. River Mondego and Santo André Lagoon were selected as representative of all types of habitats (river, estuary and coastal lagoon) present in the PT_Port EMU, which comprises the entire country. The same parameters are being collected for the river Minho, which was also included in the DCF programme to sample biological parameters from the transboundary EMP for the other EMU.

In studies of eel age which have been conducted in Portugal, sagitta otoliths have been removed, cleaned with water, stored dry, and cleared in 70% alcohol (Vollestad, 1985) for ten minutes before being examined under a stereoscope microscope. The otoliths were read by more than one

person (Gordo and Jorge, 1991), or by the same person who read them twice (Costa, 1989; Domingos, 2003; Lopes, 2013; Monteiro, 2015). In the lack of agreement between both readings, a third reading was performed and if inconsistent, otoliths were excluded from analyses.

The same procedure is being followed for age reading. Silver stage is being identified according to Durif *et al*. (2009).

Stock assessment requires the collection of stock indicators to accomplish the goals set by the Eel Regulation (mortality and biomass indicators). A combination of methods including the commercial fishery and independent surveys are being used to estimate those indicators in both EMUs.

5.4 Diseases, Parasites and Pathogens or Contaminants

There is no national programme to monitor parasites or pathogens. *Anguillicola crassus* has however, probably spread throughout the country. Despite not being mandatory, the assessment of the infection by the parasite *Anguillicola crassus* is being carried out under DCF. The results are not yet available. In previous studies, only adults were taken into consideration. A summary of the infection analysed in previous years is presented below.

In a study conducted in 2008 in five brackish water systems, Aveiro Lagoon, Óbidos lagoon, Tagus estuary, Santo André Lagoon and Mira estuary, it was concluded that *A. crassus* was spread in all systems except in Óbidos lagoon, which was probably related to the higher salinity observed in this lagoon, similarly to what happens in one sampling site (Barreiro) (Neto *et al*., 2010) located in the lower part of the Tagus estuary. Prevalence values ranged from 0 to 100% and intensity values ranging from 0.4 to 5.8 (unpublished data). Within the DCF programme, the parasite was found in the swimbladder of seven among the 404 eels examined for the Óbidos Lagoon in 2009. The low prevalence found (1.73%) reinforces the idea that the infection rate is very low in areas with higher salinity, as it is the case in this lagoon. The presence of the parasite had already been reported for the River Minho (Antunes, 1999) and River Mondego (Domingos, 2003), which suggests the parasite is probably widespread in Portugal. In River Minho, the presence of the parasite was reported for the entire international section of the river and prevalence ranged between 23% and 100% (Braga, 2011).

6 New Information

Correia *et al*. (2018) used the 40-year long time-series of glass eel fishery catch in the Minho estuary, Portugal, to assess (a) whether local recruitment followed the general pattern of decline of *A. anguilla* observed elsewhere, and (b) whether environmental variables may explain inter-annual fluctuations in glass eel recruitment in the Minho estuary. The analysis showed that, in contrast to the majority of coastal systems in northern Europe and the Mediterranean, CPUE of glass eel in the Minho estuary did not exhibit a marked decline between 1974–2015 and never dropped below 20% of the 10-year mean (1974–1983), taken as baseline. The difference between the recruitment trend observed in the Minho River and that reported by WGEEL for wider European geographical scales highlighted the need to calculate recruitment indices with a higher geographic resolution to better support the assessment of the status of the European eel population.

A project funded by Oceanário de Lisboa (EEL TREK) aims to study the European eel in the Azores and track their migration to the Sargasso Sea, using telemetry. Further objectives include the ecology and genetics of the species in the Azores. For more information, consult https://www.oceanario.pt/en/conservation/ocean-conservation-fund/2nd-edition/

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Report on the eel stock, fishery and other impacts, in Spain

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1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

European eel has disappeared from the inner communities due to the construction of large dams, thus current indicators estimates are limited to Spanish coastal regions. Stock status indicators are compiled here as reported in the Spanish EMP post-evaluation report (2018).

In that sense, and considering the tasks proposed in the 2015 Spanish EMP post-evaluation report related to the 2nd phase, the pristine escapement estimations were improved compared to the above-mentioned report. Both Andalucía and Murcia regions improved the pristine biomass estimation by using recently collected field data and in the case of Murcia including freshwater (Segura River).

This made the overall pristine biomass to increase in almost 500 000 kg comparing to the 2015 estimate. However, B_{curr} decreased compared to previous exercise while B_{best} increased.

According to the estimations of the Spanish 2018 post-evaluation report, European eel population status varies greatly among the different EMUs (Table 1), ranging from 0, in those inner regions where eel disappeared after the dam construction, to 55.2% of the target (Table 1). When the whole territory is considered, B_{curr} in Spain is 8.96% of the pristine one, and has thus slightly decreased in relation to 2015 post-evaluation report (9.1%).

According to the estimations provided by the EMUs, the most important anthropogenic mortality is fishery. But non-fishery impacts, i.e. entrainment and mortality at water intakes, habitat quantity and quality decrease are underestimated because there is insufficient data for their estimation.

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

Year	EMU_code	A_0 (ha)	A_{curr} (ha)	B_0 (kg)	B_{curr} (kg)	B_{best} (kg)	Bcurr/B_0 (%)	∑F	∑H	∑A
2017	ES_Anda	126477	60767	6057545	128457	310599	2.1	0.885	-0.006	0.879
2017	ES_Astu	3774	2591	63495	29466	81143	46.4	1.010	0.002	1.010
2017	ES_Bale	4253	4253	330883	138586	138556	41.9	NP	ND	ND
2017	ES_Basq	4050	3991	245040	127072	161787	51.9	0.242	ND	0.242
2017	ES_Cant	1936	615	9680	1723	6579	17.8	1.465	-0.125	1.340
2017	ES_Cast	1174	0	23488	0	0	0.0	NP	NP	NP
2017	ES_Cata	9895	5567	364607	95415	196371	26.2	0.740	ND	0.740
2017	ES_Gali	5535	4548	110700	12785	103785	11.5	2.087	0.054	2.141
2017	ES_Inne	66868	0	2420205	0	0	0.0	NP	NP	NP
2017	ES_Murc	13719	13500	26270	8095	54445	30.8	1.900	0.000	1.900
2017	ES_Nava	272	231	5448	1134	ND	20.8	ND	ND	ND
2017	ES_Vale	18217	6630	698026	385175	419444	55.2	0.088	0.003	0.091
2017	**TOTAL**	**10355387**	**102693**	**10355387**	**927906**	**1472739**	8.96			

Key:

EMU_code = Eel Management Unit code (see Table 2 for list of codes); A_0: Assessed pristine area; A_{curr} : Assessed current area 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.

The modified precautionary diagram (ICES, 2012) shows that the Spanish EMUs are located in different areas: safe (green), buffer (orange) and outside safe biological limits (red) (Figure 1). However, the EMUs have used different methodological approaches to calculate the indicators, so caution should be exercised in interpreting the differences between the different EMUs.

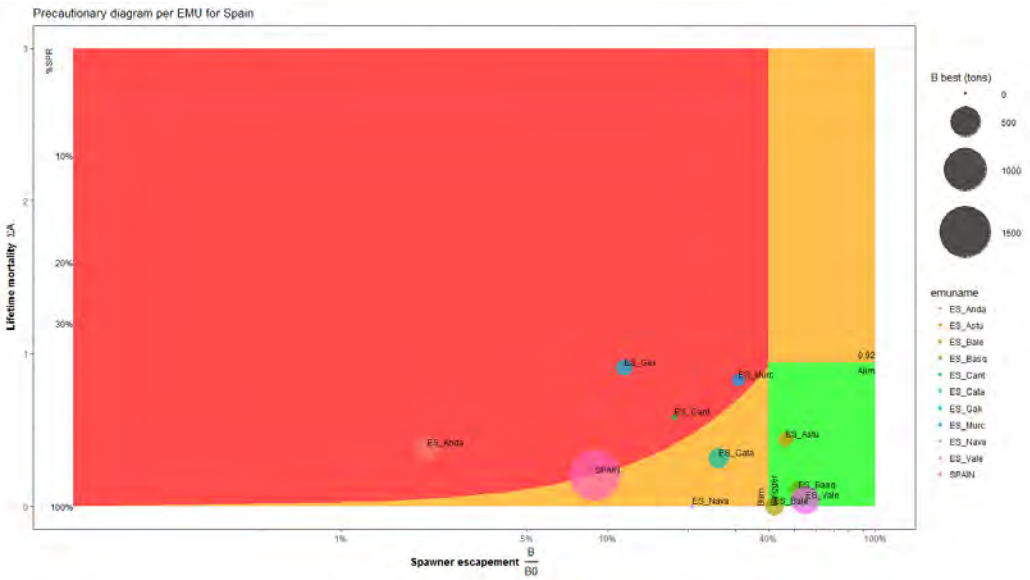

Figure 1. Stock status of the Spanish EMU (Spanish post-evaluation report 2018) according to the modified Precautionary Diagram (ICES, 2012). ES_Cast and ES_Inne not plotted because B_{best} is not available.

1.2 Recruitment time-series

All the data in this section are obtained from auctions or fishermen's guilds. Highest landings of glass eel in Spain were obtained in late 1970s prior to the decline in early 1980s (Figure 4). There are four historical dataseries for glass eel catches in Spain which are updated yearly and are used for the calculation of the WGEEL recruitment index:

- San Juan de la Arena fish market in Asturias: It includes almost all the catches from the Nalón River. Until the 1970s only land fishing existed, then fishermen started to fish in boats, and catches increased notably.
- The Albufera in C. Valenciana. In the 1949–2000 period data were collected from fishermen's guilds corresponding to three fishing points (Golas of Pujol, Perelló and Perellonet). From 2001 on, the administration of C. Valenciana also compiles data from other fishing points in the Albufera, and the rest of C. Valenciana. To maintain the coherence of the dataseries, the Pujol, Perelló and Perrellonet data will be considered for the historical dataseries of the Albufera.
- The Delta del Ebro lagoons in Catalonia. Data are obtained from the fish markets in the area. Since 1998, the administration from Catalonia compiles data for the fish markets corresponding to the Ebro river mouth, obtaining total catches in the Ebro. Additionally, since 1998 it compiles information from the rest of Catalonian Rivers also.
- The Miño. The Miño River command compiles the Spanish catches data.

The Spanish series show a decrease in catches since late 1970s. In the last years, the catches remained low showing some interannual variability without any clear trend. In 2019 catches decreased in the Atlantic series and increased in the Mediterranean series compared to 2018. (Figure 2).

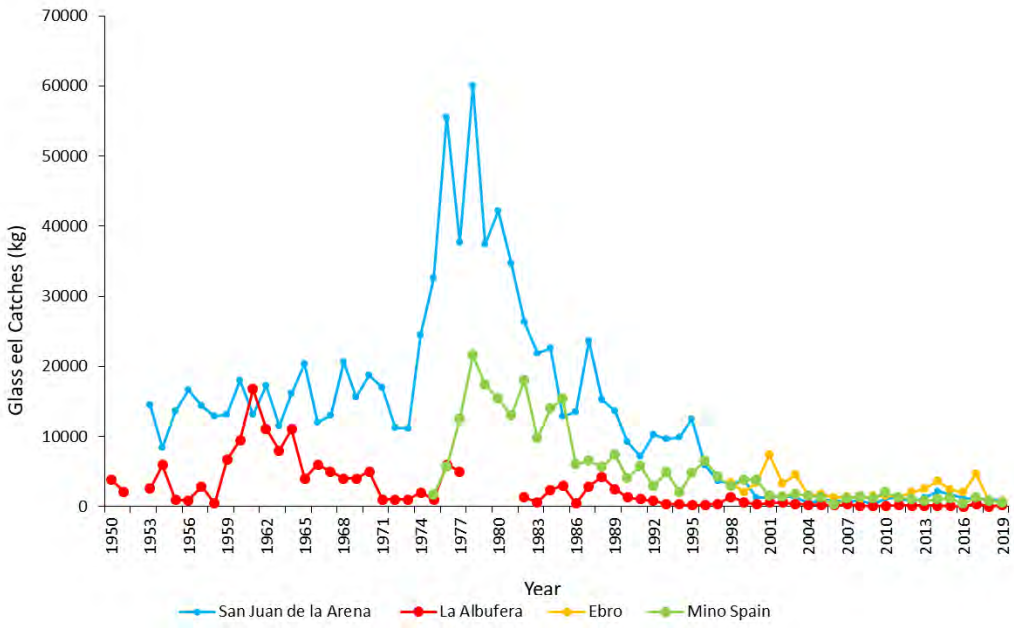

Figure 2. Evolution of the four Spanish recruitment series since 1945. Note the logarithmic scale.

In addition to these series in Spain, there are more recruitment data that are independent of the fishery. Experimental fisheries survey have been carried out in the Oria ( ), Nalón, Guadalquivir ( ) and Ter rivers. In the SUDOANG framework attempts have been made to sample recruitment; however, some methodological problems were found and a new sampling design will be applied next season.

2 Overview of the national stock and its management

No new information since last year's report (Korta and Díaz, 2018).

2.1 Describe the eel stock and its management

No data available.

2.2 Significant changes since last report

None.

3 Impacts on the national stock

3.1 Fisheries

For details about data gathering check Spanish Country report 2017 (ICES, 2017). Although some interannual variability can be observed in both glass eel and yellow and silver eel catches in Spain, they both have decreased during the last decades (Figure 5).

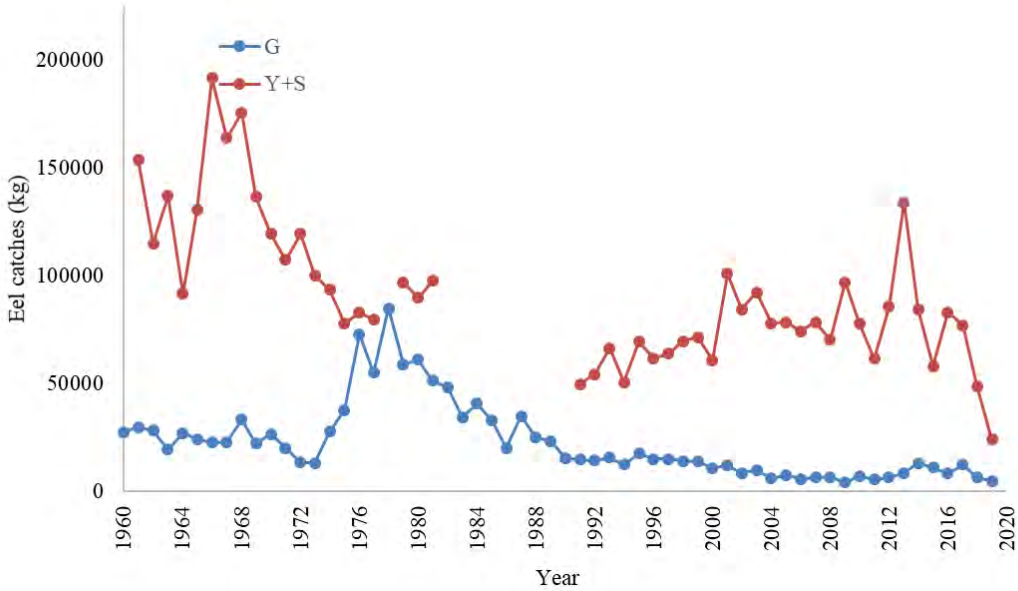

Figure 3. Total glass (G) and yellow and silver eel (YS) catches in Spain since 1960.

In Spain different regions exploit different stages of the eel and use different fishing techniques and gears. For this reason, although the effort information has been provided through data call, it is impossible to show all the information in this report.

3.1.1 Glass eel fisheries

Commercial glass eel fishery is very traditional in Spain. Although data for certain series are available since 1945 for the oldest series, data for some of the whole EMUs are only available since the 1970s.

Although some interannual variability can be observed, glass eel commercial catches in Spain have decrease since the late 1970s (Figure 3, Table 2).

Table 2. Commercial catches (kg) during the last decade fishing seasons.

Year	ES_Astu	ES_Cant	ES_Cata	ES_Mino	ES_Vale
2005	2875		1939	1331	281
2006	2175	25	1356	320	268
2007	2265	11	1483	1140	341
2008	2379	24	1249	1333	164
2009	749	14	1597	1178	117
2010	2612	21	1667	2000	167
2011	2067	45	1527	1311	256
2012	1813	42	2160	1037	274
2013	3511	24	2584	813	223
2014	5820	521	3769	985	185
2015	4452	357	2658	1158	137
2016	3627	553	2085	360	42
2017	3717	325	5082	1212	566
2018	3382	NR	645	731	3
2019	2376	NR	1003	461	253

Recreational glass eel fishery takes place in the Basque Country and Cantabria (Table 3). Since the data gathering system was established in 2004, the lowest catches were recorded in 2009 and 2014 in the EMUs of the Basque Country and Cantabria respectively. After catches increased reaching a maximum in 2014 in the Basque Country and decreased during the last three seasons following the same trend as the commercial catches. Cantabria prohibited recreational fishery from 2014 on.

Table 3. Recreational catches (kg) during the last decade fishing seasons.

Year	ES_Basq	ES_Cant
2005	1181	
2006	1282	374
2007	687	652
2008	1205	358
2009	212	227
2010	614	207
2011	376	13
2012	1082	22
2013	1534	21
2014	2405	8
2015	2316	NP
2016	1730	NP
2017	1511	NP
2018	1725	NP
2019	865	NP

3.1.2 Yellow eel fisheries

Only the Albufera catches data are split into yellow and silver and since 2014, catches from the Mar Menor (Murcia) are also separated in the two stages (Table 4). Additionally, aggregated information exits for other EMUs (Table 5). The data sources are described in the 2017 Spanish Country report (ICES, 2017). The yellow eel catches decreased in Spain since 1950s, although the catches showed a historical peak in late sixties. The combined yellow and silver eel catches show great variability among regions, but in general, there is a decreasing trend in catches.

Table 4. Commercial yellow eel catches (kg) by EMU corresponding to Albufera (Valencia) and Mar Menor (Murcia) during the last decade fishing seasons.

Year	ES_Murc	ES_Vale
2005		1472
2006		1479
2007		1911
2008		2245
2009		4640
2010		2029
2011		1543
2012		1634
2013		1678
2014	13 509	364
2015	5010	
2016	6329	1020
2017	7785	1134
2018		646
2019		437

Table 5. Yellow and silver eel catches (kg) by EMU during the last decade fishing seasons.

Year	ES_Anda	ES_Astu	ES_Bale	ES_Cata	ES_Gali	ES_Mino	ES_Murc	ES_Vale
2005			2159	13710	31705	265	32682	7439
2006		653	2067	17361	63114	277	25631	6481
2007		225	638	22640	28281	149	22789	7352
2008		159	2138		32766	447	20314	10108
2009		142	1993		45730	NP	25631	15361
2010		1168	933	12016	28497	NP	22789	10657
2011		248	339	1900	31984	NP	18662	8481
2012		635	96	17600	36140	NP	19473	10104
2013		450	70	6630	46030	NP	24490	9021
2014		130	48	13519	38795	NP	33537	5560
2015	503	184	NP	10946	28310	NP	NP	
2016	3745	NP	NP	10056	32080	NP	NP	8894
2017	3100	NP	NP	13061	23370	NP	271	9107
2018	4852	NP	NP	9956	27730	NP		7765
2019				7791	6500			6578

3.1.3 Silver eel fisheries

Silver eel catches are reported since 1951 in Valencia and more recently in Murcia (Table 6).

Table 6. Silver eel catches (kg) by EMU during the last decade fishing seasons.

Year	ES_Murc	ES_Vale
2005		4045
2006		3632
2007		4276
2008		4910
2009		6942
2010		3688
2011		2497
2012		3822
2013		3598
2014	20028	2293
2015	13580	NR
2016	24244	4190
2017	19325	5618
2018	NR	4955
2019		4467

3.2 Restocking

Stoking is carried out in freshwater in Spain. Spanish EMUs use different life stages to stock (Table 7). The majority of restocked glass eel come from SEPRONA seizures.

Table 7. Stocking kg in freshwater by EMU. G: Glass eel, GY: glass + yellow eel, Y: yellow eel, YS: Yellow and silver eel OG: Ongrown eels.

	G							GY	Y				YS		S		OG	
Year	ES_Gali	ES_Cant	ES_Anda	ES_Cata	ES_Vale	ES_Nava	ES_Basq	ES_Vale	ES_Anda	ES_Astu	ES_Cata	ES_Nava	ES_Anda	ES_Cata	ES_Anda	ES_Cata	ES_Vale	ES_Cata
2008										4		101						
2009								388		3		102		380		388		
2010								141				90						
2011		5			149				24	14	991	88		903				
2012		12	25	322	103						72				80	80		
2013		13	256		78				8859									
2014	421		19		42				42		88		421					
2015			10					695					147					
2016			1					1055			381		690					
2017			169					1406			300		629					
2018			469	36	412		473	ND			165						1035	
2019			57			130	53											305

3.3 Aquaculture

Information has been collected from the website of the Ministry of Agriculture, Fisheries and Food (https://www.mapa.gob.es/app/jacumar/datos_produccion/lista_datos_produccion2.aspx?Id=es). Although there were different farms in Spain in the 1990s, nowadays almost all the production comes from a farm in Valencia (Figure 4, Tables 8 and 9).

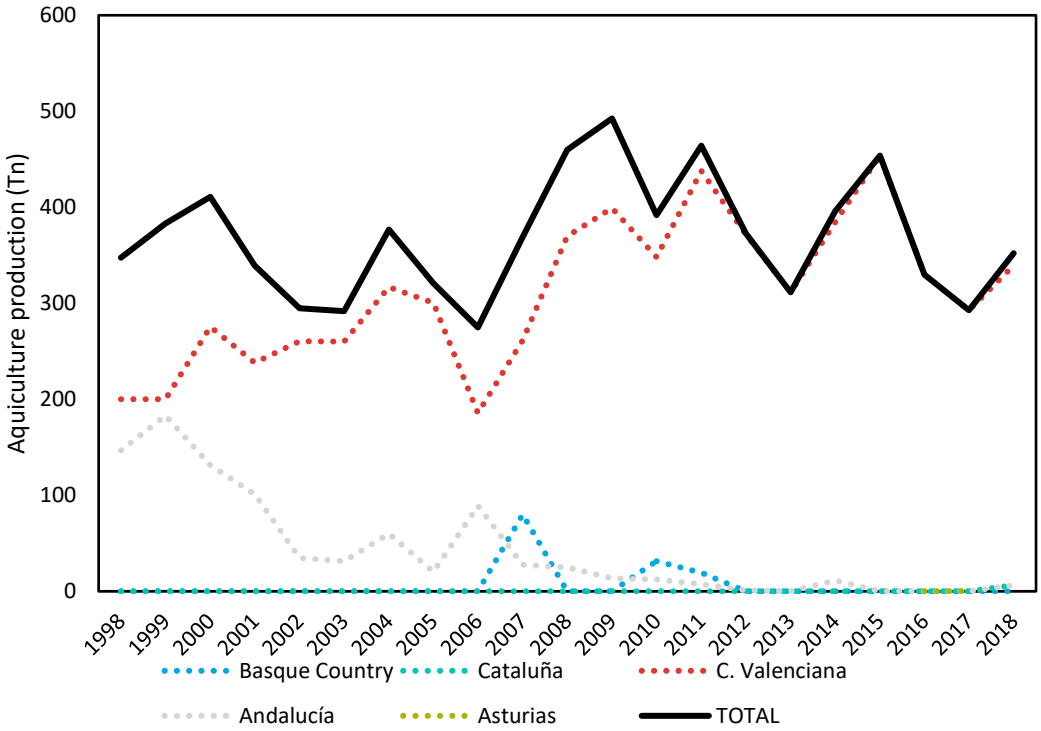

Figure 4. Aquiculture production in the Spanish EMUs since 1998.

Table 8. Freshwater aquaculture production of yellow eel (kg) by EMU.

Year	ES_Anda	ES_Basq	ES_Vale
1998	130000		100
1999	145000		90
2000	109000		80
2001	80000		70
2002			60
2003			50
2004	14000		40
2005			30
2006	70000		20
2007	11000	80000	10
2008	11000	65000	369730
2009		80000	
2010		31450	
2011		19190	4420
2013			81958
2014			5385
2015			81960
2016	0	0	0
2017	0	0	0
2018	0	0	0

Table 9. Open sea aquaculture production of yellow eel (kg) by EMU.

Year	Es_Anda	Es_Astu	Es_Cata	Es_Vale
1998	16700	0	700	200000
1999	37900	0	300	200000
2000	22500	0	3700	275400
2001	20900	0	0	238000
2002	34540	0	0	260320
2003	31370	0	0	260200
2004	46010	0	0	316650
2005	20430	0	0	300470
2006	19170	0	0	185630
2007	16700	0	0	261430
2008	14070	0	0	
2009	13380	0	0	399150
2010	12230	0	0	348000
2011	7180	0	0	437810
2012	860	0	0	371860
2013		0	0	311330
2014	11200	0	0	385430
2015	0	0	0	371970
2016	0	0	0	329880
2017	0	140	0	292300
2018	63330	0	440	339400

3.4 Entrainment

The SUDOANG Interreg SUDOE project (https://www.sudoang.eu/) that started in March 2018 will try to assess the silver eel HPP in three years. Information on two aspects is needed to assess silver eel mortality caused by HPP: HPP location and characteristics and silver eel abundance. In a recent report (Hanel *et al.*, 2019) data on HPP compiled in SUDOANG were used to make a rough estimate of HPP mortality in Spain. Regarding silver eel abundance, SUDOANG is currently building an estimate of instream silver eel production using the inspire river network. However, the model is still under development and estimation of the number of eels in rivers is

not available yet. So, the French model EDA was used in Hanel *et al.* (2019) to estimate eel abundance based in the river network built in SUDOANG, providing an order of magnitude of the potential impact of the main identified HPPs.

The first step was to classify the dams. In Spain some dams, especially in the Mediterranean area, are completely impassable and no silver eel migration can occur, as no upstream migration is possible. Thus, all dams >20 m and <250 km from the sea are in category 1. Other dams <20 m and <250 km from the sea were considered to have a potential impact on eel and are considered as category 2. According to Hanel *et al*., 2019 (Figure 11), 28% of the silver eel run is completely removed by category 1 (impassable) dams. Those represent 16% of the total number of HPP dams, assuming that all dams >20 m are HPP dams. When category 1 dams are not considered, the fraction of dams with a potential impact (category 2) was 18% of the total number of dams in Spain according to the total number of HPP in Spain.

The estimation of the total number of silver eels passing through HPP dams located <250 km from the sea (category 1 and category 2) was the same as that estimated in France (58%).

However, (see Figure 7).

However, this first estimate has to be considered with caution. Firstly, because the density of eel in the upstream river course is probably overestimated, as the dams currently have a very large impact on upstream migration in Spain, more than in France. Secondly, the SUDOANG HPP information compilation has not been totally finished yet. Thus, these estimates will be reviewed and improved by the end of SUDOANG project in 2020.

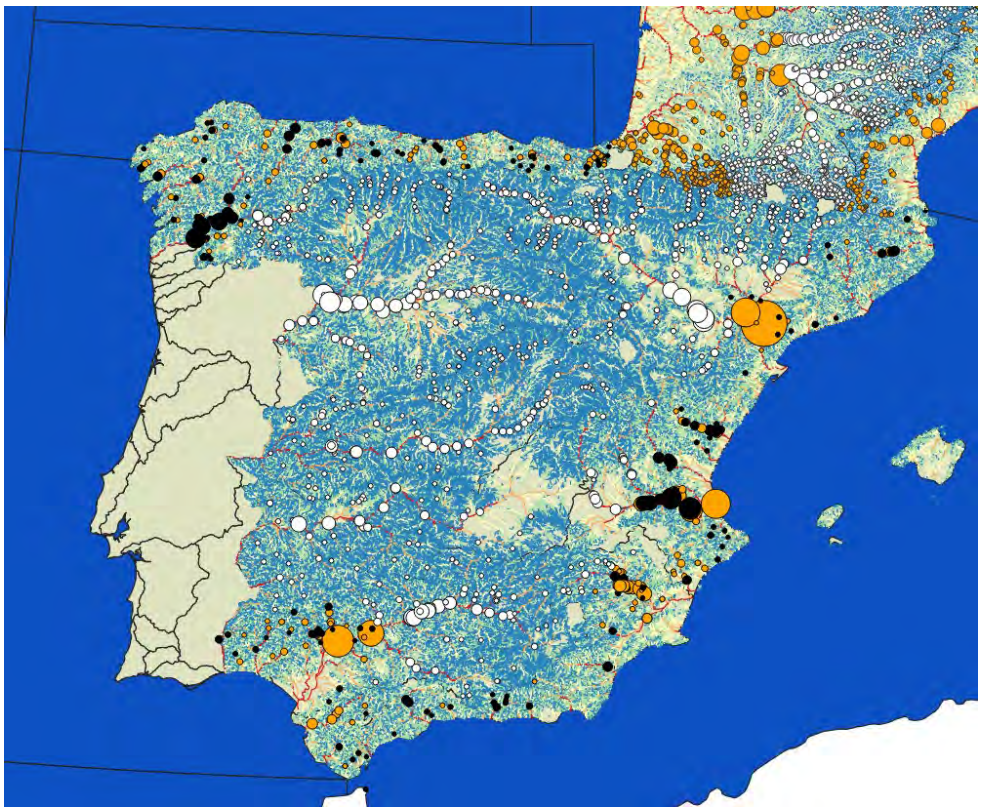

Figure 5. Map of silver eel production predicted in Spain Source: SUDOANG - AZTI, data from Spanish ministry. Impassable dams (category 1: dams >20 m and <250 km) are in Black, other HPP dams (category 2: <20 m and <250 km) are in orange, dams >250 km from the sea are in white.

3.5 Habitat Quantity and Quality

The construction of large dams since the 1960s has led to its disappearance from most of the inland river basins of the Iberian Peninsula; the eel was historically widespread throughout the Iberian Peninsula. According to Clavero and Hermoso (2015) it has lost over 80% of its original range (Figure 6).

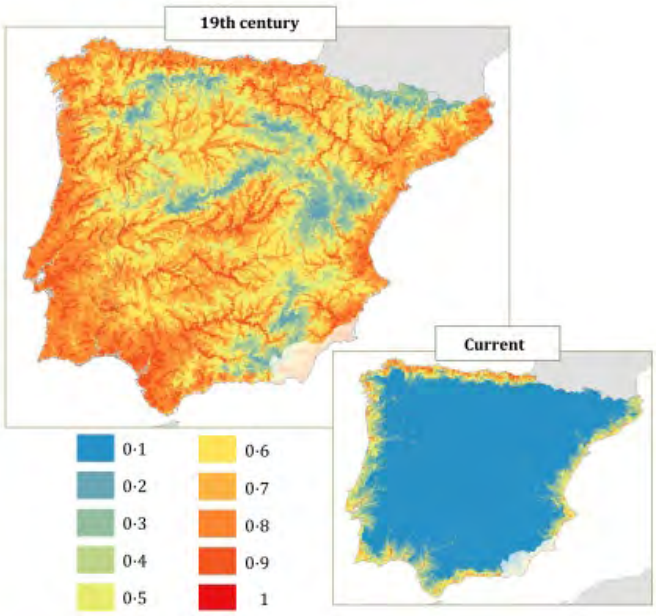

Figure 6. Probability of occurrence of the eel in the Iberian Peninsula in the 19th century and the present (Clavero and Hermoso, 2015).

In the SUDOANG project, a first implementation of the EDA model has been performed.

The first step is to implement a delta model which calculates the probability of presence of eel. The results are totally in line with the results of Clavero and Hermoso (2015) (Figure 7).

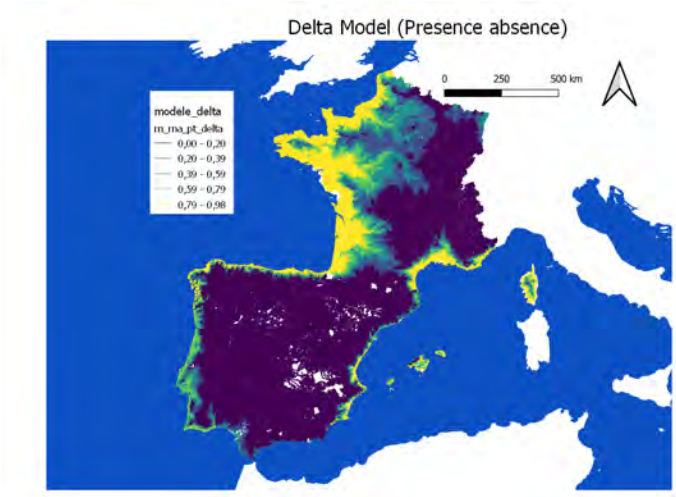

Figure 7. The delta model (probability of presence of eel) produced with the first implementation of EDA in SUDOANG.

3.6 Other impacts

No information available.

4 National stock assessment

No new information since last year's report (Korta and Díaz, 2018).

4.1 Description of Method

4.1.1 Data collection
4.1.2 Analysis
4.1.3 Reporting
4.1.4 Data quality issues and how they are being addressed

4.2 Trends in Assessment results

5 Other data collection for eel

The Spanish EMUs with current presence of eel have chosen pilot basins in which they are sampling the recruitment, standing stock and silver eel population within the EUMAP framework.

On the other hand, one of the objectives of SUDOANG is to implement a sampling network to monitor the eel in the SUDOE area using standardized methods. This network, designed to collect data to support the assessment of the population, includes ten pilot basins (Figure 8) representative of the different habitats found in the SUDOE area (South of France, Spain and Portugal). Information regarding recruitment, standing stock, silver eel population, age, growth, sex ratio and *Anguilligola crassus* presence will be recorded in these basins.

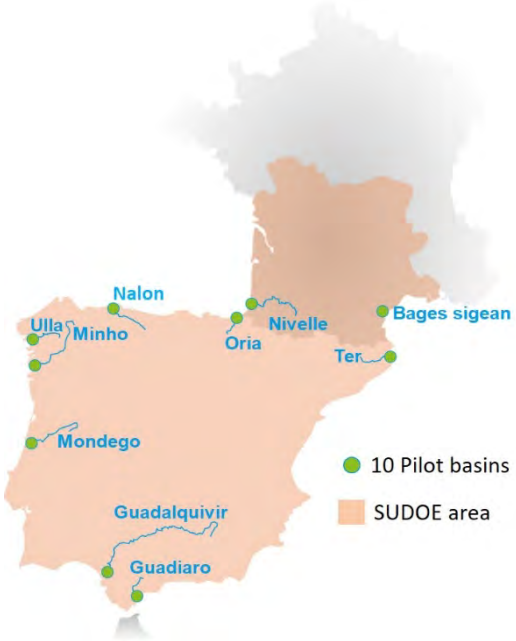

Figure 8. Location of the ten pilot basins, included in the SUDOANG eel sampling network.

In addition, many autonomous regions make periodic multispecific electrofishing surveys but few of them have been exclusively directed at eel. There is not any agreed protocol for sampling, and there is not any compilation of this information at the national level. Some of the autonomous regions envisaged making eel-specific surveys in their management plans.

Yellow eel recruitment in the Oria River is sampled in a yearly basis in a fish pass in the tidal limit.

5.1 Yellow eel abundance surveys

Yellow eel abundance and biometry in the Oria River is sampled using electrofishing in a yearly basis (double-pass electric fishing sampling without replacement, using the Seber and Lecren method (1967), based on the successive catches of De Lury (1947). The estimation of eel population abundance is based on four main length groups and six established development categories (Durif *et al.*, 2005).

Table 10. Yellow eel abundance, and biometry in the Oria River (Basque Country).

Year	N/ha	Length (mm)	Weight (gr)
2004	3603	41	249
2005	3899	42	249
2006	2695	39	242
2007	2187	51	264
2008	2834	50	257
2009	3529	51	265
2010	623	119	342
2011	1358	61	256
2012	1693	50	236
2013	940	52	246
2014	1158	36	228
2015	1167	37	229
2016	2212	36	235
2017	2768	37	227
2018	3467	32	220

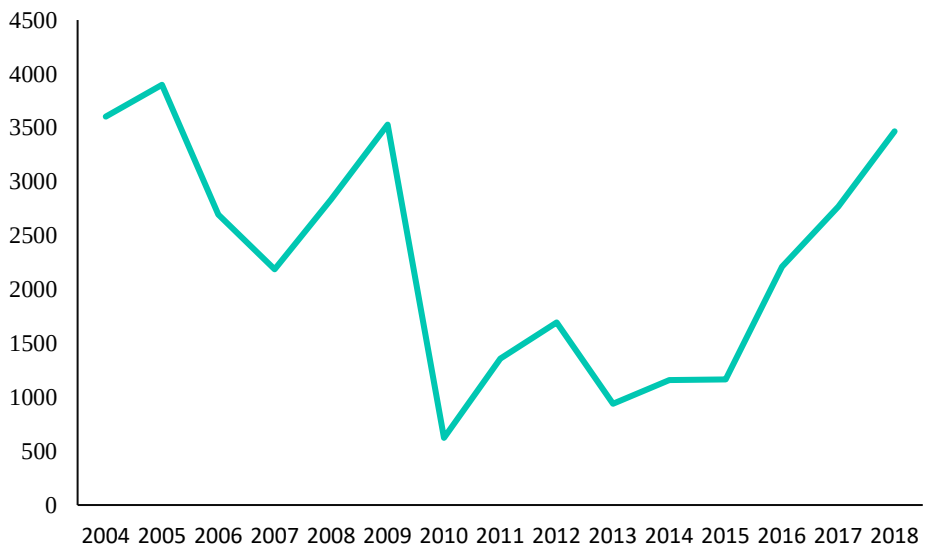

Figure 9. Location of the ten pilot basins, included in the SUDOANG eel sampling network.

In addition, in the ten basins of SUDOANG (see point 5 introduction) abundance surveys are being carried out and results will be available by the end of 2020.

5.2 Silver eel escapement surveys

The Basque management plan determines the spawning potential according to Durif *et al.* (2005) in one river per year. Results are available in the post-evaluation report. Additionally, in another study (EKOLUR S.L.L., 2012) silver eel migration period and related environmental variables were studied in the Urola River (Basque Country). The silver eel migrated between October and January, with a peak in November, and mainly during night and when there is high flow and turbidity.

5.3 Life-history parameters

No new information is available. However, in the ten basins of SUDOANG (see point 5 introduction) information is being collected on percentages of silvering, sex ratio and growth and otoliths that will be available by the end of 2020.

5.4 Diseases, Parasites and Pathogens or Contaminants

Esteve *et al.* (2017) found that prevalence of *Shewanella putrefaciens* group was 1.7% in 2008 and rose above 32% in 2014 in the Albufera Lagoon. It was due to an outbreak of shewanellosis that presented a morbidity rate of 64%. *S. putrefaciens* group strains were isolated as pure cultures from the sick eels that showed white ulcers surrounded by a reddish inflammation, damage of the mouth, extensive skin discoloration, exophthalmia, ascites and bad odour. The *S. putrefaciens* group was recovered from freshwater samples taken at the L'Albufera system, in autumn–winter 2015. Its counts significantly increased in freshwater parallel to hypoxia and temperature rising. *Shewanellae* strains were identified as *S. putrefaciens* and *S. xiamenensis* by 16S rRNA gene sequencing. These isolates recovered from sick eels or freshwater were virulent for European eel by IP challenge (LD50 10 6 CFU g($^{-1}$) body weight). They also caused 30–38% cumulative mortality, in European eels challenged by a 2-h bath (10 7 CFU mL($^{-1}$)). These results suggest that shewanellosis could be transmitted through water highlighting the fact that hypoxic conditions increase this bacterium levels in water.

Esteve and Alcaide (2018) analysed a total of 127 wild eels caught in the La Albufera Lagoon and 24 samples of lagoon freshwater for 1-year period. *Edwardsiella* strains were isolated from liver/kidney on TSA-1 plates in 31.9% of total diseased specimens, and the edwardsiellosis prevalence in the fishery was of 11.8%. The use of double-strength Salmonella-Shigella (DSSS) broth and SS agar yielded *Edwardsiella* isolation from intestine in 100% of those edwardsiellosis-diseased eels, but also in 40.4% of other sick fish with vibriosis or aeromonosis and in 28.8% of healthy eels, as well as from freshwater in 8.3% of samples. Pure cultures were isolated on SS agar from the former, but motile *Aeromonas*, *Plesiomonas shigelloides* and *Hafnia alvei* were recovered along with *Edwardsiella* in the other samples. *Edwardsiella* isolates identification at species level revealed that *E. piscicida* was distributed between wild eels and freshwater but *E. tarda* only did in freshwater. All *E. piscicida* strains were virulent for eels (LD <= 1.0x10(6) CFU/fish) but that of *E. tarda* was not. This is the first report of *E. piscicida* in wild eel intestines and natural freshwater, highlighting its role as potential reservoirs for the bacterium. A seasonal recovery was found for *E. piscicida* at water temperature above 20 degrees C.

SERIDA (The Regional Agrifood Research and Development Service) from Asturias has conducted annual studies of parasitization of *Anguillicola crassus (*Table 11) and other diseases (Table

12). In the case of *A. crassus* during 2018 used a novel ultrasound technique to detect the parasite without killing the eel in Pigüeña and Pilona. However, this technique does not detect small parasites, so the prevalence is underestimated probably.

Table 11. *Anguillicola crassus* presence is the Asturias EMU from 2015 to 2018.

River/Lake	Sampling year	N eels	Eel size (cm)			Eel stage	Prevalence	Infection intensity	Reference
			Min	Max	Mean	G/Y/S			
Bedón	2015	10	25.0	35.0	29.8	Y	50	3.4	Márquez (2015)
Zardón	2015	7	15.0	31.0	22.1	Y	14.28	1	
Pigüeña	2015	10	23.0	41.9	27.0	Y	40	4.25	
Cubia	2015	8	17.3	61.3	32.2	Y	50	1.25	
Esva	2015	10	16.6	29.5	25.4	Y	10	1.5	
Linares	2015	10	15.0	30.0	20.0	Y	20	1	
Eo	2015	10	26.0	38.0	32.0	Y	0	0	
Anguileiro	2016	2	17.5	18.8	18.5	Y	0	0	Márquez (2016)
Vio	2016	10	13.0	27.7	19.1	Y	0	0	
Anleo	2016	10	16.6	27.7	21.0	Y	60	4	
Frexulfe	2016	10	12.4	27.7	20.0	Y	60	2.6	
Barayo	2016	2	29.0	53.0	41	Y	0	0	
Ferrería	2016	10	18.0	30.5	26.8	Y	40	4.2	
Raíces	2016	10	15.0	32.0	19.3	Y	100	2.4	
Uncín	2016	10	15.0	33.0	22.2	Y	70	3.5	
Esqueiro	2016	10	15.0	28.0	20.6	Y	40	2	
Negro	2016	10	24.7	30.8	26.3	Y	40	3	
Porcía	2016	10	19.5	32.5	24.3	Y	0	0	
Casañu	2016	10	24.5	35.6	30.7	Y	0	0	
Novales	2017	24	7.2	31.5	24.1	Y	10	1	Márquez (2017)
Cabra	2017	14	11.9	26.2	17.5	Y	20	1	
Purón	2017	18	9.0	23.3	15.6	Y	20	1	

River/Lake	Sampling year	N eels	Eel size (cm)			Eel stage	Prevalence	Infection intensity	Reference
			Min	Max	Mean	G/Y/S			
Carroceu	2017	10	12.3	27.5	19.8	Y	100	3	
Ereba	2017	14	9.4	27.4	19.9	Y	40	1.5	
Guadamía	2017	10	12.1	34.2	26.4	Y	50	3.8	
Parda	2017	10	18.0	36.0	29.1	Y	60	2.8	
Acebo	2017	19	8.0	26.8	19.2	Y	50	3.4	
Espasa	2017	17	9.0	29.3	18.1	Y	50	1.4	
Llibardón	2017	22	6.7	11.7	7.8	Y	20	1.5	
España	2017	19	6.5	24.4	13.1	Y	50	1	
Peñafrancia	2017	13	16.6	33.4	23.4	Y	50	1.6	
Ñora	2017	12	11.7	29.3	19.5	Y	50	1.8	
Vioño	2017	23	8.0	27.5	14.9	Y	70	1.7	
Piloña	2017	10	18.5	32.0	25.0	Y	40	5.6	
Cares	2017	10	12.0	34.5	21.5	Y	0	0	
Aranguín	2017	10	14.0	31.0	23.0	Y	30	1.3	
Nonaya	2017	10	15.0	27.0	20.9	Y	60	1.6	
Mallene	2017	10	15.5	30.0	22.3	Y	60	2.6	
Narcea	2018	18	29.0	38.0	32.9	Y/S	27	1.4	Márquez (2018)
Pigüeña	2018	15	30.0	36.0	33.2	Y/S	0	0	
Piloña	2018	10	31.0	45.0	36.7	Y/S	0	0	

Table 12. Infectious diseases in the Asturias EMU rivers from 2015 to 2018.

River/Lake	Sampling year	N eels	Eel size (cm)			Eel Stage	*Edwarsiella tarda*	*Vibrio (Listonella) anguillarum*	*Aeromonas salmonicida*	*Streptococcus iniae*	References
			Min	Max	Mean	G/Y/S	Prev.	Prev.	Prev.	Prev.	
Bedón	2015	10	25	35	29.8	Y	0	0	20	ND	Márquez (2015)
Zardón	2015	7	15	31	22.1	Y	0	0	0	ND	
Pigüeña	2015	10	23	41.9	27	Y	0	0	0	ND	
Cubia	2015	8	17.3	61.3	32.2	Y	25	0	0	ND	
Esva	2015	10	16.6	29.5	25.4	Y	10	0	10	ND	
Linares	2015	10	15	30	20	Y	0	0	0	ND	
Eo	2015	10	26	38	32	Y	0	0	0	ND	
Vio	2016	10	13	27.7	19.09	Y	0	0	0	0	Márquez (2016)
Anleo	2016	10	16.6	27.7	20.97	Y	0	0	0	0	
Frexulfe	2016	10	12.4	27.7	20	Y	20	0	0	0	
Barayo	2016	2	29	53	41	Y	0	0	0	0	
Ferrería	2016	10	18	30.5	26.8	Y	0	0	20	0	
Raíces	2016	10	15	32	19.3	Y	0	0	40	20	
Uncín	2016	10	15	33	22.2	Y	0	0	40	0	
Esqueiro	2016	10	15	28	20.6	Y	0	0	0	0	
Negro	2016	10	24.7	30.8	26.3	Y	0	0	20	0	
Porcía	2016	10	19.5	32.5	24.3	Y	0	0	60	0	
Casañu	2016	10	24.5	35.6	30.7	Y	0	0	30	0	
Novales	2017	24	7.2	31.5	24.1	Y	0	0	0	0	

River/Lake	Sampling year	N eels	Eel size (cm)			Eel Stage	*Edwarsiella tarda*		*Vibrio (Listonella) anguillarum*		*Aeromonas salmonicida*		*Streptococcus iniae*		References
			Min	Max	Mean	G/Y/S	Pre	v.	Pre	v.	Pre	v.	Pre	v.	
Cabra	2017	14	11.9	26.2	17.5	Y	0		0		0		0		Márquez (2017)
Purón	2017	18	9	23.3	15.6	Y	0		0		0		0		
Carroceu	2017	10	12.3	27.5	19.8	Y	0		0		0		0		
Ereba	2017	14	9.4	27.4	19.9	Y	0		0		0		0		
Guadamía	2017	10	12.1	34.2	26.4	Y	0		0		0		0		
Parda	2017	10	18	36	29.1	Y	0		0		0		0		
Acebo	2017	19	8	26.8	19.2	Y	0		0		0		0		
Espasa	2017	17	9	29.3	18.1	Y	0		0		0		0		
Llibardón	2017	22	6.7	11.7	7.8	Y	0		0		0		0		
España	2017	19	6.5	24.4	13.1	Y	0		0		0		0		
Peñafrancia	2017	13	16.6	33.4	23.4	Y	0		0		0		0		
Ñora	2017	12	11.7	29.3	19.5	Y	0		0		0		0		
Vioño	2017	23	8	27.5	14.91	Y	0		0		0		0		
Piloña	2017	10	18.5	32	25	Y	0		0		0		0		
Cares	2017	10	12	34.5	21.5	Y	0		0		0		0		
Aranguín	2017	10	14	31	23	Y	0		0		0		0		
Nonaya	2017	10	15	27	20.9	Y	0		0		0		0		
Mallene	2017	10	15.5	30	22.3	Y	0		0		0		0		

Table 12. Virus presence in the Asturias EMU rivers from 2015 to 2018.

River	Sampling year	N eels	Eel size (cm)			Eel Stage	*Aquabirnavirus*	*EVE*	*EVEX*	*Herpesvirus anguillae*	*Infectious pancreatic necrosis virus*	*Rhabdoviridae*	
			Min	Max	Mean		Prev.	Prev.	Prev.	Prev.	Prev.	Prev.	
Bedón	2015	10	25	35	29.8	Y	0	0	0	0	0	0	Márquez (2015)
Zardón	2015	7	15	31	22.1	Y	0	0	0	0	0	0	
Pigüeña	2015	10	23	41.9	27	Y	0	0	0	0	0	0	
Cubia	2015	8	17.3	61.3	32.2	Y	0	0	0	0	0	0	
Esva	2015	10	16.6	29.5	25.4	Y	0	0	0	0	0	0	
Linares	2015	10	15	30	20	Y	0	0	0	0	0	0	
Eo	2015	10	26	38	32	Y	0	0	0	0	0	0	
Vio	2016	10	13	27.7	19.09	Y	0	0	0	0	0	0	Márquez (2016)
Anleo	2016	10	16.6	27.7	20.97	Y	0	0	0	0	0	0	
Frexulfe	2016	10	12.4	27.7	20	Y	0	0	0	0	0	0	
Barayo	2016	2	29	53	41	Y	0	0	0	0	0	0	
Ferrería	2016	10	18	30.5	26.8	Y	0	0	0	0	0	0	
Raíces	2016	10	15	32	19.3	Y	0	0	0	30	0	0	
Uncín	2016	10	15	33	22.2	Y	0	0	0	20	0	0	
Esqueiro	2016	10	15	28	20.6	Y	0	0	0	0	0	0	
Negro	2016	10	24.7	30.8	26.3	Y	0	0	0	0	0	0	
Porcía	2016	10	19.5	32.5	24.3	Y	0	0	0	0	0	0	
Casañu	2016	10	24.5	35.6	30.7	Y	0	0	0	0	0	0	
Novales	2017	24	7.2	31.5	24.1	Y	0	0	0	0	0	0	Márquez (2017)
Cabra	2017	14	11.9	26.2	17.5	Y	0	0	0	0	0	0	

River	Sampling year	N eels	Eel size (cm)			Eel Stage	*Aquabirnavirus*		*EVE*		*EVEX*		*Herpesvirus anguillae*		*Infectious pancreatic necrosis virus*		*Rhabdoviridae*	
			Min	Max	Mean		Pre	v.	Pre	v.	Pre	v.	Pre	v.	Pre	v.	Pre	v.
Purón	2017	18	9	23.3	15.6	Y	0		0		0		0		0		0	
Carroceu	2017	10	12.3	27.5	19.8	Y	0		0		0		0		0		0	
Ereba	2017	14	9.4	27.4	19.9	Y	0		0		0		0		0		0	
Guadamía	2017	10	12.1	34.2	26.4	Y	0		0		0		0		0		0	
Parda	2017	10	18	36	29.1	Y	0		0		0		0		0		0	
Acebo	2017	19	8	26.8	19.2	Y	0		0		0		0		0		0	
Espasa	2017	17	9	29.3	18.1	Y	0		0		0		0		0		0	
Llibardón	2017	22	6.7	11.7	7.8	Y	0		0		0		0		0		0	
España	2017	19	6.5	24.4	13.1	Y	0		0		0		0		0		0	
Peñafrancia	2017	13	16.6	33.4	23.4	Y	0		0		0		0		0		0	
Ñora	2017	12	11.7	29.3	19.5	Y	0		0		0		0		0		0	
Vioño	2017	23	8	27.5	14.91	Y	0		0		0		0		0		0	
Piloña	2017	10	18.5	32	25	Y	0		0		0		0		0		0	
Cares	2017	10	12	34.5	21.5	Y	0		0		0		0		0		0	
Aranguín	2017	10	14	31	23	Y	0		0		0		0		0		0	
Nonaya	2017	10	15	27	20.9	Y	0		0		0		0		0		0	
Mallene	2017	10	15.5	30	22.3	Y	0		0		0		0		0		0	

In addition, in some basins of SUDOANG (see point 5 introduction) information is being collected on *Anguillicola crassus* presence.

6 New Information

Briand *et al.* (2019) analysed the length and condition of glass eel for 20 years from 1997 to 2018 from nine European locations, including four Spanish estuaries, Northern Ireland and France. Morphometric data were analysed by mixed models including both long-term and cyclic intra-seasonal trends. The long-term length trend extracted from these models helped to explain the recorded short-term variation in recruitment. The minimum in 2010 and largest recruitment values in 2014 were well explained by glass eel length, which in turn suggested that oceanic processes had a strong influence. However, over the long term, glass eel length has diminished despite returning several times to historical values, and so failed to explain the decline in recruitment. The long-term trend in body condition was less clear, but the intra-seasonal trend showed a marked difference between Atlantic and Mediterranean locations. This suggests a single wave of glass eel per season in Northern Ireland and the Bay of Biscay with a more complex recruitment process, including a secondary wave of migration, in the springtime, in the Guadalquivir and the Mediterranean.

Herrera *et al.* (2019) studied the changes in the home range eel in the Mediterranean Guadiaro river (South of Spain), in relation to the animals' body length (TL), and the influence of environmental factors (water temperature and flow) on the local movements of this population through observation of their sedentary behaviour. Their results revealed relatively short movements in relation to other populations, and they hypothesize that this could be related to the high habitat diversity and low eel population density in the study area. The home range size showed a high variability and dispersion among the smallest eels, however, as TL increased, the variability of home range size decreased, and home ranges were larger. They suggest that these changes could be associated with the acquisition of a sedentary lifestyle. Once eels had become sedentary, an environmental pattern was observed between their movements and the water temperature and flow, with larger movements observed as the flow increased and water temperature decreased.

In the framework of SUDOANG harmonized sampling protocols have been produced for: P1.Yellow/silver eel sampling; P2. Glass eel recruitment; P3. Otolith preparation and age reading; P.4 *A crassus* determination and P.5 sex ratio assessment These protocols can be found at: https://sudoang.eu/wp-content/uploads/2019/02/Protocols-for-recruitment-silvering-and-otolith-preparation.zip

Haubrock *et al.*, 2019 simulated how the reintroduction of European eel in Lake Arréo (Basque Country) could help to control alien species. Their hypothesis was that the reintroduction of the European eel could lead to an increased predation on crayfish as shown by previous studies and also affects the abundance of juvenile fish. To investigate the current situation of Lake Arreo, stable isotope analyses were conducted using 15 muscle tissue samples per each fish and crayfish species, while stomach contents of the same species were analysed. Additionally, samples from the common reed *Phragmites australis*, the trophically lowest food source available for fish and crayfish species, were collected and used as baseline for the isotope analysis. To investigate the usefulness of stable isotopes to predict the effects of species reintroductions on present species communities, available stable isotope and diet data from *A. anguilla* in a German freshwater lake with a similar species composition were retrieved and included in the Arreo community analysis. While results from both, dietary and stable isotope analyses, indicate high interactions among alien species with *P. clarkia* having a central position, the modelled reintroduction of *A. anguilla* shows to possibly affect recruits of alien fish species as well as an increased feeding of *M. salmoides* on reintroduced eels.

AZTI, in its annual campaign to determine the biomass of anchovy in the Gulf of Biscay (BIOMAN), takes water samples to carry out an eDNA analysis to detect the species in the area. Some of the species detected are diadromous. The results will be published shortly. Also, AZTI is working on EDAMAME project (2019–2021) that will analyse the eDNA of different water samples in the rivers of Gipuzkoa to compare them with the eel abundances obtained with electric fishing and to see the utility of the eDNA to estimate the eel abundance.

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Report on the eel stock, fishery and other impacts, in Sweden

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1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

The assessment made in 2015 was updated in spring 2018 and revised in late summer 2018 (Dekker *et al*., 2018). Compared to the 2016 assessment, the 2018 update made no major changes in methodology, though some of the model parameters were changed slightly (notably: improved recruitment estimates and length–weight relation, both for the inland stock). Dekker *et al*. (2018) took all impacts throughout the eel's life into account – that is: including the impacts in the yellow eel stage, often in other countries in the Baltic – and noting that those impacts remain unquantified for the Baltic as a whole, reported indicators as "not available" (the impact of the Swedish fishery was reported separately, as FSE).

Since the 2018 assessment, no new results exist, i.e. Table SE. 1 copies the Swedish 2018 Country Report.

Table SE. 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
2018	SE-West	NP	NA	NA	NA	NA	0.00	0.00	0.00
2018	SE-Inland+	1 800 000	564 000	113 000	314 000	20.0	0.36	0.72	1.08
2018	SE-Inland-	1 800 000	300 000	18 000	51 000	6.1	0.36	0.72	1.08
2018	SE-East	NP	NA	3 627 000	NA	NA	NA	NA	NA

Key: EMU_code = Eel Management Unit code; B0 = the amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the stock (kg); Bcurr = the amount of silver eel biomass that currently escapes to the sea to spawn (in the assessment year) (kg); Bbest = 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.

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.

The Swedish input to international (WGEEL) recruitment series is based on data on catch of glass eels in the open sea (former ICES YFS, now IBTS, 1st quarter, Figure SE. 1), the catch of glass eels at the Ringhals nuclear power plant (Figure SE. 2) and the amounts of ascending young eels from eel passes in a number of rivers along the Swedish coasts (Figures SE. 3–4).

Recruitment of glass eel (truly unpigmented) to the Swedish west coast is monitored at the intake of cooling water to the Ringhals nuclear power plant at the Kattegat shore (Figure SE. 2). The

sampling at Ringhals is performed twice weekly in February–April, using a modified Isaacs–Kidd Midwater trawl (IKMT). The trawl is fixed in the current of incoming cooling water, fishing passively during entire nights.

The arrival of the glass eels to the sampling site varies between years, probably as a consequence of hydrographical conditions, but the peak in abundance normally occurs in late March to early April. The sampling depends on the operation of the power plant, i.e. the amount of seawater needed for cooling. In 2017, sampling was moved to an alternative intake channel (cooling the reactors 3 and 4) a few hundred meters SW along the same shoreline due to discontinued operations of reactors 1 and 2. This new sampling site was used also in 2018–2019, and will become the permanent sampling site. The annual glass eel index has been adjusted for different levels of water current by multiplying by a factor two when only one out of the two reactors was in operation at each site. Corrections like this were done for several years with similar situations. The true relationship between current and glass eel catchability is not known.

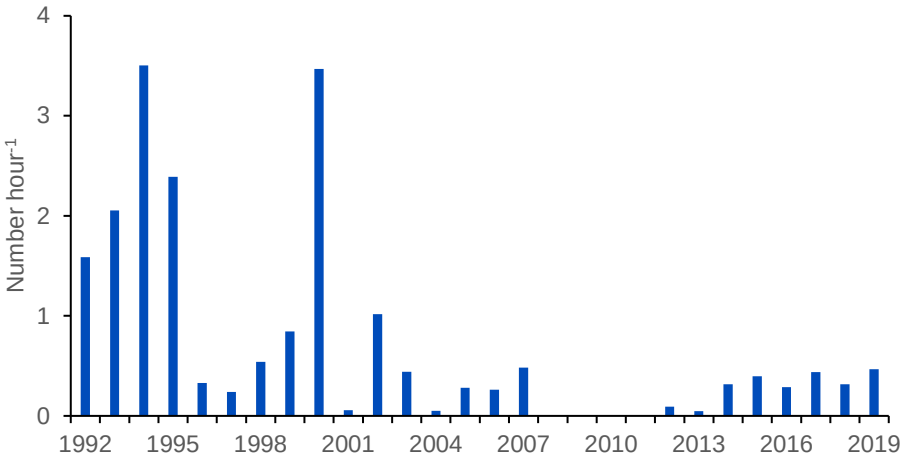

Figure SE. 1. Catch in late winter of glass eels in a MIK-trawl in open sea (Kattegat- Skagerrak). Note that in 2011, no MIK-trawling occurred, i.e. a zero catch is the actual value for years displaying n=0, except for 2011.

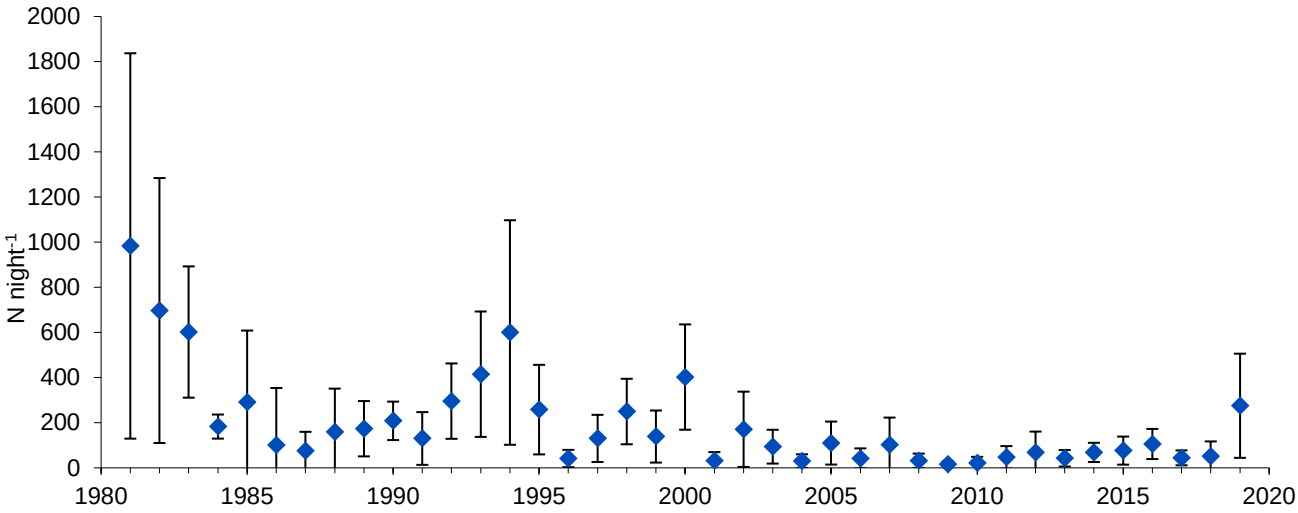

Figure SE. 2. Recruitment index of glass eel at the cooling water intake at Ringhals nuclear power plant. The index is calculated as the average number caught per night during February to April (weeks 9–18), corrected for number of nuclear reactors taking in cooling water. Error bars represent standard deviation.

As the catch of ascending young eels has seriously declined in most rivers, the interest and maintenance of the eel passes might have deteriorated in some cases. The removal of dams and the construction of bypasses at some hydropower dams have actually changed the conditions in other rivers. Today only the most reliable sites are used to construct the recruitment indices.

There was a promising peak in 2019 in glass eel number at the cooling water intake at Ringhals (Figure SE. 2). In addition, preliminary data from a few eel passes along the west coast indicate increasing numbers of recruits during the last few years. On the east coast (Baltic Sea), the number of recruits is still very low. Unfortunately, the longest recruitment series in Europe, River Göta Älv was interrupted in 2018, due to lack of staff. This seems to be the case also in 2019.

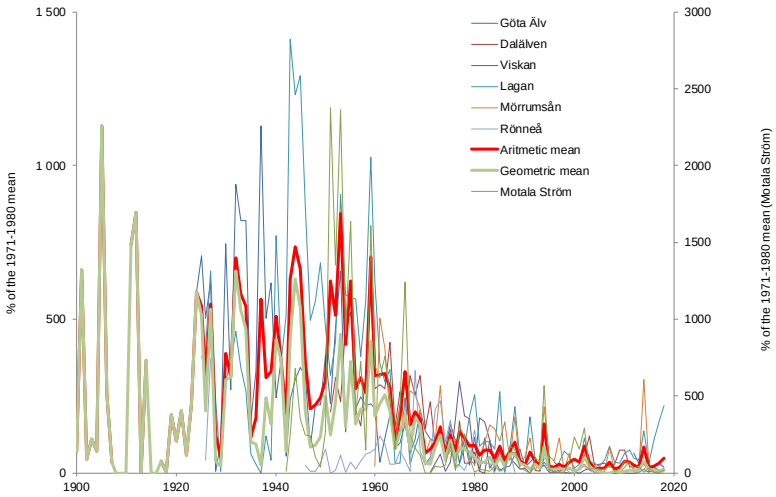

Figure SE. 3. Recruitment of young eels in seven rivers (relative to the average for 1971–1980) from 1900–2018.

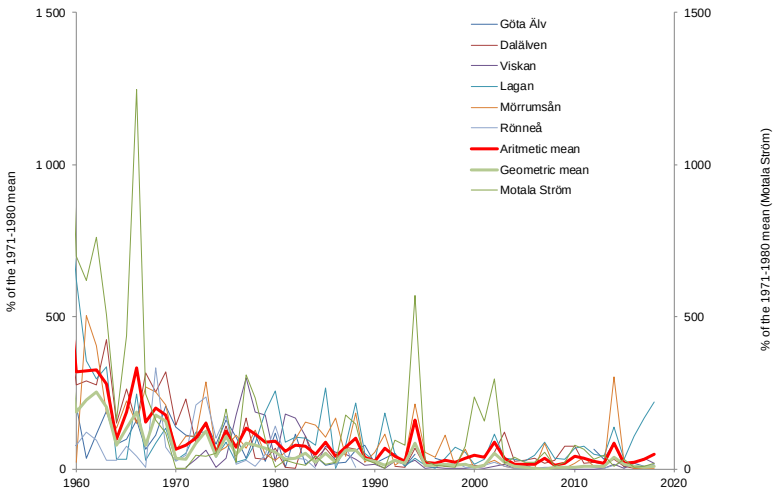

Figure SE. 4. Recruitment of young eels in seven rivers (relative to the average for 1971–1980). Same data as above in Figure SE 3, but reduced to 1960–2018 to better show recent years.

To increase and improve this kind of recruitment monitoring, we would like to open one or several stations where young-of-the-year elvers could be monitored along our west coast independently from relying on dam owners, etc. So far, this wish has not been realised. However, there is also an extensive electro-fishing programme running in Sweden. This programme runs in stream and small rivers, is financed from several different sources and the target species are

normally salmonids as salmon and trout. However, eels are also caught and reported on. All data are entered into a national database (SERS), that we would like to explore and analyse with respect to recruitment and abundance of mainly yellow eels into freshwater systems.

2 Overview of the national stock and its management

2.1 Describe the eel stock and its management

2.1.1 EMUs, EMPs

Sweden has one Eel Management Plan (EMP), covering the entire country, including the mountain region in the north and northwest where eels factually do not occur anymore. However, for various reasons, assessments are made for three separate regions, i.e. there are three Eel Management Units (EMU), namely the west coast (SE-West), Baltic (SE-East) and the Inland (SE-Inland). Data, habitats and management measures differ fundamentally between the regions.

Two ecoregions are concerned, namely the North Sea and the Baltic Sea. However, the fishery for eels along the Swedish west coast north of Torekov, in the North Sea area, was closed in spring 2012. Öresund is the strait between Sweden and Denmark where most silver eels from the Baltic Sea have to pass when leaving for the North Sea and the Atlantic Ocean. Öresund is defined as part of the Baltic Sea in this report and by all relevant eel advice and management authorities.

In the Baltic Sea there are two main types of eel fisheries. One is the traditional fishery with fixed traps (poundnets) along the "Eel Coast" in the southernmost county Scania, where silver eels are the target species. The other type of fishery also uses large poundnets, but targets several species including cod, perch, pike, flounder, etc. depending on the site and abundance of different species. Fykenets of different sizes are also used at several sites.

Finally, there is an eel fishery in a number (ca. 20) of inland lakes. The major part of eel landings today are from lakes Mälaren, Vänern and Hjälmaren. This fishery is also mainly maintained using poundnets and targets additional species to eels. Pike-perch is one of the most important species in this context and has become the most important species in many freshwater fisheries.

2.1.2 Management authorities

The fish stocks and the fisheries are managed by the governmental agency, Swedish Agency for Marine and Water Management, SwAM. Data and advice for management use are mainly given by the Department of Aquatic Resources at the Swedish University of Agricultural Sciences (SLU Aqua).

2.1.3 Regulations

The fishery for eels has been regulated in several different ways since 2007, e.g. through a mandatory eel fishing licence, an increased minimum legal size, effort restrictions in time and number of fishing gears, an upper limit in total catch per licence, and, as previously mentioned, a total closure of the eel fishery along the west coast north of Torekov in 2012.

At the EU Ministerial Council in December 11–13, 2017, a decision was taken on a moratorium for commercial fisheries on eel longer than 12 cm in all EU marine waters in the Northeast Atlantic, including the Baltic Sea. The moratorium should cover three consecutive months between September 1, 2018 and January 31, 2019. The SwAM subsequently decided in 2018 that the moratorium in Sweden should apply between November 1, 2018 and January 31, 2019.

In December 2018, a similar decision was taken by the EU Council. This time the three-month closure covers also eels smaller than 12 cm (i.e. also glass eels) and recreational fisheries, and the Mediterranean Sea has been included. Freshwater fisheries are exempted. The three-month closure should be placed within August 1, 2019 and February 29, 2020. SwAM decided to keep a November–January closure.

2.1.4 Management actions

The Swedish EMP is an adaptive plan where a restricted fishery is one management action among others; the aim of the EMP is to reduce anthropogenic impacts to a level that will allow the stock to recover. Stocking is another one, where the target was to double the earlier amounts of slightly pre-grown elvers to about 2.5 million individuals stocked annually. An improved escapement of silver eels at hydropower plants is also a management measure in the EMP as well as an improved control of the fishery.

The stocking target was reached within a few years, except in 2015 when the EU-funds were emptied. In 2017, most eels aimed for restocking were destroyed due to an infection with the Eel Virus European X (EVEX). Thus, the national eel management plan suffered a great loss in that year, both in loss of restocking fish and economically. Trap and Transport (T&T) of silver eels from upstream to downstream sites in rivers has been implemented, but a few hydropower plants have also been reconstructed to allow a safe downstream migration of silver eels. Within this T&T-program some 122 000 silver eels were safely transported downstream by road between 2010 and 2018. T&T will continue as one measure to decrease eel mortalities due to hydropower exploitation.

As mentioned, eel fishing has been reduced in Swedish coastal waters. In 2007, a licence requirement was introduced and was followed by additional restrictions. Since spring 2012, eel fishing south of Torekov (56°25′) in the Kattegat (west coast) and in the Baltic Sea has been limited to the period May 1–September 14, or an individually determined period of 90 consecutive days. In the part of Kattegat just north of Öresund this determined period is restricted to 60 days only. In freshwater eel fishing is allowed for licensed fishers during 120 individually determined days. In addition, as previously mentioned, SwAM decided in 2019 that the moratorium on coastal eel fishing in Sweden should apply between November 1, 2019 and January 31, 2020.

2.1.5 Local stock assessment

According to the Swedish Eel Management Plan, the entire Swedish national territory formally constitutes a single management unit. Several management actions, however, and most of the anthropogenic impacts differ between geographical areas: inland waters and coastal areas are contrasted and west coast vs. Baltic coast (east and south). Anthropogenic impacts include barriers for immigrating recruits, restocking, yellow and silver eel fisheries, hydropower related mortality, Trap & Transport of young recruits and of maturing silver eels, etc.

The assessment in Dekker (2012; 2015) and Dekker *et al*. (2018) is broken down along geographical lines, also considering the differences in impacts, resulting in four blocks, with little interaction in between. These blocks are described in detail in the Swedish Country Report 2018.

2.1.5.1 Reporting

Selected results from Swedish eel studies were reported to the EU as requested in 2012, 2015 and 2018. This was done by the responsible agency, SwAM, based on an assessment report published by our department report series Aqua reports (e.g. Dekker, 2012; Dekker, 2015; Dekker *et al*.,

2018). Additionally, relevant data are used for scientific papers (see the reference list below). Selected data and results are also reported to ICES and WGEEL when appropriate.

2.1.5.2 Data quality issues and how they are being addressed

The assessments reported in Dekker (2015) make use of extensive databases on recruitment, elver transport, restocking, landings, age and growth, hydropower installations, river geography, and more; covering an extended geographical area, over a period of many decades. For the 2015 assessments, an extensive re-checking of the basic data took place, applying business rules and comparing to the original sources. More importantly, the assessments making cross-links between the databases, inconsistencies have been revealed and subsequently corrected. The 2018 assessment was essentially a repetition of the 2015 assessment with a few more years of data (Dekker *et al*., 2018).

For the west coast, no assessment was produced in 2015. Historical data have been compiled, (re)-checked and analysed (Magnusson and Dekker, in prep.).

For the inland waters, Dekker (2015) predicted yellow and silver eel abundance from the available information on recruits (natural, translocated, restocked) forward in time, towards the yellow and silver eel stage. No independent verification on yellow or silver eel data had been made. In 2016, investigations have started to include information on yellow eel abundance, derived from electro-fishing surveys. This will require mixing a state-based approach (electrofishing) with a rate-based approach (recruitment, catch). Most of the eel stock is located in lakes, while electrofishing covers mainly rivers, a problem to be addressed.

For the Baltic coastal fishery, Dekker (2015) reported mortality rates on the basis of Survival Analysis of a century of mark–recapture data (Dekker and Sjöberg, 2013). Stock size (biomass) estimates were derived from the Survival Analysis results (fishing mortality), in combination with available landings data. The quality of the landings data appears to put severe constraints on the credibility of the results. Landings data constituting a census (full coverage of all operations) rather than a survey (statistical sampling), the reliability of the landings data cannot be quantified. The targeted silver eel is derived from yellow eel stocks along the Swedish coast, in Swedish inland waters, but probably mostly from coastal and inland waters in other countries all over the Baltic area. In order to cross-check the Swedish escapement biomass estimates, a joint assessment of the whole Baltic stock is required (which in itself will be required to develop joint management of this shared stock). A proposal for an international research project to develop this joint assessment has been compiled (Dekker, 2013), but was not prioritised policy-wise.

2.1.5.3 Assessment results

No new assessments have been made. We refer to the Swedish 2018 Country Report for the latest assessment results. For the inland waters, Figures SE. 5 and 6 present the assessed trends in eel production (Figure SE. 5) and impacts (Figure SE. 6).

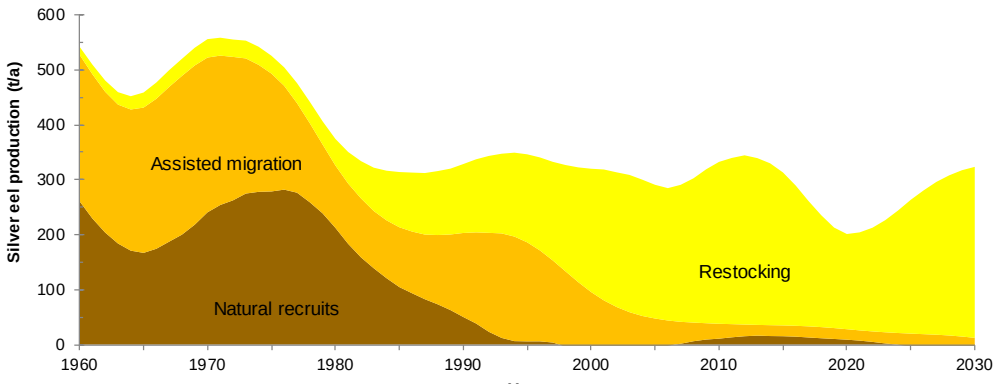

Figure SE. 5. Production of silver eel by year and by origin of the eel, that is: the estimated total production before the impact of fishery and hydropower. For these results, a natural mortality rate of M=0.10 was assumed.

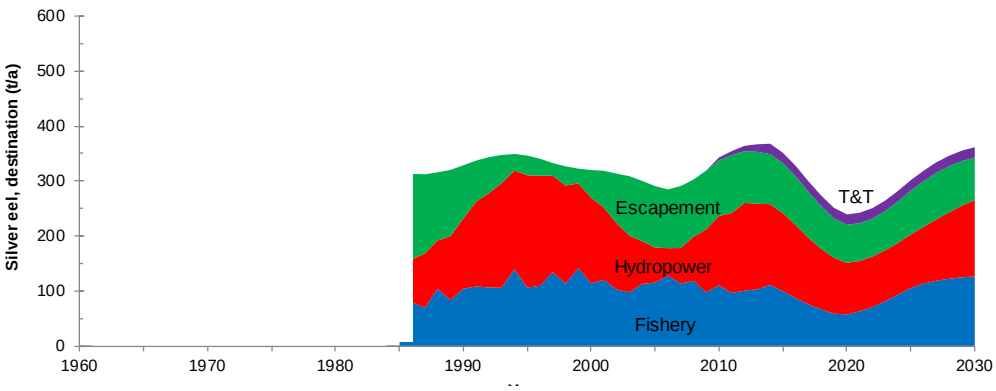

Figure SE. 6. Time trends in the destination of the silver eel produced in inland waters. Data before 1986 are incomplete.

2.2 Significant changes since last report

There have not been any major changes in the status of eel in Sweden since the previous country report, although a high recruitment index was noted at Ringhals in 2019 in relation to the previous two decades. In addition, preliminary data from a few eel passes along the west coast indicate increasing numbers of recruits during the last few years.

3 Impacts on the national stock

3.1 Fisheries

3.1.1 Glass eel fisheries

NP; there is no fishery for glass eels in Sweden. The reasons are twofold as there has never been any local demand for such small eels and the fact that high minimum legal size (700 mm) preclude fishing for glass eels.

3.1.2 Yellow eel fisheries

Most eels fished today are silver eels or "half-silver", i.e. close to the silver stage. The minimum legal size of 700 mm may explain this situation. The remaining fishery almost exclusively targets silver eel; hence, no separate samples are taken of yellow and silver, but mixed samples representative for the catch. Data are presented below in Section 3.1.3.

3.1.3 Silver eel fisheries

As detailed above in \section 3.1.2, most eels fished in Sweden are silver eels or close to the silver stage. The coastal fishery is limited to the east and south coast (the Baltic Sea), and the west coast south of 56°25′ (Öresund and the southernmost part of the Kattegat). In 2018, the Swedish coastal fisheries had a total catch of 146 tonnes, out of which 127 tonnes were caught in the Baltic Proper (Figure SE. 7–8). The freshwater catch for 2018 was 102 tonnes (Figure SE. 9), i.e. together with the brackish/marine fisheries the total Swedish catch for 2018 was 248 tonnes (Figure SE. 9). The catch per unit of effort (CPUE) in two monitored coastal fisheries of the Baltic Sea has been quite stable in recent years, in particular in southern Östergötland (Figure SE. 10). In North Kalmar, there was a peak CPUE recording in 2016, which could possibly be explained by a low fishing effort the same year (Figure SE. 10).

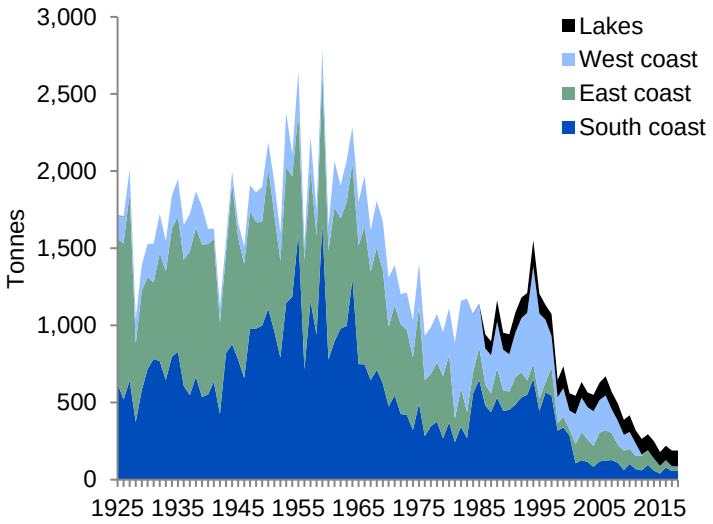

Figure SE. 7. Total commercial landings of eel (NB, this long time-series is based on sales notes reports) for lakes and for the west, east and south coast. Note that for lakes, no data prior to 1986 are available. The west coast fishing was closed in 2012.

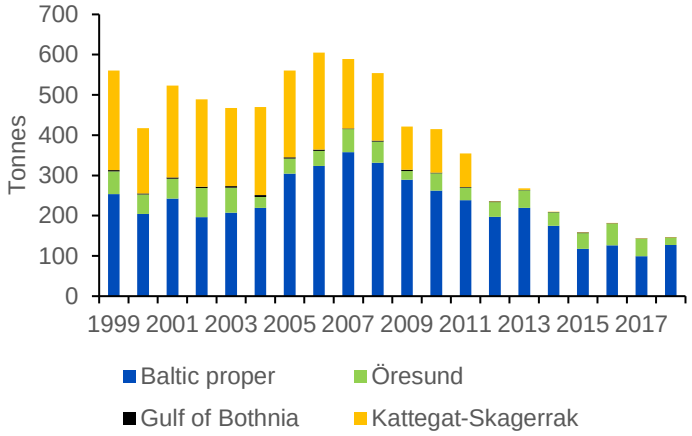

Figure SE. 8. Commercial landings of eel in marine waters (based on logbook data).

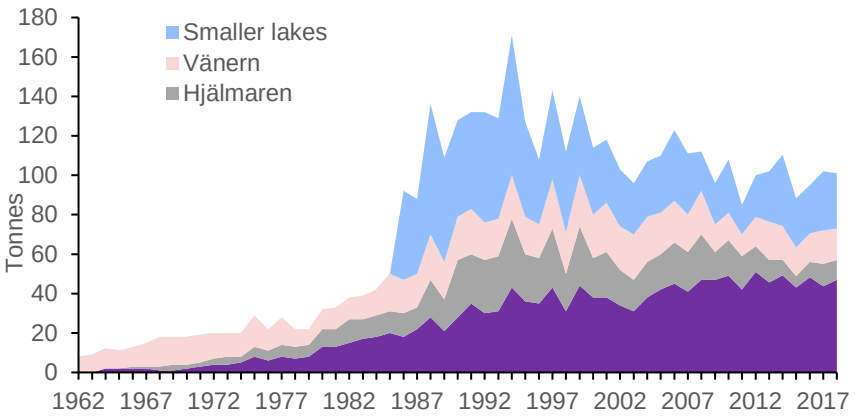

Figure SE. 9. Commercial landings of eel in inland waters. For the smaller lakes, no data prior to 1986 are available.

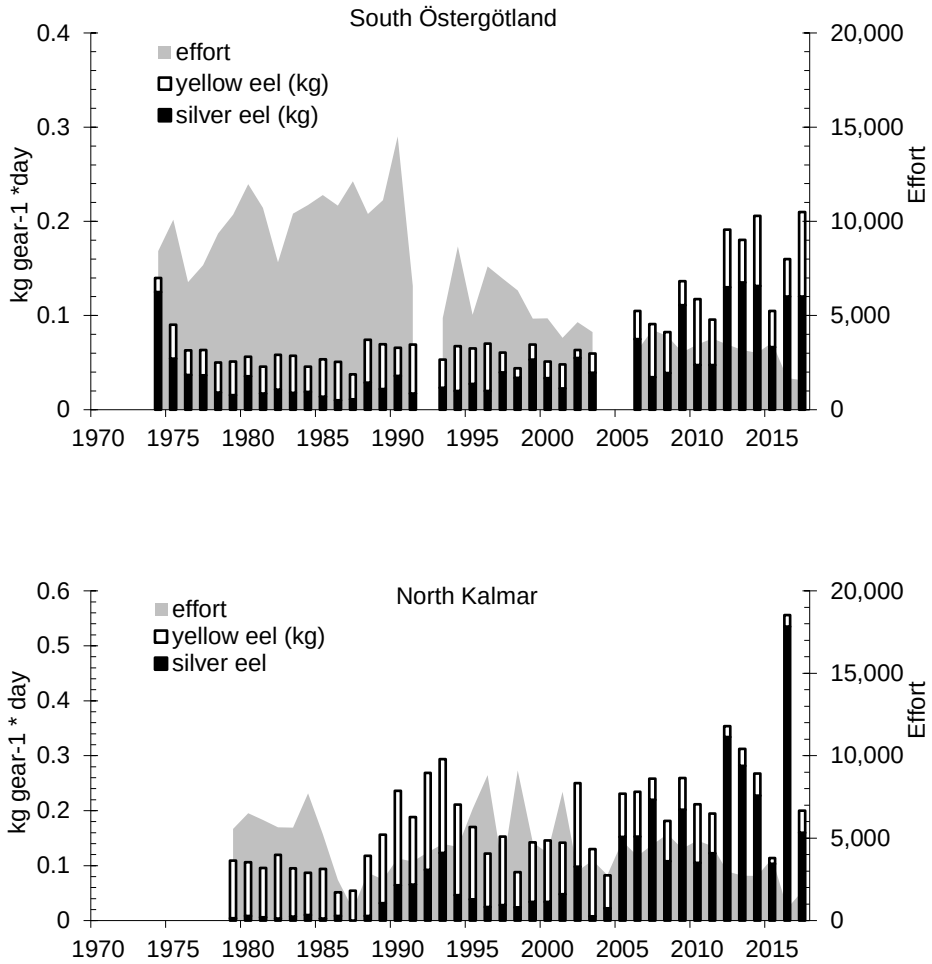

Figure SE. 10. Effort and weight per unit of effort (yellow and silver eel) by two fykenet fishermen along the Swedish Baltic Sea coast, South Östergötland and North Kalmar. Data from 2018 could not be compiled at the time of finishing this report.

Data reported in logbooks on effort and thus on CPUE are not of adequate quality to be used in our assessment work. The capacity, i.e. the number of fishers licensed in 2019 to fish eels are 191, out of which 135 are coastal fishing licences and 56 are freshwater licences (Figure SE. 11). The data come from SwAM, the responsible licensing agency. However, the realised effort is largely unknown.

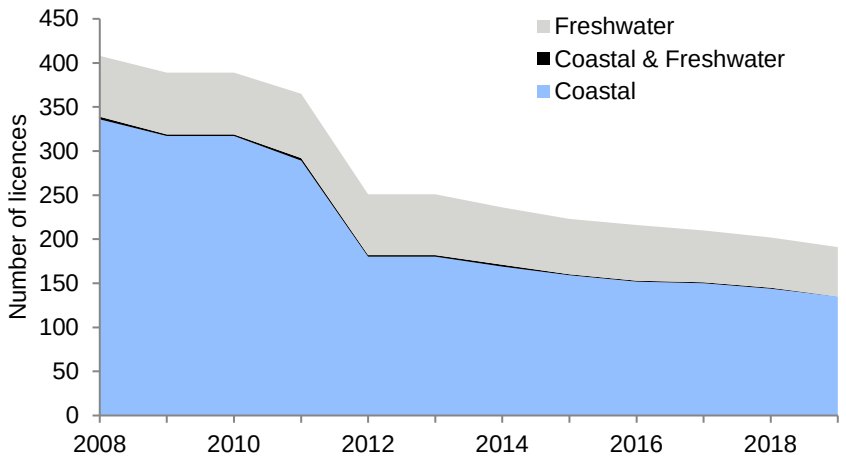

Figure SE. 11. Number of fishermen with eel fishing licences based on data from SwAM.

Recreational fishing on eel is generally banned in Sweden. However, there is an exception from the general ban on non-commercial eel fisheries in inland waters, and that is above three hydropower installations from where almost no silver eel would be able to pass safely to the sea. At present, we do not know the extent of that fishery, and whether those eels are illegally sold or not (only licensed fishermen can sell eels legally).

There have been numerous reports on illegal fisheries. SWaM and other authorities have been working actively with detecting and combatting illegal eel fishing since 2016, mainly in the counties of Skåne and Blekinge. In 2018, 204 gears and one corf were seized and destroyed. Most of the illegal fishing appears to be for household consumption, but at one site, several gears and a corf with size-sorted eels were found, indicating fishing for commercial purposes. It is very difficult for authorities to find the culprits, since gears are not tagged, and nobody has been sentenced for illegal eel fishing during these three years (Björn Stührenberg, SWaM, pers. comm.).

3.2 Restocking

The predicted number of stocked eels 2019 are 3 000 000. In addition, about 70 000 will be exported to Finland. They were all imported from River Severn in the UK. The distribution between freshwater and coastal waters in Sweden for 2018 is shown in Figure SE. 14.

In Sweden, eels must go through a quarantine period of about ten weeks before being stocked. This is to check for, and to minimise the risk of introducing, different diseases and viruses. During the quarantine period, eels are kept and handled under eel aquaculture conditions. Their mean weight is ca. 1 g each or slightly less when stocked. They are not sorted based on size before stocking in Sweden and Finland.

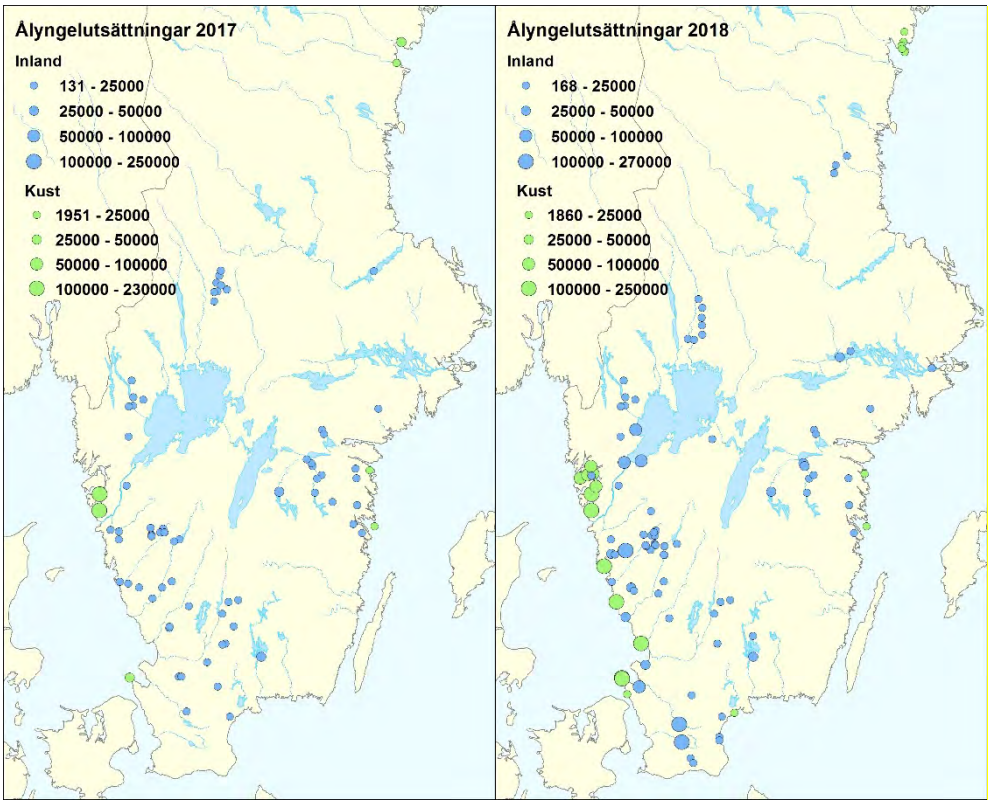

Figure SE. 14. Distribution of restocked eels in 2017 and 2018. Stocking for 2019 had not been completed at the time of finishing this report.

3.3 Aquaculture

Aquaculture production for consumption purposes was 64 600 kg in 2018 and that emanates from a single plant. In 2019, 1250 kg, corresponding to 3 720 200 glass eels, were imported from the UK. Their mortality after 80 days in a quarantine was 0.88%. More than 3 million of those eels will be used for restocking in Sweden and Finland in 2019, and the remaining part is designated for aquaculture purposes (i.e. consumption).

3.4 Entrainment

Eel entrainment with deadly consequences primarily occurs at two types of power plants in Sweden: hydropower plants (a major impact in inland waters) and nuclear power plants (probably a marginal impact).

The impact on silver eels descending to the sea from lakes and rivers is high as they most often have to pass several hydropower installations with their intake gratings and turbines before arriving at the sea. This mortality was estimated at 118 tonnes in 2017 (Dekker *et al.*, 2018). The assumptions behind this assessment was a mortality derived from the best available estimate per individual turbine passage of silver eels that were modelled to have been produced upstream based on natural recruitment and stocking. As there are several turbines to pass in most rivers, the accumulated mortality is quite high and is of the same magnitude as the commercial fishery for eels in freshwater, or higher. Uncertainty in the average impact per hydropower station hardly affects this, due to the high number of hydropower stations to pass (Dekker, 2015).

Sweden has three nuclear power plants by the sea (Ringhals, Forsmark and Simpevarp) which use seawater for cooling. During this process, eels and other fishes are entrained into or impinged in the cooling water intake or circuit. At the Ringhals nuclear power plant on the Swedish west coast, many glass eels (albeit an unknown number per time unit) pass through the whole cooling system and their mortality has been assessed at 13.4% by Bryhn *et al*. (2014); which is low compared to other juvenile fishes. Larger eels (mainly yellow eels) are also entrained at this nuclear power plant, which has a fish diversion system, resulting in an eel mortality of about 14% (Bryhn *et al*., 2013). However, the absolute number of eel entrainment at Ringhals has not been systematically investigated. The remaining two nuclear power stations do not entrain or impinge glass eel (they do not occur there), but yellow and silver eels have about 100% mortality at entrainment as they die in sieving stations. Bryhn *et al*. (2013) estimated the loss at the Forsmark nuclear power plant to 1900 individuals in 2010 and 1200 in 2011. There is an ongoing discussion with the power plant operator regarding catching eels in a large poundnet before they reach the sieving station at the cooling water intake, and subsequently releasing them into the sea, south of the plant since there is a southward coastal current. However, the financing and staff needs of such an operation had not yet been resolved in August 2019. The eel loss at the Simpevarp nuclear power plant has not been systematically investigated. The entrainment monitoring at Simpevarp was discontinued when the plant operator started to draw cooling water from the deeper and colder coastal hypolimnium where fish (but not necessarily eel) abundance might be lower than at the surface, from where cooling water was previously taken.

3.5 Habitat Quantity and Quality

There are numerous large and small lakes and rivers well suited for eel production in Sweden. The low numbers of recruits and restricted restocking, in combination with migration obstacles like dams and hydropower turbines, are the limiting factors of today, not lack of wetted areas as such. Historical habitat decreases in inland waters have most likely been substantial but have not been quantified.

Many eels in Sweden spend most of their lives in coastal waters and their habitats are generally of high quality, although the shoreline in many places been drastically altered by anthropogenic disturbance, for example leading to habitat loss (Baden *et al*. 2003). The shoreline is also altered by anthropogenic constructions (e.g. harbours, jetties, bridges, etc.). However, such habitat change is believed to constrain the eel habitat area to a much lesser extent than historical habitat changes in inland areas, e.g. due to construction of hydropower dams and historical lowering of lakes and drainage of wetlands to create agricultural land.

3.6 Other impacts

3.6.1 Predation

Predation by cormorants (*Phalacrocorax carbo sinensis*) as well as by grey seals and harbour seals (*Halichoerus grypus* and *Phoca vitulina*) have been suggested as possible major causes of eel mortality in Sweden. Studies on the food choice of cormorants normally show quite low prevalence of eel, for example complete absence (Lake Ymsen, Engström, 2001), or a 7% prevalence (data based on a tag and recovery experiment in Lake Roxen, Ovegård *et al*. 2017). However, since the total number of cormorants in lakes and along the Swedish coasts are very high, their total consumption is probably also high. Hansson *et al*. (2017) presented estimates of eel predation by seabirds (mainly cormorants) in the whole Baltic Sea (SD24 - SD32) at 340 tonnes per year which was in the same order of magnitude as landings by the commercial fishery (560 tonnes reported in Hansson *et al*. 2017). These estimations were made based on data from 2010, meaning that they

might be less valid now. Since predation pressure most likely differ between sites, estimations are uncertain and should be interpreted with care. For example, a study by Engström (2001) in Lake Ymsen report that the effect of cormorant on commercial as well as non-commercial fishes was small and did not lead to a decline in fish numbers, despite this lake having one of the highest numbers of breeding cormorants. Östman *et al*. (2012) report few associations with local fish communities and cormorant colony size in the Baltic Sea. On the contrary, there have been site-specific reports presenting estimates on eel predation by cormorants which were higher than the amounts taken by the commercial fishery (Lundström *et al*. 2010; Östman *et al*. 2013; Ovegård, 2017). Eel predation by seals had only been documented as consumption of trapped eels in fishing gears, so the Baltic-wide estimate was 0 tonnes per year (Hansson *et al*. 2017).

4 National stock assessment

4.1 Description of Method

There are several eel projects running, both in freshwater and in the brackish/marine environment. In freshwater and coastal waters, the collection of silver eels from the commercial fishery is a major part of our EU MAP program. In addition, recruitment is monitored through electrofishing in small rivers and streams as well as counting ascending young eels caught in eel passes. As part of the recruitment studies a number of eels are chemically analysed for their origin, being naturally recruited or stocked (Wickström and Sjöberg, 2013). The basis for this latter project is that all stocked eels since 2009 are marked with strontium, which makes clear marks in their otoliths. The analysis rationale is that if the stocked eels have high survival and stay where they have been released, they will be rather abundant and would hence most likely bias some of our (natural) recruitment series used for indices, both at a national and international level. So far, very few of the ascending recruits were of stocked origin. This marking project also facilitates evaluation of the restocking program. From the recruitment monitoring during 2010–2017 (using electro fishing), approximately 960 young eels were aged and 650 were analysed for the strontium mark. For 2018, approximately 120 eels will be analysed for age and strontium, and an additional 70 eels will be analysed for age only.

All sampled eels larger than 60 mm, are analysed with respect to length, weight, stage, age, prevalence and intensity of *Anguillicola crassus*, and sex (sex is only determined in eels larger than 250 mm).

Fat is measured occasionally (only on eel sampled alive and usually done when tagging) with a Fish Fatmeter (model FFM-992). Fecundity is usually not estimated, but some results and comparisons between different stocks were given by MacNamara *et al*. (2016).

To assess the fishing mortality of silver eels leaving the Baltic Sea a traditional mark–recapture programme, running since the early 1900s, was restarted in 2012, mostly using eels caught by fishermen fishing on the coast. More information about this program is presented under 5.2.1.

As prescribed in EU MAP there should be at least one designated index river in each EMU. In 2018, River Kävlingeån in Scania was chosen as suitable for this purpose as we have data on recruitment and fisheries in this drainage system. To facilitate monitoring of descending silver eels an existing Wolf trap was repaired and a fish counter with camera was installed during early 2019.

In Lake Bolmen a small project is running in 2018-2020 aiming at understanding why the production of silver eels from this lake does not match our model predictions. Growth and the prevalence of *Anguillicola crassus* are the main parameters studied.

4.1.1 Data collection

In ICES subdivisions (SD) 23 (Öresund), 25 and 27 (Baltic Proper), 200 silver eel samples have previously been bought from the pound net fishery. SD 24 no longer has any commercial fishery and SD 23 was not sampled in 2018 due to financial constraints. Length is measured, and at least five eels from each cm class are weighed and aged. Total weight of landings and discards is also registered.

In SD 23 (Öresund), fishery-independent sampling of yellow eel and silver eel is also performed using Fykenets. Yellow eels and silver eels are measured by length, but only yellow eels are

weighed and aged (at least 200 individuals; a maximum of five from every cm class). Sampling is terminated if/when more than 500 yellow eels have been caught.

The coastal fish communities along the Swedish west coast are monitored by standardized fishing with Fykenets in shallow water (2–5 m). Fishery-independent sampling of yellow eel and, occasionally (when caught), silver eel is performed in SD 20 (Fjällbacka and Stenungsund in the Skagerrak) and SD 21 (Vendelsöarna in the Kattegat). Sampling is terminated if/when more than 500 yellow eels have been caught. Eels are measured according to length and at least 200 yellow eels (a maximum of five from every cm class) are weighed and aged.

In freshwater, commercially fished eels are sampled annually from three lakes. Which three lakes that will be sampled is alternated every few years in order to cover most of the inland eel fisheries. From each lake, 125 eels are randomly sampled over the main fishing season and then analysed for size, maturity (stage) age, prevalence and intensity of *Anguillicola crassus,* etc.

4.1.2 Analysis

In order to make stock assessments we use an extensive database containing data on recruitment, elver transport, restocking, landings, age and growth, hydropower installations, river geography, and more, covering an extended geographical area, over a period of many decades (Dekker *et al.* 2018).

For the inland waters, yellow and silver eel abundance is predicted from the available information on recruits (natural, translocated, restocked) forward in time, towards the yellow and silver eel stage (Dekker *et al.* 2018). No general independent verification on yellow or silver eel data has been made. Since 2016, analyses include information on yellow eel abundance derived from electrofishing surveys. This requires mixing a state-based approach (electrofishing) with a rate-based approach (recruitment, catch). Most of the eel stock is located in lakes, while electrofishing covers mainly rivers, a problem to be addressed. This work is still in progress.

For the Baltic coastal fishery, analysis of mortality rates was performed using Survival Analysis based on a century of mark-recapture data (Dekker and Sjöberg, 2013, Dekker *et al.* 2018). Stock size (biomass) estimates were derived from the Survival Analysis results (fishing mortality), in combination with available landings data (Dekker *et al.* 2018). The quality of the landings data, especially when catch (landings) and estimated fishing mortalities are low, appears to put severe constraints on the credibility of the results. Landings data constituting a census (full coverage of all operations) rather than a survey (statistical sampling), hence the reliability of the landings data cannot be quantified. The targeted silver eel is derived from yellow eel stocks along the Swedish coast, in Swedish inland waters, but probably also from coastal and inland waters in other countries all over the Baltic area. In order to cross-check the Swedish escapement biomass estimates, a joint assessment of the whole Baltic stock is required (which in itself will be required to develop joint management of this shared stock). A proposal for an international research project to develop this joint assessment has been compiled (Dekker, 2013), but was not prioritised policy-wise.

4.1.3 Reporting

Selected results from Swedish eel studies are reported to the EU as requested in 2012, 2015 and 2018. This is done by the responsible agency SwAM, but the underlying data are also published in our department report series *Aqua reports (*e.g. Dekker *et al*. 2018). Relevant data is also used for scientific papers (see the reference list below). In addition, selected data and results are reported to ICES and WGEEL when appropriate.

4.1.4 Data quality issues and how they are being addressed

For the east and west coast, the datasets are insufficient to provide comprehensive assessments, including complete sets of stock indicators. This problem could potentially, and at least partly, be solved through a pan-Baltic stock assessment.

Freshwater landings data are reported according to two different systems (one per year for the smaller lakes, and more detailed reporting for the larger lakes), which increases the risk for errors. Eels used for Trap & Transport might also be miscounted as here too there are different reporting systems.

Recreational fishing for eel, as previously mentioned, is forbidden with some exemptions, however, recreational fishing might have a significant impact. Hidden, unmarked Fykenets, pound nets and trammel nets have been discovered along the coast during the last few years (see 3.1.3). Additionally, in some freshwater bodies there can be an eel fishery that authorities have no knowledge about, since it is legal as long as the catch is not sold.

Unfortunately, the very long river recruitment series from Trollhättan in Göta Älv (ongoing since 1900) was broken in 2018. This temporary break was due to lack of personnel and unfortunately this trap is still not operating during 2019.

4.2 Trends in Assessment results

For the west coast, no assessment was produced in 2018, but survey-trends (CPUE by length-class) are presented.

Yellow eel was among the dominating fish species in August during most years. The overall catch-per-unit-effort appears to be increasing (Figure SE. 15), although separation of the data into different length classes appears to provide a more complex picture (Dekker *et al*. 2018). This is being analysed and will be published soon.

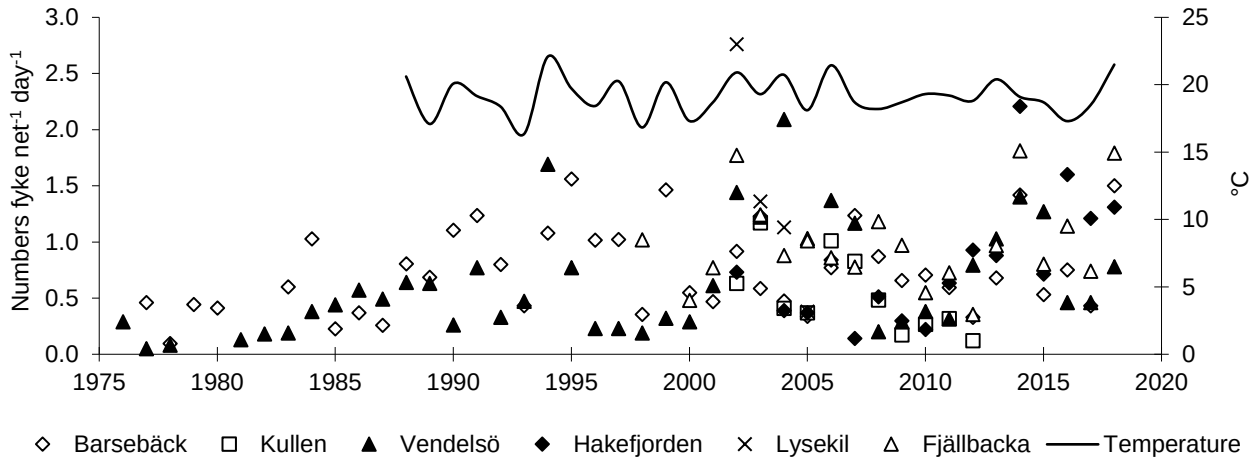

Figure SE. 15. Time-series of yellow eel catches (numbers Fykenet^{-1} day^{-1}) in coastal fish monitoring with Fykenets in August along the Swedish west coast from 1976 to 2018. Annual mean water temperature is presented for the Vendelsö area in central Kattegat (SD 21).

Length-at-age and weight-at-age for yellow eel (Figure SE. 16) suggest higher growth in the southernmost area SD 23, compared to SD 20 and SD 21. However, no clear geographical pattern could be discerned in the length-at-age and weight-at-age for silver eel (Figure SE. 17). Both of

these figures show great variability, especially at high ages for which the number of samples is low. Nevertheless, Figures SE. 16 and 17 provide valuable information on lengths, weights and ages of yellow and silver eel along the Swedish coast.

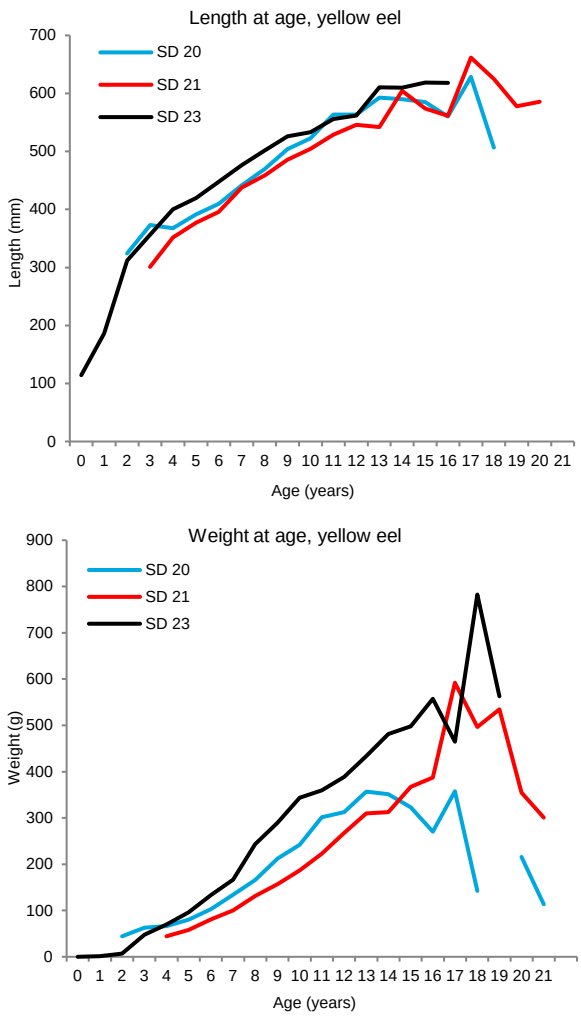

Figure SE 16. Length-at-age and weight-at-age in yellow eel caught in SD 20, SD 21 and SD 23. Data are average values for the period 2009-2018.

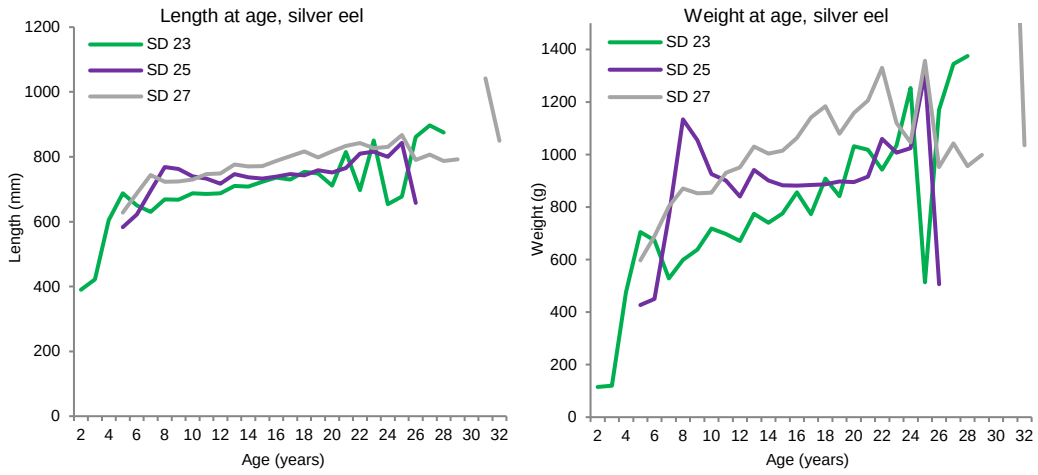

Figure SE 17. Length-at-age and weight-at-age in silver eel caught in SD 23, SD 25 and SD 27. Data are average values for the period 2009-2018.

5 Other data collection for eel

5.1 Yellow eel abundance surveys

In addition to the yellow eel abundance surveys presented in chapter 4, some smaller projects follow the development of stocked eel populations using Fykenets or outlet traps. In 1997, a cove in Lake Mälaren was stocked with 5000 marked (Alizarin) elvers. This introduced stock has been monitored in a Fykenet fishery since. After a few years the local stock was dominated by the stocked eels and their proportion has been about 60% since 2005 (Figure SE. 18). As more and more eels now become silver and leave this open system, the CPUE and the proportion of marked eels is declining. Until 2019, 14% of the stocked eels have been recaptured. In 2011 this cove was stocked with another 1862 elvers, this time marked with both strontium and barium in their otoliths. Some of them are now among the smallest eels caught, explaining the increasing ratio of unmarked eels in recent years (Figure SE. 18).

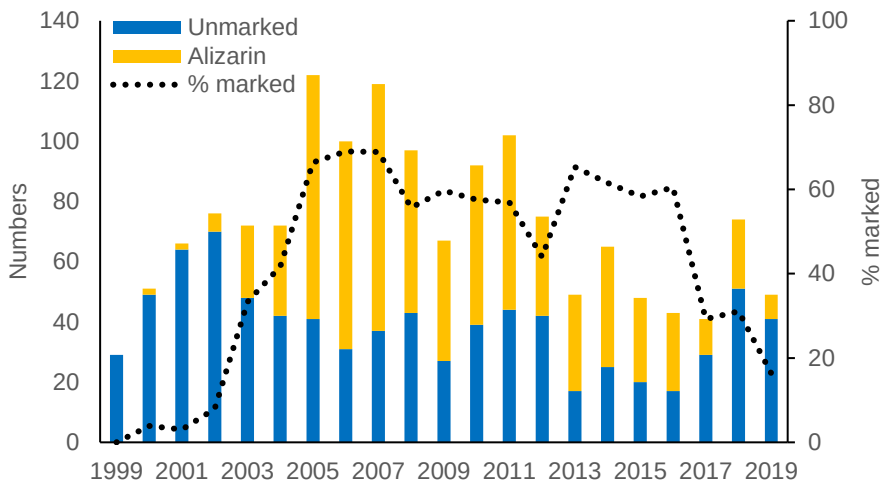

Figure SE. 18. Number of unmarked and alizarin marked eels as well as the percent marked eels in a stocked population in Lake Mälaren from 1999 to 2019.

5.2 Silver eel escapement surveys

Please see Section 4.1.

5.2.1 The traditional eel tagging in the Baltic Sea

In the Baltic region, tagging experiments started in 1903 and the objective of the first tagging experiments was to gain general information on migration direction and migration routes (Sjöberg, 2015). Since then, thousands of eels have been tagged, most of them with silver plates and Carlin tags. Recaptures of tagged eel were relatively scarce in the early 1900s, probably because fish tagging was a new phenomenon and the fishermen were unaware of the ongoing experiments (hence, recaptures might have occurred, but they were not reported). In addition, the fishery was not as extensive at this time, but increased later. As the Swedish eel landings from the Baltic Sea started to increase, so did the recapture rates (Figure 19). Similarly, when the

catches started to decrease in the 1960s, the recapture rates decreased as well. However, a bit unsynchronized since the intensity of the fishery started to decrease somewhat later, in the early 1970s, as shown in Andersson *et al*. (2012). Since 2012, tagging has continued with the same method as before. Approximately 70% of the recaptures were made in the Swedish fishery at the east and south coast, while 26% were recaptured in Denmark (Figure SE. 20, Table SE. 2). A few individuals were recaptured in Poland, Estonia and Finland as well (Figure SE. 20, Table SE. 2). The tagging programme has become an important part within the EU´s data collection program (EC No 665/2008) and it is the basis for estimating the fisheries impact on eels leaving the Baltic Sea region to spawn (Dekker and Sjöberg, 2013; Dekker, 2015). In 2018 there was a 3 months fishing closure between November-January both in Denmark and Sweden. This will presumably affect recapture numbers from the outlet straits in Öresund and the Danish Belts, in 2018 as well as in coming years.

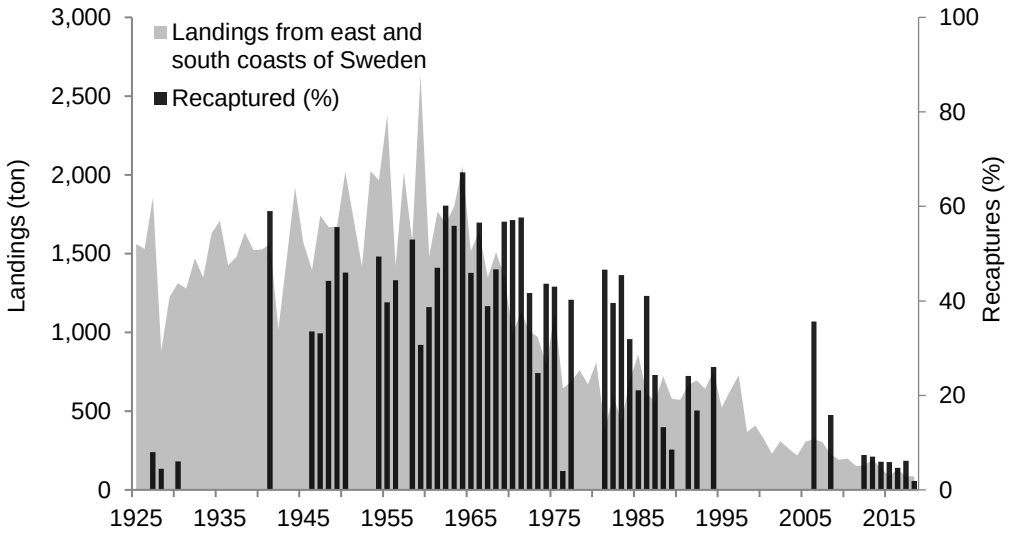

Figure SE. 19. Landings from the Swedish fishery on the east and south coast (grey area). Recaptures of tagged eels made in Sweden, Denmark, Germany, Poland, Estonia, and Finland (black bars).

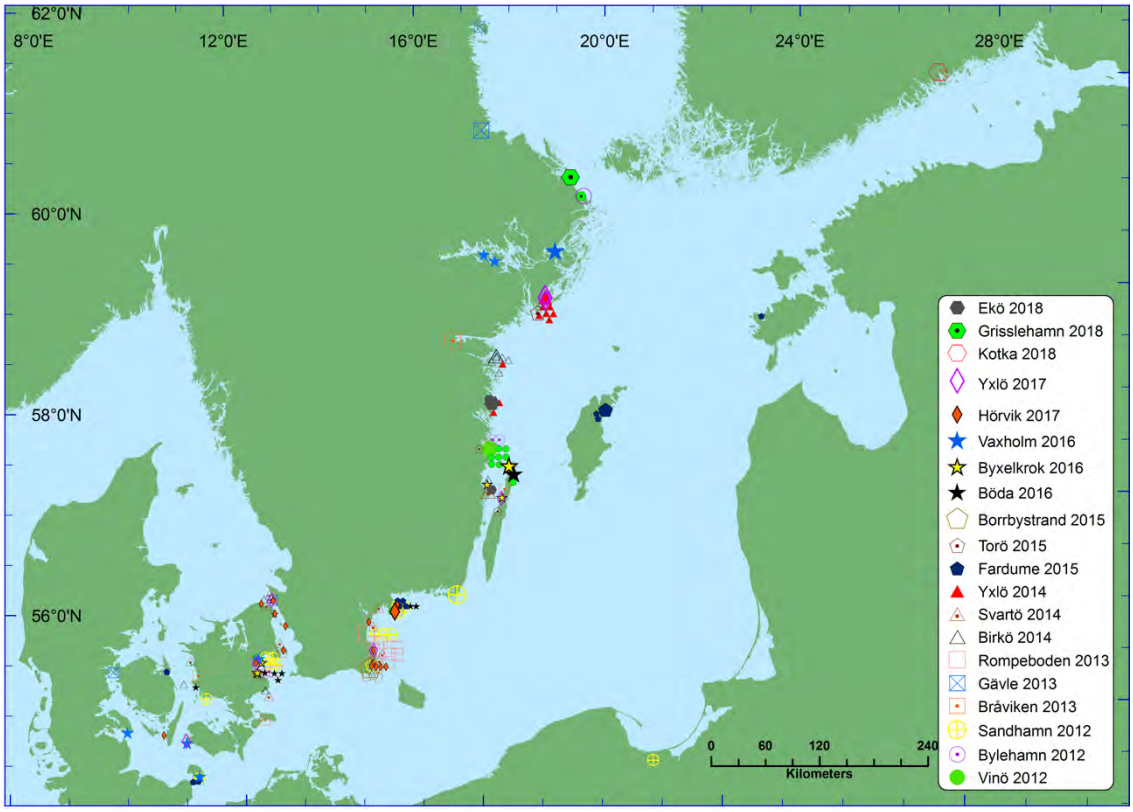

Figure SE. 20. Recaptures of tagged eels within the EU MAP program along the Swedish east coast 2012-2018. For exact recapture numbers see Table SE. 2.

Table SE. 2. Tagging experiments within the EU MAP program between 2012 and 2018. Total number of tagged and released eels, proportion and number of recaptures, and the national distribution of recaptured eels in Sweden (SE), Denmark (DK), Poland (PL), Estonia (EE) and Finland (FI).

Release location	Year of release	Tagged (N)	Recaptures (%)	Recaptures (N)	SE	DK	DE	PL	EE	FI
Bylehamn	2012	150	3	4	2	2	0	0	0	0
Vinö	2012	120	9	11	9	2	0	0	0	0
Sandhamn	2012	150	9	14	8	4	1	1	0	0
Gävle	2013	34	9	3	2	1	0	0	0	0
Bråviken	2013	150	2	3	1	1	1	0	0	0
Rumpeboden	2013	150	14	21	17	4	0	0	0	0
Yxlö	2014	150	6	9	9	0	0	0	0	0
Birkö	2014	301	8	24	20	4	0	0	0	0
Svartö	2014	150	7	10	6	4	0	0	0	0
Fardume	2015	170	7	12	7	1	2	1	1	0
Torö	2015	151	5	7	6	1	0	0	0	0
Borrbystrand	2015	140	9	13	5	8	0	0	0	0
Vallentuna_Vaxholm	2016	154	5	7	3	3	1	0	0	0
Byxelkrok	2016	147	3	5	3	2	0	0	0	0
Böda	2016	151	7	10	4	6	0	0	0	0
Yxlö	2017	320	4	14	13	1	0	0	0	0
Hörvik	2017	200	10	20	13	7	0	0	0	0
Kotka	2018	136	1	1	0	0	0	0	0	1
Grisslehamn	2018	191	3	5	5	0	0	0	0	0
Ekö	2018	140	3	4	4	0	0	0	0	0
Total		3255	6	197	137	51	5	2	1	1

5.3 Life-history parameters

As part of our EU MAP data collection, eels from a number of commercially fished lakes were sampled since 2010 (Table SE. 3). The measurements are mostly taken on previously frozen eels, where relevant variables are corrected for freezing shrinkage. Typically, approximately 1700 eels from freshwater areas and 1000 from coastal areas are analysed annually by SLU Aqua.

Table SE. 3. Length, weight, age and growth in all commercially fished eels sampled from freshwater within the EU MAP -programme. Mean growth rate was calculated based on individual length, with glass eel length (73 mm) subtracted, divided by age.

Lake/year	Total N	Mean length (mm)	Mean weight (g)	Mean age (year)	Growth rate (mm year-1)	Aged (N)	Aged (%)
Bolmen							
2017	126	706,1	669,4	21,7	30,2	126	100%
2018	128	708,5	707,9	20,8	31,1	128	100%
Hjälmaren							
2010	125	875,8	1565,6	16,1	51,1	119	95%
2011	111	882,0	1552,3	15,7	53,1	108	97%
2012	127	893,1	1632,9	15,4	54,2	125	98%
2013	127	907,2	1697,3	14,3	60,3	125	98%
Mälaren							
2010	254	786,9	1084,6	17,7	41,3	239	94%
2011	252	786,7	1062,1	17,5	41,3	236	94%
2012	251	806,3	1144,1	17,9	41,7	233	93%
2013	249	807,2	1127,2	16,7	44,7	236	95%
2014	237	803,7	1046,4	18,7	40,4	232	98%
2015	261	800,7	1040,5	19,3	38,3	261	100%
2016	265	799,2	1040,5	19,8	37,3	262	100%
Ringsjön							
2011	124	678,5	619,8	16,1	38,7	113	91%
2013	127	699,5	666,7	15,7	40,2	117	92%
Roxen							
2014	88	886,9	1465,9	15,8	52,4	84	95%
2015	100	879,4	1456,1	16,5	49,6	100	100%
2016	140	903,6	1537,3	16,8	50,0	137	98%
2017	105	912,9	1526,5	19,3	44,1	105	100%
2018	66	945,6	1795,2	20,3	43,4	66	100%
Vombsjön							
2014	124	764,4	957,2	15,3	45,9	123	99%
2015	127	764,5	934,2	18,0	39,2	127	100%

Lake/year	Total N	Mean length (mm)	Mean weight (g)	Mean age (year)	Growth rate (mm year-1)	Aged (N)	Aged (%)
2016	125	738,8	888,7	14,5	46,5	123	98%
2017	127	793,9	1023,4	21,3	35,5	125	98%
2018	130	751,7	827,5	-	-	-	-
Vänern							
2010	255	783,5	1017,5	14,1	52,6	247	97%
2011	257	801,9	1055,8	16,3	46,5	235	91%
2012	247	822,0	1174,9	16,9	45,5	236	96%
2013	249	843,7	1321,6	16,2	48,5	235	94%
2014	230	835,5	1250,8	16,1	48,2	226	98%
2015	251	821,3	1161,0	18,0	42,2	251	100%
2016	248	850,2	1318,4	18,2	43,4	245	99%

5.4 Diseases, Parasites & Pathogens or Contaminants

5.4.1 5.4.1 Parasites & Pathogens

All eels analysed at the Department of Aquatic Resources are screened for *Anguillicola crassus* by the naked eye. At the Institute of Freshwater Research, both prevalence and intensity are reported, and at the Institute of Coastal Research, prevalence only. A considerable proportion of eels from most sites are infested but the prevalence has levelled out. The prevalence in Swedish western coastal waters generally appears to be lower than in lakes (Figures SE. 21–24). In 2018, 778 eels caught in freshwater were analysed and 61% were infested. From test fishing in coastal waters, 868 yellow eels and 345 silver eels were analysed in 2018, and 20% of the yellow eels and 52% of the silver eels were infested.

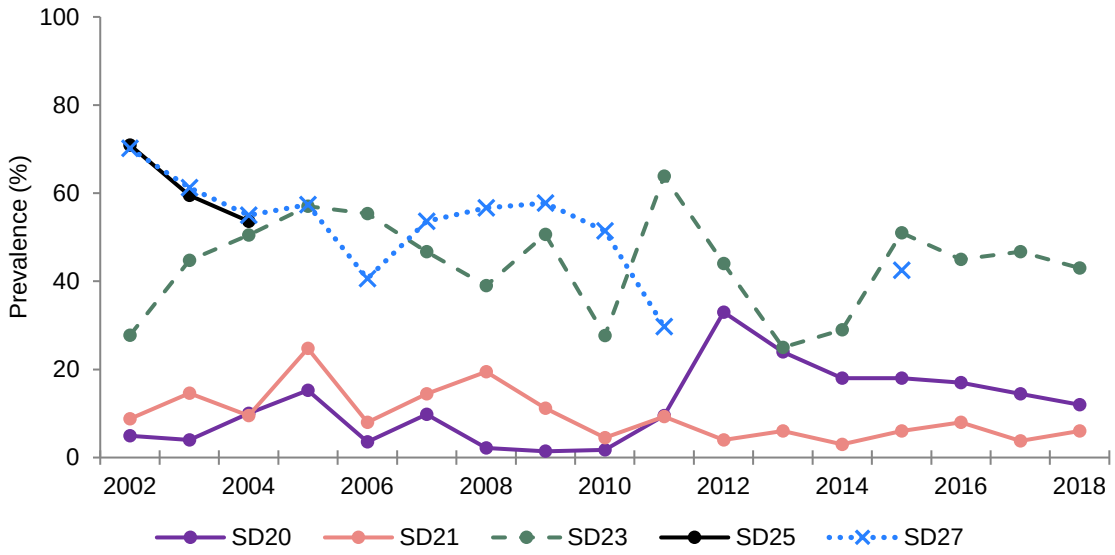

Figure SE 21. Prevalence (%) of the parasite *Anguillicola crassus* in yellow eel in Swedish coastal waters 2002–2018. SD refers to ICES subdivisions.

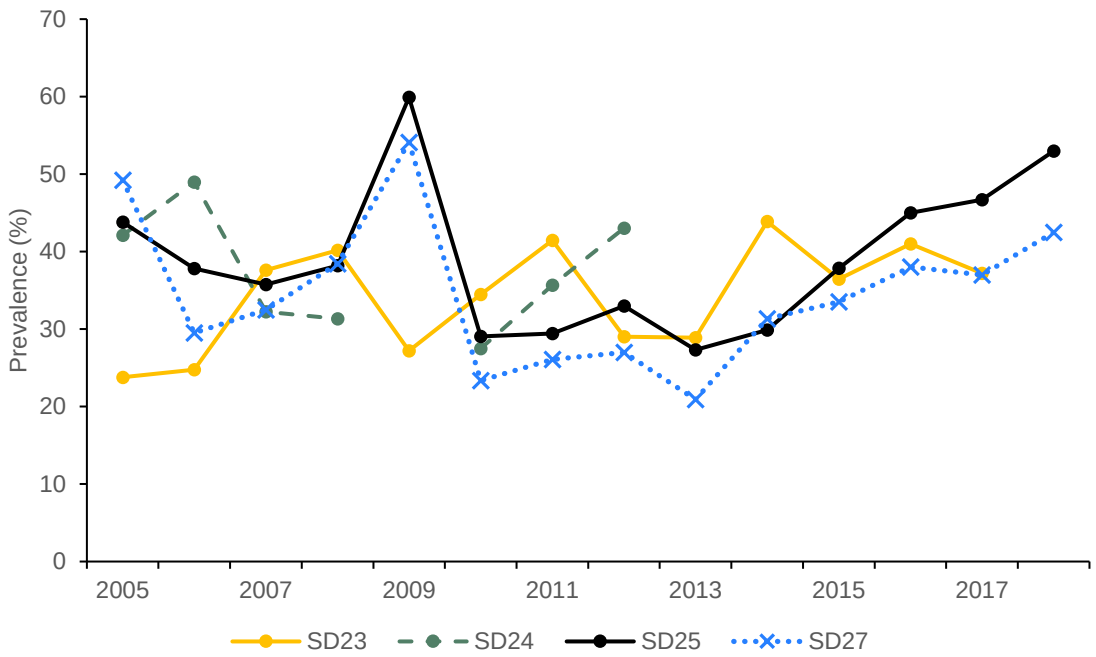

Figure SE 22. Prevalence (%) of the parasite *Anguillicola crassus* in silver eel in Swedish coastal waters 2002–2018. SD refers to ICES subdivisions.

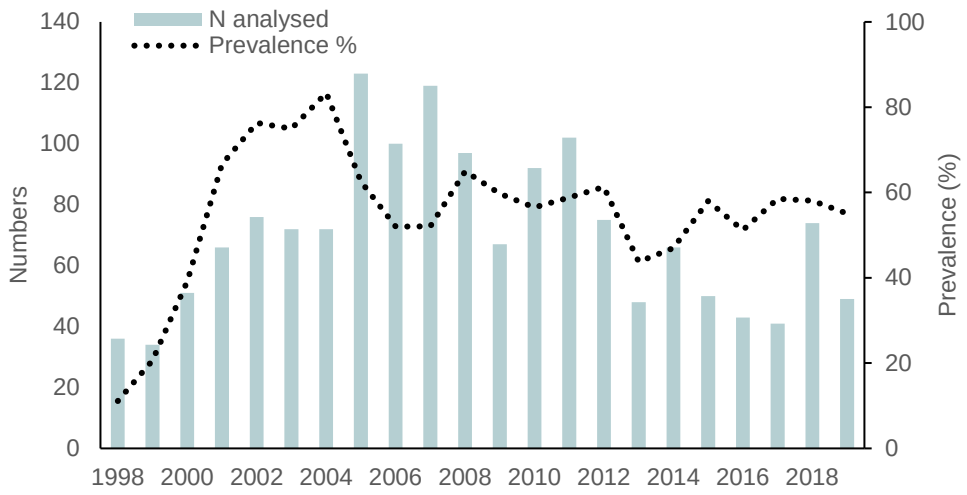

Figure SE. 23. Prevalence (%) and number of eels analysed for *Anguillicola crassus* at one site in Lake Mälaren 1998–2019.

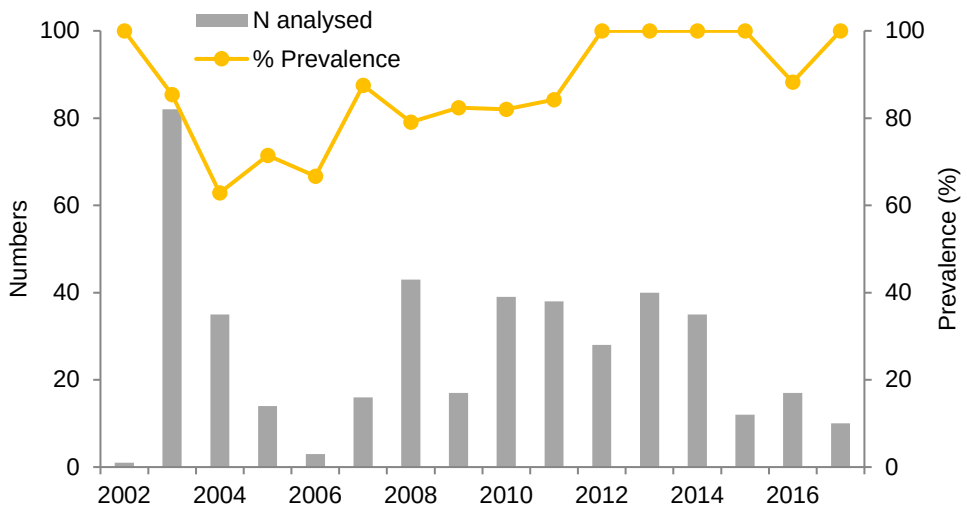

Figure SE. 24. Prevalence (%) and number of eels analysed for *Anguillicola crassus* in Lake Ymsen 2002–2018.

Imported eels used for stocking and for aquaculture purposes are monitored by the Swedish National Veterinary Institute (SVA) mainly for Infectious pancreatic necrosis virus (IPNV) during the quarantine phase, investigating both glass eel initially and finally sentinel species (Axén C. SVA pers. comm.).

In 2019, glass eels were imported from River Severn in the UK, and no issues occurred during the quarantine period. During that period of 80 days, mortality was 0.88%. Thus, the planned numbers to be stocked was realized.

Parasites and pathogens are diagnosed by SVA in case of suspected disease/ acute mortality, or due to temporary investigations. At necropsy, standard routine fish necropsy protocol is followed, with examination of skin, gills, fins, eyes, muscle tissue, organs etc. Bacteriology samples are always taken from the kidney as well as organs with pathological changes. Samples are cultured on agar, and bacteria are typed according to ordinary identification protocol or MALDI-TOF. If findings indicate suspected viral disease, samples are taken for cell cultures (general cells sensitive for IPN, EVEX and VHS). Growth of virus is further cultured and typed.

5.4.2 Contaminants

No new data since the 2018 Country Report.

6 New Information

Tamario *et al*. (2019) investigated the effects of barriers with and without fish-passage solutions (FPSs) on ascending eel distribution. They found that dams with eel ramps or technical fish ways, as well as dams without FPSs, had a significant negative effect on the probability of eel occurrence upstream. This negative effect was not found for dams fitted with nature-like fishways. The probability of eel occurrence decreased with distance from the sea and increased with area sampled, number of electrofishing runs, water temperature, and with the size of the bottom substrate.

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Reporting Period: This report was completed in August 2019 and contains data up to 2018 and some provisional data for 2019.

1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

Table 1.1 shows the most recent stock indicators of silver eel escapement biomass, mortality rates, and assessed habitat area, for the 14 different Eel Management Units (EMU) reported by the UK (see Table 1.2). The international transboundary IE_NorW EMU which is shared between Northern Ireland and the Republic of Ireland, is reported by the latter so not included in this table. Stock indicators for EMUs in England and Wales were last updated for the 2018 triennial EMP report and were based on datasets for the years 2014–2016. These stock indictors will not be updated until the next triennial EMP progress report in 2021, in which the 2017–2019 datasets will be used.

Table 1.1 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
2016	GB_Nort	11816	60876	4970	10243	8.2	0.000	0.723	0.723
2016	GB_Humb	57 853	137859	4463	49581	3.2	0.011	2.397	2.408
2016	GB_Angl	54 373	341084	67785	123715	19.9	0.171	0.430	0.602
2016	GB_Tham	42 811	251699	14397	60336	5.7	0.082	1.351	1.433
2016	GB_SouE	11 443	121340	49096	62932	40.5	0.019	0.229	0.248
2016	GB_SouW	35 850	1327684	7881	548510	0.6	2.667	0.256	2.924
2016	GB_Seve	75 071	899687	81252	707732	9.0	0.763	0.399	1.162
2016	GB_Wale	26 570	429944	30826	43564	7.2	0.103	0.196	0.299
2016	GB_Dee	14 130	636166	16224	28336	2.6	0.019	0.503	0.521
2016	GB_NorW	46 783	865449	19806	47753	2.3	0.178	0.559	0.737
2016	GB_Solw	87 496	1473755	45801	59460	3.1	0.261	0.000	0.261
2017	GB_NorE	5000	4 000	989	989	24.7	0.000	0.000	0.000
2017	GB_Neag	40 000	500000	247000	569810	49.4	1.210	-0.120	1.090
2017	GB_Scot	214241	267717	203521	255510	76.0	0.000	0.227	0.227
2018	GB_Scot	214241	267717	176256	218114	65.8	0.000	0.213	0.213

Key:

EMU_code = Eel Management Unit code (see Table 1.2 for list of codes); 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.

Table 1.2. Names and abbreviations for the 15 Eel Management Units (EMU) across the UK, and the ICES ecoregion(s) that they discharge into. Jurisdiction codes: Sco = Scotland, NI = Northern Ireland, Eng = England, RoI = Republic of Ireland, Wal = Wales.

EMU code	ICES Ecoregion	River Basin District (RBD)	Jurisdiction
GB_Scot	Celtic Sea & North Sea	Scotland	Sco
GB_Neag	Celtic Sea	Neagh Bann	NI
GB_NorE	Celtic Sea	Northeastern	NI
IE_NorW*	Celtic Sea	Northwestern	NI + RoI
GB_Nort	North Sea	Northumbria	Eng
GB_Humb	North Sea	Humber	Eng
GB_Angl	North Sea	Anglian	Eng
GB_Tham	North Sea	Thames	Eng
GB_SouE	North Sea	Southeast	Eng
GB_SouW	Celtic Sea	Southwest	Eng
GB_Seve	Celtic Sea	Severn	Eng + Wal
GB_Wale	Celtic Sea	Western Wales	Wal
GB_Dee	Celtic Sea	Dee	Wal + Eng
GB_NorW	Celtic Sea	Northwest	Eng
GB_Solw	Celtic Sea & North Sea	Solway-Tweed	Eng + Sco

*** = international, transboundary EMU shared with the Republic of Ireland (reporting on this EMU is led by RoI so it has the country code IE, hence shown in italics here).**

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.

1.2.1 International recruitment time-series

The ICES Recruitment Analysis uses the total UK commercial glass eel catch time-series (catch returns from the EA) and is shown in Figure 1.1 below.

As the glass eel catch data reported directly to the EA are now recorded against each EMU, and have been so since 2005, these time-series could be considered for the ICES analyses at some point in future.

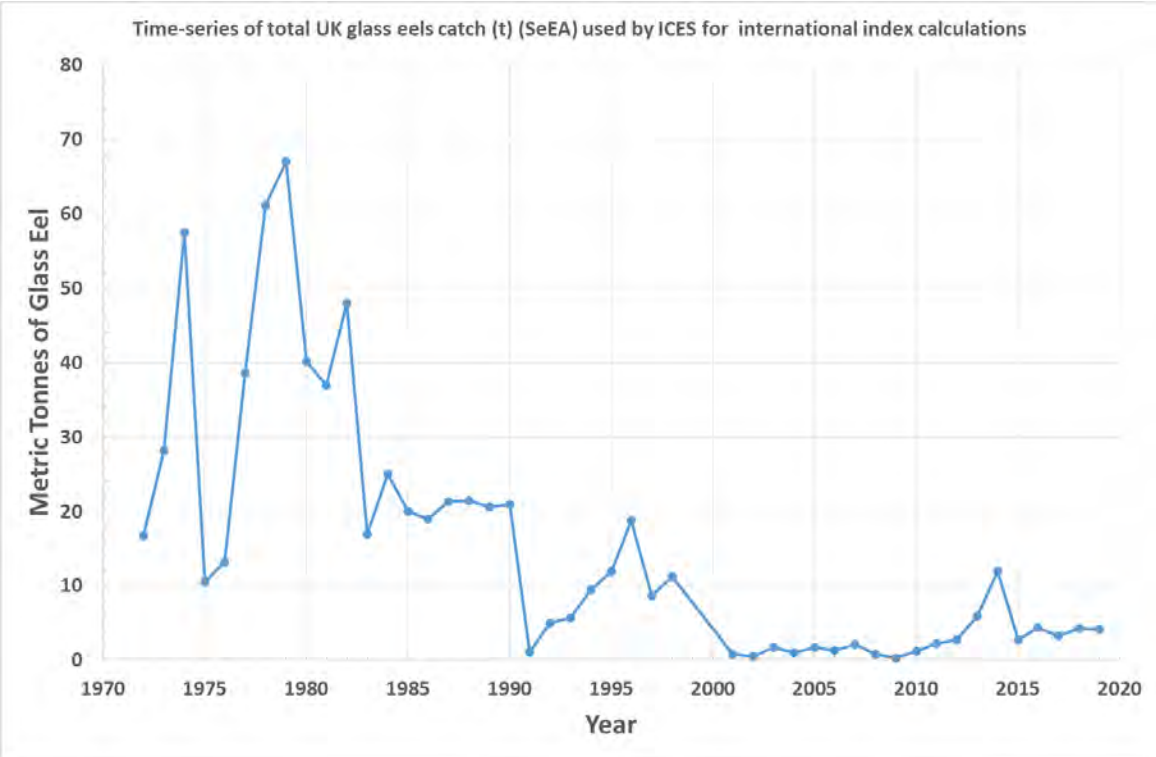

Figure 1.1. Time-series of total UK glass eels catch (t) which is used as input data to ICES global stock Glass Eel index calculations.

1.2.2 Other recruitment time-series

Fisheries-independent glass eel recruitment data are available from several sites in four EMUs.

GB_Angl & GB_SouW

Table 1.3 contains data on glass eel/elver recruitment for three counter sites in GB_Angl and one in GB_SouW. Data are available for the Brownshill site on the River Great Ouse between 2011 and 2018, although in 2012 the trap was not operational for a long period due to summer flooding, and represents a partial count. The trap operation in other years was consistent throughout the time-series. Data for glass eel traps on the river Stour (Flatford, Judas Gap site) and the river Chelmer (Beeleigh Weir site) are available respectively from 2007 and 2006 onwards. The numbers of glass eel and elvers (<120 mm) using a camera trap at the Greylake site on river Parrett (GB_SouW) are available from 2009–2018.

GB_Scot

An ascending yellow eel monitoring trap was set up in 2008 on the Girnock Burn, fishing from May to September. The trap was destroyed by flooding in December 2015 and rebuilt to different design in April 2017. A time-series for glass eels at the Shieldaig river mouth in Wester Ross (N 57°30.65, W 5°38.72), using pinhole traps at the upper tidal limit, fishing from March to July inclusive, was instituted in 2014. A second series using skirt traps in still water at the barrier formed by the Shieldaig trap (50 m upstream of the tidal limit), was instituted in 2017, fishing from March to September inclusive (Table 1.3).

GB_Neag

The LNFCS catch glass eels using dragnets with an area of 0.94 m^2, fished below a river-spanning sluice gate, which creates a barrier to upstream juvenile eel migration on the River Bann. Total

catch per night is recorded, but not catch per individual net. These, and elvers trapped at the same location, are transported upstream to be stocked into the Lough. These catches provide a time-series of 'natural' recruitment into the Lough (Table 1.3). Recruitment had shown an overall downward trend to only 16 kg (approximately 48 000 glass eel) in 2011, which was the lowest catch on record. For 2017, recruitment was very similar to 2016 (432 kg) at 429 kg. 2018 showed a marked increase with the total number of glass eels doubling to 890 kg. For the sixth year in succession (since 2013) elvers were once again captured very late in the season (September), while migrating silver eels were leaving the same system. However, at the time of writing this report recruitment for 2019 stands at 282 kg, with indication it is at the end and less than 1/3 of 2018 level.

IE_NorW

The elver run to the River Erne is monitored by capture at a box at the foot of the dam of Cathleen's Fall hydropower station (at tidal head) and transported to upper and lower Lough Erne. This EMU is transboundary between Northern Ireland and the Republic of Ireland. The glass eel fishery operates in the Republic of Ireland, but upstream transport of that catch is distributed to both countries. The elver run to the Erne fell markedly in 2017 to 150.3 kg, but as it is often the case showed a significant increase with a catch of 1969.7 kg in 2018. Recruitment for 2019 has fallen yet again to the lowest recorded value in a 60-year dataset of 40 kgs. The full time-series index of glass eel recruitment for this basin is reported in the Republic of Ireland Country Report.

GB_NorE

See Section 6 (New Information) in relation to the establishment of a new glass eel monitoring site at Strangford Lough. Once the collection of this dataset has progressed beyond a continual ten-year standard (2021), this information will be registered as a new index site within the ICES datacall database.

Table 1.3. Recruitment measures for glass eels/elvers/yellow eels in different length categories in England and Wales: Brownshill on the Great River Ouse (GB_Angl), Flatford, Judas Gap on the River Stour (GB_Angl), Beeleigh Weir on the River Chelmer (GB_Angl) and at Greylake on the River Parrott (GB_Sou), Scotland: Girnock Burn (GB_Scot), Shieldaig River at tidal limit (GB_Scot), and at the Shieldaig trap (GB_Scot) and Northern Ireland: River Bann (GB_Neag). Glass eel recruitment in the River Bann, Northern Ireland is shown from 2006 to 2019 and the full dataset can be seen in older reports.

Site	Brownshill* (Number of glass eels/elvers)		Flatford (Number of glass eels/elvers)		Beeleigh Weir ǂ (Number of glass eels/elvers)		Greylake‡ (Number of glass eels/elvers)		Girnock Burn (Number of yellow eels)	Shieldaig tidal limit (Number of glass eels)	Shieldaig Trap (Number of glass eels)	River Bann (Glass eels in kg)
Year	<80 mm	>80<120 mm	<80 mm	>80<120 mm	<80 mm	>80<120 mm	<80 mm	<120 mm	>120<160 mm	<80 mm	<80 mm	n/a
2006	-	-	-	-	1290	NA	-	-				456
2007	-	-	11135	16671	3055	NA	-	-				444
2008	-	-	9979	481	4055	NA	-	-	572			24
2009	-	-	3145	153	776	NA	NA	33414	370			158
2010	-	-	NR	NR	1240	NA	NA	12170	89			68
2011	5175	21331	4171	449	992	NA	NA	12810	48			16
2012	24	560	17199	974	371	NA	NA	39005	273			189
2013	36908	139531	NR	NR	33338	NA	NA	22345	181			344
2014	633	24101	16316	2579	17554	NA	NA	33351	276	177		699
2015	476	79178	8529	997	17863	NA	NA	19265	23	45		317
2016	50	38735	10295	2191	10388	NA	NA	48074	ND	24		432
2017	97	32839	5033	741	4575	NA	NA	37726	242	103	408	429
2018	213	30404	10757	632	20785	NA	NA	13645	302	129	989	870
2019	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	282

***~~2012~~ represents a partial count for this site; ǂ Camera trap records a mixture of glass eel and elvers (<120 mm).**

2 Overview of the national stock and its management

2.1 Describe the eel stock and its management

2.1.1 Eel Management Units (EMUs)

Eels are widespread throughout estuaries, rivers and lakes of the UK, with the exception of the upper reaches of some rivers, particularly in Scotland, due to difficulties of access. There are 15 EMUs across the UK, including one shared with the Republic of Ireland (Table 1. 2; Figure 2.1). Most of the UK EMUs have been set at the River Basin District (RBD) level, as defined under the Water Framework Directive (WFD). The RBDs in Northern Ireland deviate slightly from those defined for the WFD, owing to their transboundary nature. An Eel Management Plan (EMP) has been implemented for each EMU (see https://www.gov.uk/government/publications/2010-to-2015-government-policy-freshwater-fisheries/2010-to-2015-government-policy-freshwater-fisheries).

2.1.2 Management authorities

Responsibility for the management of eel, including human impacts and the delivery of EMPs rests with the Environment Agency (EA) in England and with Natural Resources Wales (NRW) in Wales. In Scotland, Marine Scotland is responsible for the management of all anthropogenic impacts and for the conservation of stocks and the delivery of the Scotland EMP (the EA is responsible for delivery of the Solway-Tweed EMP). In Northern Ireland, overall responsibility for the supervision and protection of eel fisheries, and for the establishment and development of those fisheries rests with the Department of Agriculture Environment & Rural Affairs (DAERA). The Agri-Food and Biosciences Institute for N. Ireland (AFBI) is employed by DAERA to provide the scientific basis for eel management in Northern Ireland. The Inland Fisheries Institute (IFI), Ireland is responsible for the delivery of the transboundary Northwest International EMP (IE_NorW).

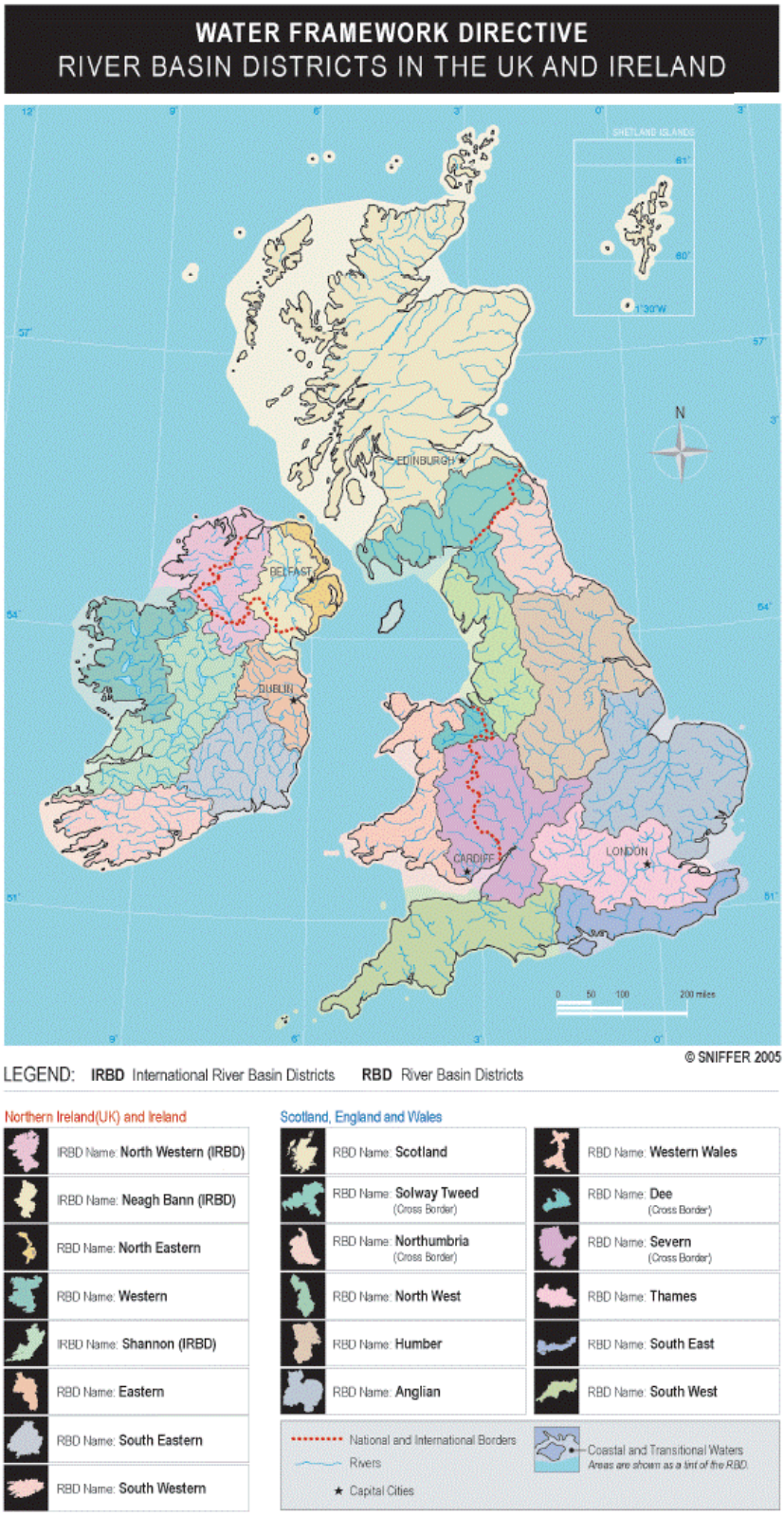

Figure 2.1. Map of the 15 Eel Management Units across the UK (after SNIFFER, 2005).

2.1.3 Fisheries and their regulations

All fishing for eel in England and Wales requires authorisation, which is subject to standard national conditions that control seasons, methods, and apply geographic restrictions and other

measures to protect bycatch species. The EA, under formal agreement, issues authorisations on behalf of NRW for those fisheries operating in Wales.

Standard conditions allow the use of four instrument types for eel fishing: permanently fixed traps (e.g. weir or rack traps and 'putts'); moveable or temporary nets or traps without leaders or wings and with a maximum diameter of less than 75 cm; moveable or temporary nets or traps with leaders or wings with a maximum diameter of less than 100 cm (usually fykenets); and elver (glass eel) dipnets. Recreational angling is permitted using rod-and-line, but all rod-caught eels must be returned alive to the waters from where they were caught. Appendix 1 in the 2007 UK report to the WGEEL provides a summary description of netting and trapping methods used to catch eels in England and Wales.

Conditions also stipulate that all eel (apart from glass eel) less than 300 mm in length must be returned to the water, that no part of any net, wing or leader shall be made of a mesh greater than 36 mm stretched mesh, and that monofilament material is prohibited (except for an elver dipnet or fishing with rod-and-line). It is also a requirement that nets set in tidal waters should not dry out, unless they are checked just before they do so, and that nets should not cover more than half the width of the watercourse, or should not be set closer than 30 m apart (apart from in still waters and tidal waters). All fykenets must be fitted with an otter guard (a 100 mm square mesh hard plastic frame, fitted in the mouth of the first trap) to prevent otters becoming trapped in the nets. No fishing is allowed within 10 m upstream or downstream of any obstruction. Elver dipnets must be used singly, by hand and without the use of chains, or boats. Small wingless traps and winged traps (fykes) can be used across the whole of England and Wales unless local byelaw restrictions apply.

Since 2010, the yellow and silver eel fisheries have been limited to those individuals who were already licensed, and these individuals are limited to the number of nets that they can apply for based on previous effort. Applications from newcomers are considered, but only for scientific studies, stock monitoring or for personal consumption. Thus, commercial fishing is effectively capped to existing fisherman who can use up to a maximum number of nets.

The glass eel fishery is restricted to two zones: in parts of South Wales and Southwest England, and in parts of Northwest England.

Every authorized instrument must carry an identity tag issued by the EA and it is a legal requirement that all eel and elver fishermen submit a catch return. The EA, under formal agreement, collates catch return information on behalf of NRW. Eel fishers are required to give details of the number of days they have fished, the location and type of water fished, the total weight of eel caught and retained or a statement that no eel have been caught. Annual eel and elver net authorization sales and catches are summarized by the instrument type for England and Wales and reported in the "Salmonid and Freshwater Fisheries Statistics for England and Wales" series (https://www.gov.uk/government/publications/salmonid-and-freshwater-fisheries-statistics).

Eel fisheries have never been regulated in Scotland, and the last known fishery closed in 2005. Legislation was introduced in 2009 requiring that anyone wishing to fish for eel in Scotland by any method must obtain a licence from the Scottish ministers.

Lough Neagh in Northern Ireland (GB_Neag) is the largest freshwater lake in the UK. Prior to 1983, estimates of annual recruitment of glass eel to the Lough consistently exceeded 6 million and averaged in excess of 11 million (based on a mean weight of 3000 glass eel per kg). Productivity is such that the Lough sustains a large population of yellow eel and produces many silver eels that migrate via the outflowing Lower River Bann.

The system sustains the largest commercial wild eel fishery in Europe, producing 13.8% of total EU landings and supplying 3.1% of the entire EU market (wild-caught + aquaculture) in 2016. Fishing rights to all eel life stages are owned by the Lough Neagh Fishermen's Co-operative

Society (LNFCS). The fishery is managed to enable the capture of approximately 250–350 t of yellow eel and 75–100 t of silver eels annually, with an escapement of silver eels at least equivalent to the catch of silvers. While it is illegal to fish for glass eels in N. Ireland, provision is made whereby LNFCS staff are allowed to catch glass eels using dragnets below a river-spanning sluice gate, which creates a barrier to upstream juvenile eel migration, for onward placement into L. Neagh. Elvers are also trapped at the same location and placed into the Lough.

The yellow eel fishery (May–September, five days a week) supports a peak season average of 85–95 boats, each with a crew of two men using draftnets and baited longlines. Eels are collected and marketed centrally by the cooperative. Silver eels are caught in two weirs in the Lower River Bann. Profit from the less labour-intensive (five to six men) silver eel fishery sustains the management of the whole cooperative venture, providing working capital for policing, marketing and stocking activity.

Natural recruitment has been supplemented since 1984 by the purchase of glass eel from outside the EMU. As of 2019, approximately 115.3 million (38.3 t) additional glass eel have been stocked by the LNFCS. Reviews on the fishery, its history and operation can be found in Kennedy (1999) and Rosell *et al*. (2005).

The transboundary Erne system (IE_NorW* and reported in Ireland Country Report) is comparable in size to L. Neagh and produces a fishery yield in the region of 33 t of eels per year. Within N. Ireland, the Upper and Lower Lough Erne sustained a small-scale yellow eel fishery, which was closed in 2010 under the terms of the EMP. There has been no commercial silver eel fishery on the Erne since 2001, but a trap and truck conservation silver eel fishery was instigated in 2009. Elvers are trapped at the mouth of the River Erne using ladders placed at the base of the hydroelectric facility that spans the Erne, and trucked upstream into the Erne lake system. A comprehensive study into the structure, composition and biology of the eel fisheries on the Erne was conducted by Matthews *et al*. (2001).

2.1.4 Management actions

An updated list of management measures became available in June 2018 within the 2018 UK EMP progress report. Since the implementation of EMPs in 2009/2010, new management actions have delivered:

- Introduction of 100% catch and release for eel by angling;
- Close season for net and trap fishing for eel;
- Limits on the geographical extent of the eel fishery;
- Creation of no fishing areas;
- Restrictions on eel fishing methods and gear;
- A programme of eel-specific monitoring for all eel life stages;
- Between 2009 and 2013, a total of 328 new eel passes were installed restoring access to over 4200 ha of river habitat;
- Between 2014 and 2016 in England and Wales, 23 eel screens and 136 eel passes were installed, opening up a further 2333 ha of habitat and potentially supporting a further 4800 kg of silver eel equivalent.
- Legislation providing new powers to require passes and screening to protect eel (UK Eel Regulation 2009);
- Raised awareness and widespread engagement with key stakeholder groups, including Water Companies, Internal Drainage Boards (IDBs), Power Generation and, Hydro-Power sector representatives;

- In 2016, the LNFCS increased the size of hook used in the longline fishery from a Mustad size 4 to a size 3. This was driven by scientific advice provided by AFBI following intensive studies into reducing the % of undersized (<400 mm) eel caught in this fishery.

In January 2010, the Eels (England and Wales) Regulations, 2009 Statutory Instrument came into force. This legislation was specifically developed to facilitate the implementation of Council Regulation (EC) No 1100/2007 in England and Wales. The legislation makes provisions to monitor exploitation, imposed a temporary close season on fishing for eels, enabled some control on the fishery and makes provision to protect the passage of eels. Much time and effort has been (and will continue to be) dedicated to the implementation of these Regulations.

In Scotland (GB_Scot) the principal management measure is the prohibition of fishing for eel of any stage by any method without a licence from Scottish ministers (under The Freshwater Fish Conservation (Prohibition on Fishing for Eels) (Scotland) Regulations 2008). To date (August 2019) no licences have been issued for either commercial or recreational fisheries.

In N. Ireland, DAERA produce an annual Fisheries Statistics Digest online, containing statistics on all aspects of eel catches including both commercial trade and conversation trap and transport catches (https://www.daera-ni.gov.uk/publications/digest-statistics-salmon-and-inland-fisheries-daera-jurisdiction-2019).

2.2 Significant changes since last report

Changes in fishery catches are reported elsewhere in this document.

The latest triennial assessment of eel escapement in EMUs was submitted to the European Commission in June 2018, and the results are reported here. Most changes in stock status since the 2015 report have been relatively minor, but significant reductions have been recorded in the Humber and Thames RBDs, dropping from 31% to 1.9% and 20% to 5.4%, respectively. In part, these reductions were due to large (ca. two thirds) decreases in observed yellow eel densities and hence in silver eel equivalent biomass estimates (B_{best}). In the Humber, B_{best} declined from 1.14 kg.ha^{-1} to 0.41 kg.ha^{-1}, while in the Thames it declined from 1.52 kg.ha^{-1} to 0.56 kg.ha^{-1}.

3 Impacts on the national stock

3.1 Fisheries

3.1.1 Glass eel fisheries

3.1.1.1 Commercial

Commercial glass eel fisheries currently exist in only five EMUs: GB_NorW, GB_Dee, GB_Wal, GB_Seve and GB_SouW (Table 3.1). The fishery in GB_SouE has not been authorised since 2010 and any commercial fishing for glass eel in other UK EMUs is forbidden. The fisheries are prosecuted by hand-held dipnets, in rivers and estuaries draining into the Bristol Channel, in particular from the Rivers Severn and Wye (GB_Seve) and Parrett (GB_SouW), with smaller fisheries elsewhere, such as that in Morecambe Bay, Cumbria (GB_NorW).

Glass eel fisheries are obliged to report their annual catch by weight, effort in terms of days and gears fished, location and water type (coastal, river, still water). Catches reported to the EA have historically been aggregated and reported to the WGEEL as the catch for England and Wales. In addition to these catch returns, annual trade statistics from Her Majesty's Revenue & Customs (HMRC) provided an alternative indication of catches, for the period 1979–2006. Trade reports did not discriminate by eel size or stage, and therefore a procedure was developed to estimate glass eel trade into and out of the UK, and hence net export trade (see the 2010/2011 UK Country report for further details). Comparison between the catch reported to the EA and the net exports HMRC data for 1979–2006 suggested a significant but variable level of underreporting to the Agency, by between five and 15 times.

In 2009, legislation was introduced to improve the traceability of eel caught, such that there are now three sources of data:

1. Catch returns to the Agency;
2. The quantity of glass eel bought by the dealers from the fishermen (consignment notes);
3. The quantity of glass eel exported from the UK or stocked within the UK.

Since 2005, catches and effort have been reported per "nearest waterbody", allowing the catch data to be assigned to EMUs (Table 3.1).

Table 3.1. Commercial catches (kg) of glass eel from England and Wales RBDs reported to the EA, from 2005 to 2019. Note that the 2018 catches are updated from the provisional data reported in the 2018 report, the 2019 catches are provisional (as of July 2019), and that no glass eel fisheries operate in the other EMUs, NP = not pertinent, in this case because glass eel fishing was not authorised in the Southeast since 2010.

Year	GB_NorW	GB_Dee	GB_Wal	GB_Seve	GB_SouW	GB_SouE
2005	166.2	39.0	87.0	784.8	626.5	0.0
2006	116.1	5.5	37.0	631.3	482.7	1.5
2007	200.0	6.3	26.0	1172.5	669.0	0.0
2008	91.6	2.0	3.8	370.7	348.6	0.0
2009	19.6	0.5	0.0	76.8	194.5	0.0
2010	30.3	4.8	1.1	531.7	756.5	NP
2011	75.8	12.9	2.5	897.5	1249.8	NP
2012	35.8	16.9	0.0	1151.5	1568.7	NP
2013	81.0	14.8	23.3	2693.0	3095.0	NP
2014	1.4	0.0	33.9	6125.9	5610.8	NP
2015	105.9	17.0	0.0	1418.7	1154.2	NP
2016	84.0	5.0	36.9	1971.3	1942.9	NP
2017	73.8	9.3	9.5	1585.7	1607.2	NP
2018	105.3	54.5	24.8	2345.2	1731.1	NP
2019	19.6	0	8.2	2227.9	1861.9	NP

The final catch reported to the EA for 2018 was 4.26 t of glass eel (Table 3.2). For 2019, the provisional data (as of July) of glass eel catch reported to the EA was 4.12 t (Table 3.2). Between 2009 and 2014, there was an increase in glass eel catch from the low of 0.29 t in 2009, to a recent high of 11.77 t for 2014, which was the highest elver catch since 1996 (Table 3.2). These figures are thought to have reflected a true increase in the availability of glass eel to the fishery at that time. However, catches have decreased since 2014, the catch of UK glass eel remains at the very low levels compared to those reported in the late 1990s (Table 3.2). Though underreporting of catch and effort are recognized, the consistency in the data collection over the time period (2005–2018) allows an evaluation of the trend in stock over this time period.

The mean CPUE for the confirmed 2018 data for all EMUs with glass eel fisheries was 0.91 kg/day. The confirmed 2018 data for the two main fishery areas, GB_SouW and GB_Seve, were 0.69 kg/day and 0.60 kg/day, respectively. The provisional 2019 total glass eel fishery CPUE was 0.61 kg/day (Table 3.2). Estimated transport losses (from shrinkage and mortality) of glass eel were 8%. This was estimated from the mean of the 2010–2018 percentage differences between dealer purchases and export (consignment notes) data.

Table 3.2. Time-series of 'UK' glass eel commercial fishery catches reported to EA, and as estimated from the consignment notes at first sale and dealer's purchase, with catch per unit of effort based on fisherman returns from 2010 onwards. *2019 reported catch is provisional, as of July 2018, ǂ Percentage transport losses were estimated from changes in dealer purchases and export (consignment notes) data.

Year	Catch reported to the EA (T)	Consignment notes (T)	Dealers purchase (T)	CPUE (kg/day) EA catch returns	ǂTransport losses (%)
2010	1.32	1.72	1.89	0.37	9.0
2011	2.24	3.28	3.64	0.31	9,9
2012	2.77	3.61	3.82	0.29	5.5
2013	5.91	7.79	8.66	0.65	10.0
2014	11.77	12.30	11.60	1.98	-6.0
2015	2.70	2.18	2.80	0.43	22.1
2016	4.04	3.82	4.28	0.53	10.7
2017	3.29	3.36	3.53	0.45	4.8
2018	4.26	4.37	4.66	0.65	6.2
2019*	4.12	6.09	6.95	0.61	12.4

3.1.1.2 Proportion retained for stocking

Table 3.3. Percentage of glass eel caught in the UK and sold for stocking throughout the EU, according to first sale registrations. Note the subsequent fate of glass eel after first sale is sometimes difficult to trace and therefore there is some uncertainty around these values.

Year	Stocking
2009	100.0
2010	53.8
2011	43.9
2012	84.7
2013	72.6
2014	63.0
2015	72.3
2016	54.0
2017	56.3
2018	80.5
2019*	72.2

**Provisional data as of August 2019.

3.1.1.3 Recreational

No recreational fisheries for glass eel are permitted in the UK.

3.1.2 Yellow eel fisheries

3.1.2.1 Commercial

Commercial fisheries for yellow eel deploy fykenets in ten EMUs of England and Wales (Table 3.4). A draftnet and longline fishery exists in GB_Neag (in NI, which is reported separately to that for England and Wales). There are no commercial fisheries for yellow eel in GB_Scot, GB_NorE or IE_NorW.

The total UK yellow eel fishery for 2018 amounted to 267.44 t, a slight increase of 3% compared to 2017 (259.13 t) (Table 3.4).

Prior to 2005, catches were reported as annual values for the whole of England and Wales, and for yellow and silver eel, combined. Since 2005, catches have been reported separately by stage and EMU (Table 3.4). The reported yellow catch for 2018 was 32.45 t for England and Wales, which was a 46.6% increase on the previous year (22.13 t), and 14.5% higher than the average annual catch over the past five years, 2013–2016 (30 437 t).

Commercial fisheries for yellow eel in the GB_Neag EMU use draftnets and longlines. Catches since 2005 are presented in Table 3.4, but it must be noted that a daily quota operates per boat in this fishery. Eel fishing on Lough Neagh is controlled by the LNFCS who license the fishery to approximately 200 fishermen, though in 2017 this number ranged from 40 to 186 fishermen operating at different times during the fishing season. Around 1990, there were 200 boats (400 fishermen) fishing the Lough, but this number has steadily declined to the present-day peak of season average of 85 to 95 boats as a result of an ageing fisher population, availability of alternative employment and falling market prices for eel. Boat size on L. Neagh is restricted to 8.6 m long and 2.7 m wide. Information on licence applications, number of boats, fishing activity, recruitment to the fishery and the catch of yellow and silver eels from L. Neagh is collected and maintained by the LNFCS with several aspects of these data spanning over 100 years. This information is made available to DAERA and AFBI for scientific analysis and the provision of management advice.

Approximately 40% of the Lough Neagh yellow eel catch is derived from draftnets, the other 60% from longline fishing using a maximum of 1200 standard sized hooks baited with earthworms, ragworms, fish fry or the larvae of the flour beetle (mealworm). The fishery is run on a quota-based system driven by management decisions in consideration of conservation target compliance and commercial needs (usually 50 kg per boat per day). Economic margins have decreased due to increasing operational and distribution costs in conjunction with currency fluctuations. A record is kept of each individual boat's daily (Monday–Friday) catch, and noted against that day's quota. New technologies such as hydraulic draftnet haulers have been introduced over the last 20 years, thereby reducing the labour needed in the fishery or enabling fishermen to fish for longer if required.

Yellow eel catches in L. Neagh in 2018 amounted to 235 t, a two-tone decrease compared to 2017. This is the lowest yellow eel catch since 1959. Catches per boat per day in the longline and draftnet fisheries continue to meet daily quotas imposed by the cooperative, implying that sufficient stocks are maintained for the steadily falling (1–2 boats decline per year) number of boats fishing in the Lough, but fishermen have commented that it takes longer to catch their quota. Provisional data for 2019 suggest reduced landings to 2018 and are consistent with poor recruitment history.

The quota-based catch management system combined with varying boat numbers (on an almost daily basis) means it is impossible to calculate an annual CPUE for the yellow eel fishery. However, a comparison of catch against average boat numbers (95 boats) produces a mean catch of

3463 kg boat^{-1} in 2009–2013 and 2684 kg boat^{-1} in 2014–2018, (decrease of 22.5%). Analysis of the Lough Neagh data reveals no relationship between CPUE and time-lagged input stock density. This is most likely because (i) two different gears are operated (nets and baited longlines) with very different catch vs. effort parameters and with catch reported as a combined daily catch for both gear types, and (ii) there is a variable daily cap on the amount of eel that fishermen are allowed to catch.

Table 3.4 Commercial catch (t) of yellow eel for all UK EMUs with a fishery during the reporting period, together with total UK catch, 2005–2018.

Year	GB_Nort	GB_Humb	GB_Angl	GB_Tham	GB_SouE	GB_SouW	GB_Seve	GB_Wale	GB_Dee	GB_NorW	GB_Neag	Total
2005	0.005	1.295	13.065	7.175	0.406	3.787	0.565	0.240	0.034	1.619	317.10	345.29
2006	0.001	1.160	6.282	5.688	3.069	6.788	0.170	0.475	0.028	1.250	242.20	267.11
2007	0.000	2.138	3.739	6.963	1.807	2.019	0.068	0.273	0.023	0.211	351.30	368.54
2008	0.000	1.429	9.903	5.548	0.602	6.626	0.027	0.118	0.642	0.474	290.00	315.37
2009	0.045	0.411	6.616	4.745	7.029	2.546	0.000	0.022	0.070	0.114	345.20	366.80
2010	0.060	3.033	10.708	5.655	1.432	2.722	0.150	0.345	0.053	0.150	337.40	361.71
2011	0.000	4.857	16.478	6.082	1.879	3.792	0.350	0.252	1.082	1.477	342.00	378.25
2012	0.000	3.267	15.335	1.815	2.116	5.966	0.000	0.647	0.478	2.972	302.00	334.60
2013	0.000	3.865	9.315	3.991	0.286	8.688	0.000	0.100	0.152	0.669	321.00	348.07
2014	0.000	3.522	16.875	3.222	0.284	10.117	0.000	0.000	0.415	0.087	297.00	331.52
2015	0.000	1.381	8.379	2.696	0.957	16.828	0.000	0.000	0.074	0.093	255.50	285.91
2016	0.000	0.155	12.273	2.473	0.825	10.261	0.000	1.345	0.073	0.187	262.00	289.59
2017	0.000	1.542	6.129	2.264	0.364	11.168	0.000	0.000	0.333	0.326	237.00	259.13
2018	0.000	4.838	11.796	1.971	0.216	13.347	0.000	0.000	0.123	0.154	235.00	267.44

3.1.2.2 Recreational

No recreational fisheries for yellow eel are permitted in the UK. Where eels are caught in rod-and-line fisheries they must be returned alive to the water where they were caught. No information is collected on these catch rates nor on post-release survival rates.

However, the undersized yellow eels (<400 mm long) captured via longline in Lough Neagh are returned to the Lough at the point of capture with hooks in place. Every month 100 undersized eels are sampled at the fishery, their hook location recorded and in conjunction with analysis of the catch composition, attempts are made to quantify possible losses to the fishery through hook mortality.

3.1.3 Silver eel fisheries

3.1.3.1 Commercial

Commercial fisheries in the ten EMUs of England and Wales are prosecuted using both fixed weir-traps and mobile fykenet gears (Table 3.5), while there is a coghill net silver eel fishery in GB_Neag. There are no commercial silver eel fisheries in GB_Scot, GB_Solw, GB_NorE or IE_NorW.

Yellow and silver eel catches in England and Wales have been reported separately for yellow and silver eels and assigned to separate EMUs since 2005. The reported silver eel catch for 2018 was 5.17 t, an increase of 45.1% compared to 2017 (3.56 t) and an increase of 10.8% on the five-year rolling average catch (5.73 t) over the years 2013–2017.

GB_Neag

Silver eel from Lough Neagh were caught in the River Bann using coghill nets fished on three weirs at two locations, but from 2012, the LNFCS reduced this to two weirs as an additional conservation measure. The number of coghill nets fished at each weir depends on weather and river flow conditions, and normally ranges from 2–4 nets per fishing night. The record of nightly catch is estimated at the time. True daily catch is only obtained if the catch is processed and sold the following day. Otherwise, catches are retained in tanks and sold as and when market conditions are more favourable. Therefore, a 'single' catch sale record may be a total for several nights fishing. This practice does not affect the annual catch reporting. Fishing capacity is recorded as the number of licensed silver eel weirs in operation.

The two weirs operate at different efficiencies dependent upon river flow rates. The data on silver eel catch are not available per net per night per weir. Given that a night's catch from the silver eel fishery in the River Bann may not be marketed the next day, but is combined with several nights' capture (with this reported at the time of sale as the "catch"), it is difficult to calculate a CPUE for the silver eel fishery that would provide a meaningful indicator of stock abundance. The 2018 catch of 94 t was above expectations and believed to have been affected by long warm summer water temperatures, which may have encouraged yellow eels to feed more and silver a year "earlier" than expected. (Table 3.5)

Table 3.5. Commercial catch (t) of silver eel for all UK EMUs with a fishery during the reporting period, together with total UK catch, 2005–2018.

Year	GB_Nort	GB_Humb	GB_Angl	GB_Tham	GB_SouE	GB_SouW	GB_Seve	GB_Wale	GB_Dee	GB_NorW	GB_Neag	Total
2005	0.00	0.24	6.66	1.07	3.59	1.89	0.40	0.01	0.01	0.20	116.5	130.57
2006	0.00	0.32	2.42	0.97	4.10	1.90	0.15	0.03	0.01	1.10	104.4	115.40
2007	0.00	2.19	0.20	0.48	2.62	0.23	0.12	0.14	0.01	0.09	75.9	81.98
2008	0.09	0.86	1.97	0.40	1.65	0.55	0.12	0.01	0.02	0.26	78.3	84.23
2009	0.01	0.11	0.59	0.12	3.20	0.30	1.22	0.04	0.01	0.08	87.9	93.58
2010	0.00	0.20	0.74	0.07	0.82	0.17	0.10	0.01	0.02	0.07	96.8	99.00
2011	0.00	0.26	2.01	0.51	0.69	0.07	0.38	0.01	0.12	0.27	73.3	77.62
2012	0.00	1.63	2.98	0.20	0.65	0.53	0.00	0.00	0.00	0.46	72.8	79.25
2013	0.00	0.26	2.49	0.31	1.99	0.95	0.00	0.00	0.03	0.11	72.8	78.94
2014	0.00	0.48	5.02	0.38	0.75	1.17	0.00	0.00	0.03	0.03	66.8	74.66
2015	0.00	0.74	3.76	0.20	0.11	0.91	0.00	0.00	0.03	0.06	49.3	55.11
2016	0.00	0.05	3.66	0.15	0.25	0.95	0.00	0.15	0.02	0.03	52.5	57.76
2017	0.00	0.02	2.11	0.01	0.03	1.12	0.00	0.00	0.02	0.25	59.7	61.46
2018	0.00	1.12	2.26	0.13	0.08	1.34	0.00	0.00	0.02	0.22	94.1	99.27

3.1.3.2 Recreational

No recreational fisheries for silver eel are permitted in the UK. It is thought unlikely that silver eel would be accidentally caught in rod-and-line fisheries but if this were to occur then they must be returned alive to the water where they were caught. No information is collected on these catch rates nor on post-release survival rates.

3.1.4 Illegal, underreported or unrecorded catch

No data exist for illegal, underreported or unrecorded catches in England and Wales EMUs for silver or yellow eels. All eel fishing in Scotland is illegal without licence (and no commercial licences have been issued since the introduction of legislation in 2009), however, no data on the extent of illegal activity are available.

3.1.5 Bycatch

Few data are collected on the bycatch of other species in gears targeting eel but a series of surveys by AFBI confirmed previous assertions that any level of bycatch is small.

GB_Neag

Toome weir (four nets) in one night caught 87 377 fish of which 9.1% was bycatch and of that bycatch 6.2% was released alive.

Kilrea weir (three nets) in one night caught 31 373 fish of which 0.02% was bycatch.

No data are collected on the bycatch of eel in gears targeting other fish species.

3.2 Restocking

3.2.1 Stocking in the UK

Glass eel have been stocked into ten UK EMUs in recent years (Table 3.6). Data on the amounts stocked are available from the Neagh Bann EMU since 1984, and from other EMU since 2009. In most years, the glass eel originated from the commercial fisheries in the Severn and Southwest EMUs. However, in 2010, the 996 kg of glass eel stocked in Neagh Bann originated from fisheries in San Sebastian, Spain and the west coast of France, and in 2011 and 2012, stocked material was sourced from France and the UK fisheries. There was no stocking of glass eel into Lough Neagh in 2016 because of issues with availability and supply from the UK fishery. Glass eel are not routinely quarantined before stocking into Lough Neagh, but arrive from UK Glass Eels Ltd with a Veterinary Health certificate and approved biosecurity protocols. However, following the recent purchases from outside the UK, 1 kg of each new delivery is held in tanks at the LNFCS HQ and survival rates monitored for several weeks by AFBI. In 2018 and 2019, 343 kg and 307 kg respectively of glass eels stocked into Neagh were of French (Gironde) origin.

Table 3.6. Recent amounts (kg) of glass eel stocked into various UK EMUs. Note that the source of stocked materials usually UK fisheries, except that the stocking of GB_Neag in 2010 was solely from France and Spain, and in 2011 and 2012 were from France and UK.

EMU										
Year	GB_Humb	GB_Angl	GB_Tham	GB_SouE	GB_SouW	GB_Seve	GB_Wale	GB_NorW	GB_Neag	GB_NorE
2006									330.0	
2007									1000.0	
2008									428.0	
2009	18.5	4.6	0.0	0.0	0.0	0.0	0.0		215.0	
2010	38.0	15.2	0.0	0.0	0.0	0.4	0.0		996.0	
2011	0.0	11.3	0.0	0.0	0.0	38.8	0.0		1035.0	
2012	10.0	1.5	3.2	0.0	5.0	21.5	0.0		1300.0	
2013	3.0	9.1	2.00	7.0	12.8	37.0	1.0		1866.0	
2014	3.8	0.0	14.0	7.5	8.7	21.5	0.0	0.0	2690.0	20.0
2015	0.0	0.0	0.0	0.0	0.3	17.0	0.0	0.0	604.0	
2016	0.0	0.0	0.0	0.0	0.6	17.0	0.0	0.0	0.0	
2017	0.0	0.0	0.0	0.0	0.0	17.0	0.0	0.0	817.0	
2018	0.0	0.0	0.0	0.0	0.0	17.0	0.0	0. 0	754.0	
2019	0.0	0.0	0.0	0.0	0.0	17.0	0.0	0.0	1252.0	

GB_Neag

A form of assisted migration is also conducted in the Neagh Bann EMU, where glass eels are trapped in the lower reaches of the River Bann and then transported to Lough Neagh bypassing in-river obstacles. This catch is used as natural recruitment in any stock analyses (Table 3.7).

Table 3.7. Quantities (kg) of glass eel trapped in the lower River Bann and assisted into Lough Neagh (GB_Neag EMU).

Year	Assisted migration (kg)
2006	456
2007	399
2008	24
2009	158
2010	68
2011	16
2012	203.3
2013	384
2014	698
2015	317
2016	432
2017	429
2018	890
2019	282

3.2.2 Stocking of UK glass eel into other countries

Glass eel from UK fisheries are also stocked into other European countries (see Table 3.8), but the fate of exported glass eels is often not known.

Table 3.8. The export destinations and kg of glass eel caught in the UK. *2019 is provisional.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Belgium					4					2	
Bulgaria								70			
Czech Rep			30	76	470	594	32	80	63	70	65
Denmark		200	515	400		400	250				
Estonia			307	90	480	420	250	152	150	162	608
France						863	100	185		320	98
Germany		97	882	384	470	1199	323	1074	1134	1081	904
Greece			411		1005	650	40	600	96		
Latvia			100	343	15	483		10	290	226.8	230
Lithuania					180	330		120	158	505	805
Netherlands		1288	593	100	1620	2232	350	51	109	309	1020
Poland				120	95	15	5	127		35	120
Slovakia		85	80						14		60
Spain						500		460			
Sweden	205			1200	1300	1400	672	892		1250	1250

3.3 Aquaculture

There is no eel aquaculture in the UK. Some glass eels are exported to other EU countries for aquaculture and these are reported in Table 3.9.

There are historic issues of underreporting the catch, which mean that it is not appropriate to derive a proportion stocked from this historical catch data. New measures to accurately record catch and proportion retained for stocking have been implemented as part of the EMPs and therefore these proportions are available from 2009 onwards (Table 3.9). Since 2009 with the exception of 2019, UK glass eel landings have consistently achieved their EU conservation target of providing 60% or more of the catch for stocking purposes (Table 3.9).

Table 3.9. Percentage of glass eel caught in the UK and sold for stocking, aquaculture or direct consumption, according to dealer's reports. [Note these percentages may not add up to 100% because of mortality and weight loss after capture].* 2019 Provisional data.

Year	Stocking	Aquaculture	Direct consumption
2009	100.0	0.0	0.0
2010	53.8	36.5	0.0
2011	43.9	45.3	0.0
2012	84.7	10.5	0.0
2013	72.6	27.4	0.0
2014	62.9	28.2	6.7
2015	72.3	27.2	3.70
2016	54.0	45.7	0.3
2017	56.3	43.7	0
2018	80.5	19.5	0
2019*	72.2	27.7	0

3.4 Entrainment

3.4.1 Tidal flaps/gates

A total of 1048 tidal sluices exist within England and Wales. A study was undertaken to produce a nationally consistent, prioritised list of tidal outfall structures in England and Wales where upstream and/or downstream fish passage is adversely affected (HIFI, unpublished). The decision of which sluices to assess was initially made on the basis of channel width, with the narrowest watercourses (those <5 m wide) rejected because these are unlikely to provide large quantities of habitat for eel (even if channel length is long). This reduced the number of structures from 1048 to 449. These 449 were prioritised based on (1) fish stock status; (2) passage efficiency; (3) channel length; (4) channel width and (5) habitat quality.

An initial assessment of the impact on eel production was estimated for the top 106 of the prioritised tidal structures. Assuming that all the area upstream of the tidal gates/flaps is lost production, the total loss in terms of silver eel biomass was derived from total wetted area upstream * B_{best} production (kg/ha) in that EMU. In the absence of site-specific information on impacts, a conservative approach was taken to assume total loss of eel production upstream of the top 10% of tidal structures, and no loss of production from the remainder. This assessment will likely be revised as and when further information becomes available.

3.4.2 Pumping stations

In England and Wales, there are 321 pumping stations identified as having the greatest potential to impact on eel, based on: 1) distance from head of tide (shorter distance = greater impact) and 2) the predicted presence of eel.

To estimate the impact, it has been assumed that all the area upstream of the pumping station is lost to eel production. The total annual loss in terms of silver eel biomass is derived from wetted area upstream * B_{best} production (kg/ha) for the relevant EMU.

3.4.3 Surface water abstraction sites

Surface water is abstracted at 29 863 sites in England and Wales. Those sites with the greatest potential to impact on eel were identified using the following criteria: distance from head of tide, size of the abstraction, predicted presence of eel, the sensitivity of the waterbody to abstraction; and were quality assured by consultation. 772 sites were identified as posing the greatest threat to eel.

A study of eel entrainment and mortality has been carried out at twelve surface water abstraction sites. The average number of eel entrained at these twelve sites was 627 eels per year, with the average age of those eel being two years (~150 mm). The equivalent in terms of silver eel biomass is estimated to be 0.03 kg per entrained eel. This equates to 18.81 kg per year entrained per abstraction.

3.4.4 Hydropower facilities

In England and Wales, there are 212 hydropower facilities in operation affecting 11 188 ha of eel producing habitat. The impact of each hydropower facility is estimated according to the B_{best} production (kg/ha) for the relevant EMU, the area of habitat upstream, the presence or absence of screens (preventing eel entrainment) and the type of turbine. For those sites with screens, the proportion of eel entering the turbine(s) was assumed to be zero if the spacing between the bars/mesh was <15 mm, 50% if the spacing was between 16–29 mm and 100% if >30 mm: 27.6% of hydropower schemes (excluding Archimedes screws) are adequately screened to prevent the entrainment of eel (i.e. spacing was <15 mm). The estimates of turbine mortality were taken from the WGEEL 2011 report and were; Archimedes screw 0%, Francis Turbine 32%, Kaplan turbine 38%. All hydropower facilities have some form of bypass channel that provides an alternative route for fish around the turbine. On this basis, it has been assumed that approximately 50% of the silver eels produced upstream of a turbine will become entrained therein.

On those river systems where there is more than one hydro facility, the loss of production from the upstream turbine(s) has been accounted for in estimating the potential impact of turbines further downstream, i.e. the cumulative impact of all turbines has been calculated.

In Scotland, a more conservative assessment approach has been adopted in which, in the absence of further information, eel production upstream of hydropower facilities is assumed to be zero.

3.4.5 Transboundary EMU: IE_NorW

AFBI undertook a hydroacoustic telemetry turbine mortality study in December 2018 assessing turbine passage and associated mortality at the two hydroelectric plants at the outflow of the River Erne into the Atlantic Ocean (Transboundary EMU IE_NorW). Sixty silver eels were tagged and released in December. The tagging and associated releases were in two separate batches of 30 to coincide with low flow (6/12/18) and high flow (19/12/18) regimes out of the system to coincide with different turbine/spilling operating regimes. The findings from this study will be presented at WGEEL and form part of the outputs from the Subgroup specific study into Hydropower impacts. The study will be repeated in 2019.

3.5 Habitat Quantity and Quality

3.5.1 GB_Neag

Amount and characteristics of eel habitat

Lough Neagh comprises 38 600 hectares of open water and has a mean depth of 9.5 m with a maximum of 30 m (Figure 3.1). It is the largest lake by surface area in the British Isles and due to the size of Lough Neagh, the remaining potential eel producing areas of small lakes and rivers in the catchment are minor by comparison, amounting to at most perhaps 5% of total water surface area. As the water in Lough Neagh does not stratify and is generally aerated by wind driven circulation throughout the water column, the entire lakebed area is available to eel. It is classified as hypertrophic due to phosphorus and nitrogen nutrient inputs, now mainly from agricultural land but also from human domestic sources. For these reasons, the production of eel from rivers and lakes upstream and downstream of L. Neagh is considered to be relatively minor and, therefore, this plan focuses primarily on eel production in L. Neagh.

Passability to upstream and downstream migrating eel

The outflow from Lough Neagh through the lower River Bann is regulated by a series of weirs and sluices (Figure 3.2). These sluices are operated by the Northern Ireland Rivers Agency under legislation designed to maintain water levels in Lough Neagh within narrow bounds to facilitate lake–shore agriculture, navigation, and drinking water abstraction. Eel passes are in place on all sluice gate systems, and these passes are annually maintained by LNFCS with traditional methods (straw rope coverings) to facilitate upstream migration of any young eels which by-pass the trap and transport operation, although under current recruitment levels, most are helped upstream by the trap and tanker transport operation undertaken by LNFCS from tidal head traps 40 km to Lough Neagh. Under the high recruitment conditions in the early and mid-1900s, there was considerable natural upstream migration, given the lack of anthropogenic influences in the system at that time.

Any silver eels which use the minimum 10% free gap past active silver fisheries are therefore free to run to sea. The outflowing River Bann is free of any turbine, power generation system or major water abstraction which might impede the escapement of silver eels to the sea.

Chemical quality

The chemical quality of Lough Neagh and the River Bann is assessed by the Northern Ireland Environment agency at sites in the Lough and the outflowing River Bann at quarterly intervals. Three determinants are used to score the quality according to the UK: biochemical oxygen demand (BOD), dissolved oxygen (DO) and ammonia, and categorised under the UK General Quality Assessment (GQA) system. In this system, there are six quality classes ranging from Very Good through Fair to Bad. Monitoring results for rolling 3-year sampling periods are used. Thus, for example, the GQA chemical classification for 2003 is based on a combination of the results obtained during 2001, 2002 and 2003. Lough Neagh currently scores at GQA class 3 (fairly good) which means that it is suitable for potable supply after treatment, all other abstractions, good cyprinid fisheries, and is capable of supporting a natural ecosystem.

Trophic status

AFBI monitors nutrient levels (forms of Nitrogen and Phosphorus, Silica, Algal species and quantity) on a fortnightly basis, along with Chlorophylla and Secchi disk transparency. These data class Lough Neagh as eutrophic or hypertrophic on the OECD/Vollenweider system, as a result of mainly agricultural but also some domestic N and P inputs. While this is a concern for other interests (e.g. the salmon and trout fisheries), the turbidity and high biological productivity are

actually positive factors to the eel, and probably account for the lake's capability to produce extraordinary quantities of eel relative to glass eel inputs. Some eel food items, particularly chironomid larvae, are present in very high abundance.

Contaminants

Lough Neagh has an essentially agricultural catchment with very low levels of industrialisation and only small or medium sized towns. Hence, in the absence of routine monitoring of eel quality, it is inferred that there is no local problem of contamination of eel with organic chemical residues, heavy metals, or other pollutants which would give grounds for concern for human consumption or indeed for eel spawner viability (see Section 5.4.2).

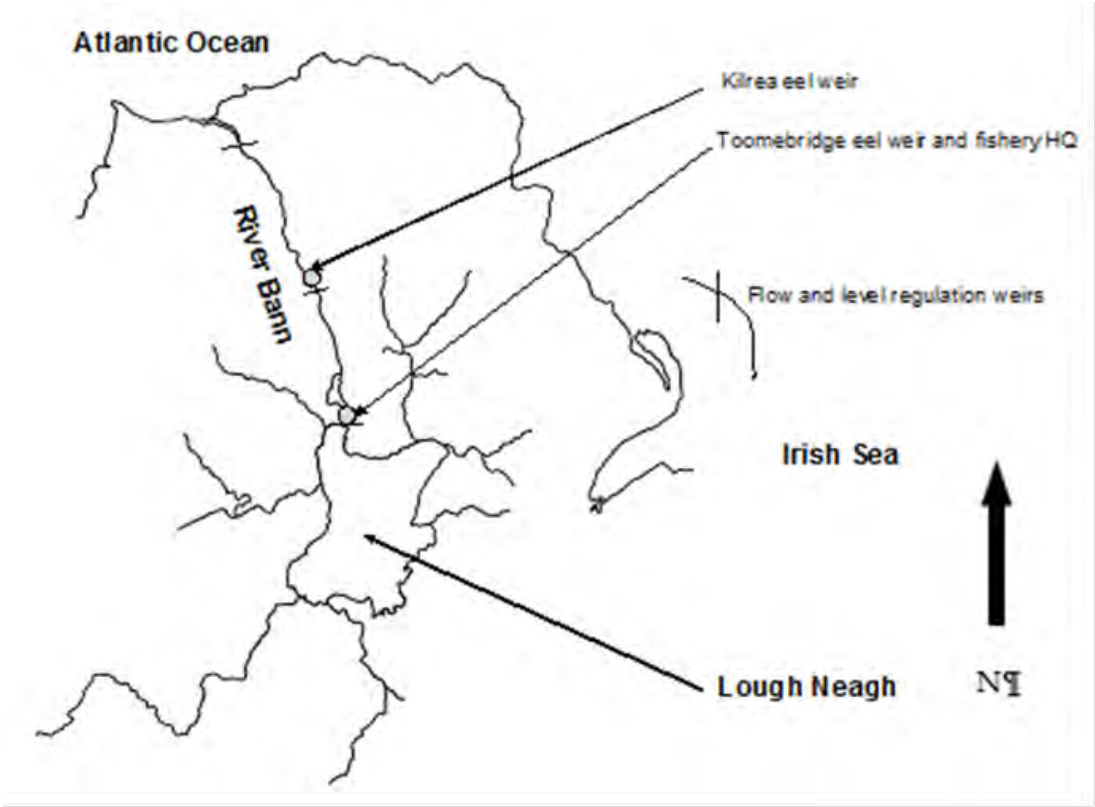

Figure 3.1. Schematic map of Lough Neagh in N. Ireland indicating silver eel weirs and sluice gates along the River Bann corridor.

Figure 3.2. Sluice gates on the Bann corridor.

3.5.2 GB_NorE

This EMP covers the Northeast coastal fringe of Northern Ireland, comprising the Northeastern River Basin District as defined for Ecoregion 17 (The Island of Ireland) for WFD purposes, with the addition of those County Down coastal catchments draining into Carlingford Lough from Northern Ireland and those parts of the river catchments of South County Armagh not draining north to Lough Neagh but draining southward to the Irish Republic.

This EMP is entirely contained within one Member State (UK, Northern Ireland). A small part of the area contains the headwaters of streams draining to the Fane catchment in the Republic of Ireland (RoI). The Republic of Ireland Eastern EMP will include the RoI portion of the River Fane system.

This EMP contains a diverse range of river and lake habitats, ranging from highgradient mountain streams of low productivity and little or no production of eel, to lowland inter-drumlin lakes in areas of high productivity and with significant capability, at least on a per unit area basis, to produce eel. The potential eel productive area in the region is largely in two of these sections or catchment groups, i.e. the River Lagan and associated rivers entering the Irish Sea at Belfast, and the collected catchments draining to the fjord-like Strangford Lough.

3.6 Other impacts

There is no information available on other impacts.

4 National stock assessment

4.1 Description of Method

Different methods are applied in different jurisdictions within the UK.

England and Wales: GB_Nort, GB_Humb, GB_Angl, GB_Tham, GB_SouE, GB_SouW, GB_Seve, GB_Wale, GB_Dee, GB_NorW, GB_Solw

Silver eel escapement estimates for these EMUs are derived from yellow eel electric fishing surveys extrapolated to silver eel escapement using the SMEP II model and various analyses to estimate losses due to fisheries and other human impacts.

The numbers of potential silver eel emigrants arising from the yellow eel population in the survey year, is estimated from the abundance and length distribution of those eels considered to be long enough to have a probability >0 of becoming silver eels in that year. The biomass of silver eels is estimated from the numbers-at-length using a length–weight relationship derived from data for over 16 000 eels sampled throughout England and Wales (Aprahamian *et al.*, 2007; Walker *et al.*, 2013).

To estimate fishing mortality rate, the yellow and glass eel catches were first converted to silver eel equivalents. The biomass of yellow eel caught was considered to be the equivalent of the potential silver eel escapement as the instantaneous mortality rate of 0.139 yr^{-1} (Dekker, 2000) approximated to the instantaneous growth rate of 0.2 yr^{-1} (Aprahamian, 1986).

For the glass eel catch, 1 kg of glass eel was considered equivalent to 59.4 kg of silver eel, based on the instantaneous mortality of 0.00915 day^{-1} for the first 50 days post-settlement and there after a mortality of 0.139 yr^{-1}, a 50:50 sex ratio with males maturing at 12 (@90 g) and females at 18 years (@570 g) (Aprahamian, 1988).

The methods used to estimate other human-induced mortality rates are described in the 2018 UK EMP report.

Estimation of B_0

The 2015 triennial UK Eel Management Plan (EMP) progress report had an updated methodology for the calculation on historical biomass (B_0) compared to the 2012 and 2013 assessments. The improved model better reflected the actual state of eel stocks in rivers. Although the basic life-history model used for compliance calculations did not change, some of the assumptions and key datasets used within the model changed significantly (for more details on the methodology, see annex A in the 2015 UK EMP report). The same method was used in for the 2018 UK EMP Report. Although our model has been improved, the confidence limits around the biomass estimates are inherently wide.

Scotland: GB_Scot

Stock assessment methods have been developed for the Scotland EMU based on quantification of upstream and downstream eel movements at traps on three rivers. The estimates of B_0, $B_{current}$ and B_{best} rely heavily on the extrapolation of data from small study areas to the EMU as a whole, with the inherent possibility of bias. To derive an estimate of current production and anthropogenic mortality for the EMU from the available data has required a number of assumptions; these have tended to be precautionary in nature (i.e. likely to underestimate current production and overestimate current anthropogenic mortality (see Scotland RBD EMP, 2010 for details). Some of

these precautionary assumptions could be tested, and the production/mortality estimates adjusted accordingly, if resources become available. Scotland RBD EMP is available at: http://www.gov.scot/Resource/Doc/295194/0118349.pdf.

From 2013, and following the methods used in England and Wales, Scotland has adopted the inclusion of a silver eel production estimate for transitional waters based on the simplistic assumption that this is equivalent to silver eel production in the lowland rivers and lochs of Scotland (<240 m). Pristine production for transitional waters is assumed to be equivalent to pristine production in Scottish freshwaters during the reference period. For this reason, the inclusion of transitional waters has no effect on modelled silver eel output as a percentage of pristine output. However, because anthropogenic mortality (∑A) is assumed to be zero in transitional waters, as there are no fisheries, the inclusion of transitional waters leads to a substantial reduction in the estimate of the value of ∑A for the Scotland EMU.

Pristine escapement, B_0, was estimated via three different methods: one based on historical measures of escapement from the Girnock Burn 1967–1980; one based on reference to a similar habitat elsewhere (Burrishoole data); and one based on the Irish Catchment Geology model. Details are presented in the Scotland RBD EMP (http://www.gov.scot/Resource/Doc/295194/0118349.pdf). All three methods yielded broadly similar results, and accordingly the mean value for pristine escapement of the three methods was adopted as B_0. Since the EMP was published, the estimate of B_0 has been slightly increased to take account of trap efficiency in one of the estimated methods. Further details can be found in the UK 2015 EMP progress report to the EC.

Northern Ireland

GB_NorE

The estimate of pristine escapement from the Northeast RBD was calculated with reference to the ecology and hydrology of similar systems (option c Article 5 of the Regulation) as described in Section 2.4.1 of the EMP. Current escapement was monitored in autumn and winter of 2017 and 2018 providing an extrapolated $B_{current}$ across the EMU of 969 kg and 847 kg respectively. All rivers and upland lakes which are suitable for eel, have been assessed as having no barriers to migration. As such under adequate recruitment levels and an adherence to the criteria laid down in the Northeast RBD EMP, this EMU should reach or better the 40% target naturally.

GB_Neag

The monitoring of silver eel migration and subsequent estimations of silver eel escapement from the GB_Nea EMU are carried out by direct measurement. Given the geography of the RBD, in particular the single outflow point of Lough Neagh via the Lower River Bann at Toome, an annual mark–recapture programme of silver eel emigrating from Lough Neagh was initiated in October 2003, to estimate silver eel escapement ($B_{current}$) past the weir fishery, which is subject to a trap-free gap in the river channel, a three-month fishing season (some silver eel movement occurs outside this season), and inefficient fishing when river flows are very high. Recaptures occur both during the year of release and at least one or even two years afterwards. To date, 10 439 silver eels have been tagged and maximum estimates of escapement, based on the proportion of recaptured FloyTM tagged eels, range from 111 t to 338 t during 2003 to 2018 (Table 4.2). No tagging was undertaken in 2007 due to the sporadic nature of the silver eel run. The Neagh/Bann estimate of B_{best} is derived from a known history of natural recruitment plus enhancement stocking, time-lagged for known growth rates of silver eel. The current fishery management arrangements significantly contribute to the outputs from this system.

IE_NorW*

The assessment methods for the Northwestern International RBD (IE_NorW*) are detailed in the original EMP (Section 8; Action 2a). Stock assessment was carried out on the Erne as part of the Erne Eel Enhancement Programme, which ended in 2001 (Matthews *et al.*, 2001).

The values for B_0 for the UK derived from these various assessment measures are shown in Table 4.1.

Table 4.1. Value and reference period for B_O.

EMU_CODE	B_0 (kg/ha)	Reference time period	Change from 2015 value
GB_Nort	5.16	1983–1986	Y
GB_Humb	2.38	1983–1986	Y
GB_Angl	6.27	1983–1986	Y
GB_Tham	5.88	1983–1986	Y
GB_SouE	10.60	1983–1986	Y
GB_SouW	37.03	1977–1990	Y
GB_Seve	11.98	1983	Y
GB_Wale	16.18	1977–1990	Y
GB_Dee	45.02	1984	Y
GB_NorW	18.50	1977–1990	Y
GB_Solw	16.84	1977–1990	Y
GB_Scot	1.18	Pre-1980	N
IE_NorW	3.70	Pre-1980	N
GB_NorE	4.00	Pre-1980	N
GB_Neag	12.5	Pre-1980	N

Table 4.2. Results of mark–recapture estimation of silver eel escapement from the Lough Neagh silver eel fishery 2003–2018.

Recaptures								
Year	No. tagged	Toome	Kilrea	Carry over to catch (T+1,T+2y)	Total	Rate (%)	Total annual silver catch (t)	Max.possible escapement estimate (t)
2003	189	33	7	7	47	24.9	114	343
2004	838	302	15	4	32	38.3	99	159.4
2005	792	118	0	7	125	15.8	117	623
2006	700	197	1	2	199	28.4	104	262
2007	0	No tagging due to sporadic nature of silver eel run					76	
2008	950	193	18		211	22.2	76	266.2
2009	486	187	0	1	188	38.8	85	134.1
2010	491	167	14	0	181	36.9	97	165.9
2011	474	82	64	3	149	31.4	73	159.5
2012	452	65	19	2	86	19.0	74	315.9
2013	451	74	19	3	96	21.2	72	267.6
2014	956	139	57	3	196	20.5	66	253.2
2015	898	164	110	0	274	30.5	49	111.1
2016	776	151	42	0	193	24.9	52.5	158.3
2017	465	81	2	1	83	18.1	59.7	274.7
2018	1007	165	85	2	250	24.8	94	388.0
							15 year mean	228.7
							1st EMP mean	153.2
							2nd EMP mean	278.9
							3rd EMP mean	181.4
							TARGET	200.0

4.1.1 Data collection

GB_Neag

Eel are sampled regularly as part of a long-term research programme which investigates all life stages throughout the year. Yellow eel catches are sampled weekly over 20 weeks (from May to September). A sample of 20 eels is chosen to reflect all size ranges caught, and analysed for age and length. In addition, the entire, ungraded landing of two fishing crew on one day each month

is sampled, usually comprising 400–600 eels captured by longline and a similar number by draft-net, to enable comparison between methods. Every eel is measured for length, and the total catch recorded.

Preliminary analysis indicates that a larger proportion of small eels (<40 cm) are captured by draftnets (34%, compared to 21.4% on longlines), whereas more of the larger eels (>60 cm) are taken on longlines. Furthermore, there was significant variation in the numbers of small eels captured by longlining dependent upon bait type (earthworms caught more) and hook size (larger hook caught fewer small eels).

GB_NorE

A fykenet survey was undertaken in Killough within this EMU in summer 2017 and was directly assessed for silver eel migration in autumn and winter of 2017 and 2018, data provided in the datacall.

4.1.2 Analysis

No information available.

4.1.3 Reporting

No information available.

4.1.4 Data quality issues and how they are being addressed

No information available.

4.2 Trends in Assessment results

4.2.1 Habitat quantities

The wetted area used for calculating the stock assessment indicators for each EMU are shown in Table 4.3. Such wetted area habitatsinclude rivers, lakes, inland waters, lagoons, coastal waters, and estuaries.

Table 4.3. The areas of habitat used in the assessment to determine B_0, $B_{current}$ and B_{best} for the 14 UK EMUs (transboundary IE_NorW not reported here), N/A indicates not applicable.

EMU CODE	RIVER		LAKE		ESTUARY		LAGOON		COASTAL	
	Area (ha)	Assessed (Y/N)	Area (ha)	Assessed (Y/N)	Area (ha)	Assessed (Y/N)	Area (ha)	Assessed (Y/N)	Area (ha)	Assessed (Y/N)
GB_Nort	5760	Y	3599	Y	2457	Y	0	N/A	70 461	N
GB_Humb	15 305	Y	9743	Y	32 805	Y	0	N/A	32 885	N
GB_Angl	12 048	Y	9539	Y	32 786	Y	0	N/A	225 599	N
GB_Tham	34	Y	9162	Y	33 615	Y	0	N/A	4268	N
GB_SouE	3954	Y	2061	Y	5428	Y	0	N/A	171 207	N
GB_SouW	9798	Y	2621	Y	23 431	Y	0	N/A	349 787	N
GB_Seve	14 372	Y	6157	Y	54 542	Y	0	N/A	0	N/A
GB_Wale	8824	Y	4271	Y	13 475	Y	0	N/A	433 095	N
GB_Dee	1579	Y	1623	Y	10 928	Y	0	N/A	0	N/A
GB_NorW	9076	Y	9780	Y	27 927	Y	0	N/A	151 109	N
GB_Solw	10 933	Y	6760	Y	69 803	Y	0	N/A	191 300	N
GB_Scot	138 557	Y	48 104	Y	60 502	Y	0	Y	4 589 412	N
GB_Neag	0	N	38 000	Y	0	N	0	N/A	0	N
GB_NorE	0	N	5000	Y	0	N	0	N/A	0	N

GB_Scot

The wetted area of rivers and lakes in the GB_Scot were calculated from UK Ordnance Survey MasterMaps, scales 1:10 000 and 1:1250. Below a certain channel width (defined as normal winter flow width) the digital network represents channels as a single dimensional line, which thus provides no data on the width of river channels. On 1:10 000 scale maps, this occurs nominally on channels below 5 m in width; at the 1:1250 scale, it is for channels below 1 m. To provide a reasonable measure of the true extent of water area represented by all non-determined widths of channels, these were attributed 1 m width. In some cases, this will overestimate and in others underestimate the true width and hence wetted areas.

Area of the WFD defined transitional waters, combining estuarine and lagoon waters, was also calculated in GIS, with a value of 60 502 ha.

4.2.2 Silver eel biomass indicators

See Table 1.1.

4.2.3 Anthropogenic mortality rates

Fisheries and other anthropogenic mortality rates for each EMU are shown in Tables 4.4 to 4.7. Anthropogenic mortality rates include hydropower, surface water abstractions, pumping stations (recorded under Hydro & Pumps) and barriers (including tidal).

Commercial fisheries and hydropower installations have been assessed for all EMUs, with tidal gates, pumping stations and surface water abstractions being additionally assessed in the eleven EMUs of England and Wales. Since the last report, a new assessment of the impacts of other manmade obstructions has been completed for these E&W EMUs and this barrier assessment methodology is detailed in Annex A of the UK EMP 2018 report. The impacts of the recreational fishery, predators and contaminants and parasites are treated as part of natural mortality and therefore not accounted for in these estimates.

Table 4.4. Glass eel fisheries and other sources of anthropogenic mortality per EMU. The loss is in kg for each impact or as MI = not assessed minor, MA = not assessed major, AB= impact absent. Where data are pooled for several years, the average annual loss for those years is shown. Note, glass eel fisheries are not equivalent to mortality as a proportion of the catch is restocked (see Table 3.9).

YEAR	COUNTRY	EMU CODE	COMMERCIAL FISHING	RECREATIONAL FISHING	HYDRO & PUMPS	BARRIERS (INCLUDING TIDAL)	RESTOCKING	PREDATORS	INDIRECT IMPACTS
2009–2011	UK	GB_Nort				MI		MI MI	MI/MA
2009–2011	UK	GB_Humb				MI		MI MI	MI/MA
2009–2011	UK	GB_Angl				MI		MI MI	MI/MA
2009–2011	UK	GB_Tham				MI		MI MI	MI/MA
2009–2011	UK	GB_SouE				MI		MI MI	MI/MA
2009–2011	UK	GB_SouW				MI		MI MI	MI/MA
2009–2011	UK	GB_Seve				MI		MI MI	MI/MA
2009–2011	UK	GB_Wale				MI		MI MI	MI/MA
2009–2011	UK	GB_Dee				MI		MI MI	MI/MA
2009–2011	UK	GB_NorW				MI		MI MI	MI/MA
2009–2011	UK	GB_Solw				MI		MI MI	MI/MA
2009–2018	UK	GB_Neag	0.0		0.0	AB	MA	NA MI	MI/MA
2009–2018	UK	GB_Scot	0.0		0.0	MA	MA	AB MI	MI/MA
2014–2016	UK	GB_Nort	0.0		0.0	MI		MI MI	MI/MA
2014–2016	UK	GB_Humb	0.0		0.0	MI		MI MI	MI/MA

YEAR	COUNTRY	EMU CODE	COMMERCIAL FISHING	RECREATIONAL FISHING	HYDRO & PUMPS	BARRIERS (INCLUDING TIDAL)	RESTOCKING	PREDATORS	INDIRECT IMPACTS
2014–2016	UK	GB_Angl	0.0		0.0	MI		MI MI	MI/MA
2014–2016	UK	GB_Tham	0.0	0.0	MI			MI MI	MI/MA
2014–2016	UK	GB_SouE	0.0	0.0	MI			MI MI	MI/MA
2014–2016	UK	GB_SouW	2902.7	0.0	MI			MI MI	MI/MA
2014–2016	UK	GB_Seve	3172.0	0.0	MI			MI MI	MI/MA
2014–2016	UK	GB_Wale	23.6	0.0	MI			MI MI	MI/MA
2014–2016	UK	GB_Dee	7.3	0.0	MI			MI MI	MI/MA
2014–2016	UK	GB_NorW	63.7	0.0	MI			MI MI	MI/MA
2014–2016	UK	GB_Solw	0.0	0.0	MI			MI MI	MI/MA

Table 4.5. Yellow eel fisheries and other sources of anthropogenic mortality per EMU. The loss is in kg for each impact or as MI = not assessed, minor, MA = not assessed major, AB = impact absent. Where data are pooled for several years, the average annual loss for those years is shown.

YEAR	COUNTRY	EMU CODE	COMMERCIAL FISHING	RECREATIONAL FISHING	HYDRO & PUMPS	BARRIERS (INCLUDING TIDAL)	RESTOCKING	PREDATORS	INDIRECT IMPACTS
2009–2011	UK	GB_Nort					MI	MI	MI/MA
2009–2011	UK	GB_Humb					MI	MI	MI/MA
2009–2011	UK	GB_Angl					MI	MI	MI/MA
2009–2011	UK	GB_Tham					MI	MI	MI/MA
2009–2011	UK	GB_SouE					MI	MI	MI/MA
2009–2011	UK	GB_SouW					MI	MI	MI/MA
2009–2011	UK	GB_Seve					MI	MI	MI/MA
2009–2011	UK	GB_Wale	3.0	0.0	10.0	14.0	0	MI	MI/MA
2009–2011	UK	GB_Dee	124.0	0.0	20.0	12.0	0	MI	MI/MA
2009–2011	UK	GB_NorW	94.0		2.0	64.0	MI	MI	MI/MA
2009–2011	UK	GB_Solw	1.0	0.0	3.0	5.0	MI	MI	MI/MA
2017	UK	GB_Neag	237000.0	0.0	AB	AB	MI	MI	MI/MA
2018	UK	GB_Neag	235000.0	0.0	AB	AB	MI	MI	MI/MA
2008	UK	GB_Scot	ND	ND	MA	MA	AB	MI	MI/MA
2009–2018	UK	GB_Scot	0.0	0.0	MA	MA	AB	MI	MI/MA

YEAR	COUNTRY	EMU CODE	COMMERCIAL FISHING	RECREATIONAL FISHING	HYDRO & PUMPS	BARRIERS (INCLUDING TIDAL)	RESTOCKING	PREDATORS	INDIRECT IMPACTS
2014–2016	UK	GB_Nort	0.0	0.0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Humb	966.7	0.0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Angl	13204.9	0.0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Tham	3577.8	0.0	MI		MI	MI	MI/MA
2014–2016	UK	GB_SouE	585.1	0.0	MI		MI	MI	MI/MA
2014–2016	UK	GB_SouW	13286.7	0.0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Seve	0.0	0.0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Wale	454.3	0.0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Dee	225.1	0.0	MI		MI	MI	MI/MA
2014–2016	UK	GB_NorW	136.1	0.0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Solw	0.0	0.0	MI		MI	MI	MI/MA

Table 4.6. Silver eel fisheries and other sources of anthropogenic mortality per EMU. The loss in kg for each impact or MI = not assessed, minor, MA = not assessed major, AB = impact absent. Where data are pooled for several years, the average annual loss for those years is shown.

YEAR	COUNTRY	EMU CODE	COMMERCIAL FISHING	RECREATIONAL FISHING	HYDRO & PUMPS	BARRIERS (INCLUDING TIDAL)	RESTOCKING	PREDATORS	INDIRECT IMPACTS
2009–2011	UK	GB_Nort	3	0	10	14	0	MI	MI/MA
2009–2011	UK	GB_Humb	124	0	20	12	0	MI	MI/MA
2009–2011	UK	GB_Angl	94	0	2	64	1	MI	MI/MA
2009–2011	UK	GB_Tham	1	0	3	5	0	MI	MI/MA
2009–2011	UK	GB_SouE	2	0	2	17	0	MI	MI/MA
2009–2011	UK	GB_SouW	6	0	9	4	0	MI	MI/MA
2009–2011	UK	GB_Seve	0	0	0	9		MI	MI/MA
2009–2011	UK	GB_Wale			MI		MI	MI	MI/MA
2009–2011	UK	GB_Dee			MI		MI	MI	MI/MA
2009–2011	UK	GB_NorW			MI		MI	MI	MI/MA
2009–2011	UK	GB_Solw			MI		MI	MI	MI/MA
2017	UK	GB_Neag	57900	0	AB	AB	MI	MI	MI/MA
2018	UK	GB_Neag	94000	0	AB	AB	MI	MI	MI/MA
2008	UK	GB_Scot	ND	ND	3721	24257	AB	MI	MI/MA
2009	UK	GB_Scot	0	0	6409	39706	AB	MI	MI/MA
2010	UK	GB_Scot	0	0	3250	19475	AB	MI	MI/MA
2011	UK	GB_Scot	0	0	3051	19672	AB	MI	MI/MA
2012	UK	GB_Scot	0	0	3349	23908	AB	MI	MI/MA
2013	UK	GB_Scot	0	0	4063	26006	AB	MI	MI/MA
2014	UK	GB_Scot	0	0	11330	67089	AB	MI	MI/MA
2015	UK	GB_Scot	0	0	6851	41169	AB	MI	MI/MA

YEAR	COUNTRY	EMU CODE	COMMERCIAL FISHING	RECREATIONAL FISHING	HYDRO & PUMPS	BARRIERS (INCLUDING TIDAL)	RESTOCKING	PREDATORS	INDIRECT IMPACTS
2016	UK	GB_Scot	0	0	6132	38218	AB	MI	MI/MA
2017	UK	GB_Scot	0	0	6698	45290	AB	MI	MI/MA
2018	UK	GB_Scot	0	0	5,611	36,247	AB	MI	MI/MA
2014–2016	UK	GB_Nort	0.0	0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Humb	181.3	0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Angl	3312.3	0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Tham	178.7	0	MI		MI	MI	MI/MA
2014–2016	UK	GB_SouE	409.1	0	MI		MI	MI	MI/MA
2014–2016	UK	GB_SouW	1669.2	0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Seve	16.7	0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Wale	53.3	0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Dee	38.6	0	MI		MI	MI	MI/MA
2014–2016	UK	GB_NorW	126.0	0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Solw	0.0	0	MI		MI	MI	MI/MA

Table 4.7. Silver eel equivalents of fisheries and other sources of anthropogenic mortality per EMU. The loss in kg for each impact or MI = not assessed, minor, MA = not assessed major, AB = impact absent. Where data are pooled for several years, the average annual loss for those years is shown.

YEAR	COUNTRY	EMU CODE	COMMERCIAL FISHING	RECREATIONAL FISHING	HYDRO & PUMPS	BARRIERS (INCLUDING TIDAL)	RESTOCKING	PREDATORS	INDIRECT IMPACTS
2009–2011	UK	GB_Nort			MI		MI	MI	MI/MA
2009–2011	UK	GB_Humb			MI		MI	MI	MI/MA
2009–2011	UK	GB_Angl			MI		MI	MI	MI/MA
2009–2011	UK	GB_Tham			MI		MI	MI	MI/MA
2009–2011	UK	GB_SouE			MI		MI	MI	MI/MA
2009–2011	UK	GB_SouW			MI		MI	MI	MI/MA
2009–2011	UK	GB_Seve			MI		MI	MI	MI/MA
2009–2011	UK	GB_Wale			MI		MI	MI	MI/MA
2009–2011	UK	GB_Dee			MI		MI	MI	MI/MA
2009–2011	UK	GB_NorW			MI		MI	MI	MI/MA
2009–2011	UK	GB_Solw			MI		MI	MI	MI/MA
2017	UK	GB_Neag	295000	0	AB	AB	MI	MI	MI/MA
2018	UK	GB_Neag	329000	0	AB	AB	MI	MI	MI/MA
2008	UK	GB_Scot	ND	ND	3721	24257	AB	MI	MI/MA
2009	UK	GB_Scot	0	0	6409	39706	AB	MI	MI/MA
2010	UK	GB_Scot	0	0	3250	19475	AB	MI	MI/MA
2011	UK	GB_Scot	0	0	3051	19672	AB	MI	MI/MA
2012	UK	GB_Scot	0	0	3349	23908	AB	MI	MI/MA
2013	UK	GB_Scot	0	0	4063	26006	AB	MI	MI/MA
2014	UK	GB_Scot	0	0	11330	67089	AB	MI	MI/MA
2015	UK	GB_Scot	0	0	6851	41169	AB	MI	MI/MA

YEAR	COUNTRY	EMU CODE	COMMERCIAL FISHING	RECREATIONAL FISHING	HYDRO & PUMPS	BARRIERS (INCLUDING TIDAL)	RESTOCKING	PREDATORS	INDIRECT IMPACTS
2016	UK	GB_Scot	0	0	6132	38218	AB	MI	MI/MA
2017	UK	GB_Scot	0	0	6698	45290	AB	MI	MI/MA
2018	UK	GB_Scot	0	0	5611	36247	AB	MI	MI/MA
2014–2016	UK	GB_Nort	0.0	0	2359.5	2976.7	0.0	MI	MI/MA
2014–2016	UK	GB_Humb	1148.1	0	19114.0	25860.9	75.2	MI	MI/MA
2014–2016	UK	GB_Angl	16517.2	0	6133.1	35163.9	0.0	MI	MI/MA
2014–2016	UK	GB_Tham	3756.4	0	7122.6	36219.3	277.2	MI	MI/MA
2014–2016	UK	GB_SouE	994.1	0	4157.3	11479.5	148.5	MI	MI/MA
2014–2016	UK	GB_SouW	532210.3	0	4882.1	7562.5	189.7	MI	MI/MA
2014–2016	UK	GB_Seve	565264.3	0	1121.6	61157.8	1098.9	MI	MI/MA
2014–2016	UK	GB_Wale	4713.8	0	1687.7	5349.1	0.0	MI	MI/MA
2014–2016	UK	GB_Dee	1570.6	0	1631.6	9085.4	0.0	MI	MI/MA
2014–2016	UK	GB_NorW	11621.2	0	7524.7	8885.5	0.6	MI	MI/MA
2014–2016	UK	GB_Solw	0.0	0	135.0	13524.1	0.0	MI	MI/MA

5 Other data collection for eel

5.1 Yellow eel abundance surveys

Rivers

England and Wales EMUs

The EA and NRW survey yellow eel abundance across EMUs using a six-year rolling programme of electrofishing surveys. In 2019, eel monitoring of yellow eel was planned in nine EMUs, across a number of rivers at a total of 344 sites in England (Table 5.1). These data are used to assess the biomass of silver eel escaping from each eel management unit (equivalent to a River Basin District), as required by the EU Eel Regulation (1100/2007), using SMEP II + Impacts Models. These data have yet to be processed, but previous years' data are summarised in Table 1.1 for when the last time the model was run. At each site, the following data are collected; number and size (mm) of each eel, together with the site's dimensions (length and average width).

Table 5.1. Planned Eel-specific 2019 monitoring for data input to SMEP models for English EMUs.

EMU	River	Number of sites
GB_Solw	England (various)	56
GB_Nort	England (various)	18
GB_Humb	England (various)	20
GB_Tham	England (various)	94
GB_SouE	England (various)	41
GB_SouW	England (various)	42
GB_Angl	England (various)	34
GB_NorW	England (various)	18
GB_Seve	England (various)	21

GB_Scot

Since 2008, the Scottish Environment Protection Agency (SEPA) has undertaken routine electrofishing surveys for all fish species, including eels. In 2015, 119 sites were fished, of which 18 were multipass and 101 single pass. The minimum density of eels estimated from three pass electrofishing at the 39 sites fished in 2008 ranged from 0.3–23.7 eels per 100 m^2, giving a mean minimum density across GB_Scot of 6.7 eels per 100 m^2 (or 5.4 eels per 100 m^2 including those sites from which eels were absent).

Annual electrofishing is conducted by Marine Scotland Science at the Girnock Burn (eight sites), Baddoch Burn (three sites) and River Shieldaig (12 sites) (GB_Scot) by Marine Scotland Science. Densities from these sites are reported in the ICES/WGEEL data call.

One further site monitored by Marine Scotland Science is the Allt Coire nan Con Burn, which is situated in the Strontian region of western Scotland and drains into the River Polloch, an inflow to Loch Shiel, GB_Scot. The catchment covers 790 ha and its altitude falls from 756 m to 10 m at

the sampling point, where the river is 5–6 m wide. Riparian vegetation at the sampling sites is predominantly mature deciduous woodland. Annual electrofishing surveys show no clear evidence of declines in yellow eel densities since 1992 (Adams *et al*., 2013).

Standing waters

England and Wales EMUs

A fykenet survey was undertaken on the River Avon (GB_Seve), on the stretch that had been fished in 1996, 2000, 2006 and again in 2012–2014 (Table 5.2). The survey was undertaken over a four-week period in summer (July/August), similar to the timing in previous years. There is evidence of a decline in catch over the ten-year period from 1996–2006, with an increase in 2012–2014.

The 2014 survey showed a rise in the population, apparently above that of 1996 level. However, much of that (2014) weight was made up of silver females (unlike previous years). As these eels are migratory, these results have to be treated with caution as these eels were probably passing through. Numbers of yellow eels were slightly down but the presence of elvers was evident throughout and in very large numbers, although not quantified. The traps were possibly more efficient as the survey was carried four weeks earlier than previous surveys (July 15–August 15). This site was surveyed in 2015 and 21.9 kg of eels were recorded; however, the timing of the sampling period was later than usual. As of 2016, no more data will be recorded at this site because the third-party operator who provided this information is no longer recording the information.

Table 5.2. Total catch of yellow and silver eel per ten codends between 1996 and 2016 on the river Avon, GB_Seve, (Roger Castle, pers. comm.).

Year	Catch (kg)
1996	50.0
2000	28.0
2006	12.0
2012	30.0
2013	37.0
2014	62.0
2015	21.9
2016	NR

GB_Scot

Data from eel captured on trash screens of a pumping station (1982–2003) on Loch Lomond showed no evidence of a decline in yellow eels (Adams *et al*., 2013) during the period.

GB_NorE

Eel are known to be present but there are limited scientific data. Yellow eel populations are present in every lake examined thus far, though there were significant differences between two of these sites in length and age distribution. Results were incorporated into the reviewed EMP for this RBD in 2012. Killough (transitional waterbody) within the EMU was surveyed using

fykenets for yellow eel during summer 2017 and assessed for silver eel migration in autumn 2017.

IE_NorW*

An intensive fykenet survey into the yellow eel population of Lower Lough Erne is carried out on a rolling biennial basis as part of the DCF commitment to this EMU. All reports are included in the Ireland Country Report under the agreed reporting terms for this Transboundary IRBD. Results from 2018 survey can be found under Section 6.

GB_Neag

Eel are sampled regularly as part of a long-term research programme, which investigates all life stages throughout the year. Yellow eel catches are sampled weekly over 20 weeks (from May to September). A sample of 20 eels is chosen to reflect all size ranges caught, and analysed for age and length. In addition, the entire, ungraded landing of two fishing crew on one day each month is sampled, usually comprising 400–600 eels captured by longline and a similar number by draftnet, to enable comparison between methods. Every eel is measured for length and the total catch recorded.

Results indicate that a larger proportion of small eels (<40 cm) are captured by draftnets (34%, compared to 21.4% on longlines), whereas more of the larger eels (>60 cm) are taken on longlines. Furthermore, there was significant variation in the numbers of small eels captured by longlining dependent upon bait type (earthworms caught more) and hook size (larger hook caught fewer small eels a finding used in direct management action by changing the legal size of hook used{increased}).

5.2 Silver eel escapement surveys

GB_Scot

Downstream migrating silver eels have been trapped at three sites in Scotland: the Girnock Burn and Baddoch Burn (two adjacent tributaries of the river Dee, emptying ultimately into the North Sea), and the Shieldaig (an entire small catchment on the western seaboard). The biomass of migrating silver eels for each available year have been converted to area production rates (kg/ha) and are reported in Table 5.3.

Table 5.3. Silver eel escapement from three catchments in GB_Scot (kg.ha^{-1}).

Year	Girnock	Baddoch	Shieldaig	Year	Girnock	Baddoch	Shieldaig
1966	0.53	-	-	1993	-	-	-
1967	0.44	-	-	1994	-	-	-
1968	1.42	-	-	1995	-	-	-
1969	1.02	-	-	1996	-	-	-
1970	0.86	-	-	1997	-	-	-
1971	1.25	-	-	1998	-	-	-
1972	0.84	-	-	1999	-	-	0.57
1973	1.59	-	-	2000	-	-	-
1974	1.07	-	-	2001	-	-	-
1975	2.23	-	-	2002	-	-	0.69
1976	1.91	-	-	2003	1.05	-	0.51
1977	1.42	-	-	2004	-	-	-
1978	1.25	-	-	2005	0.86	-	-
1979	1.07	-	-	2006	-	0.32	1.59
1980	0.61	-	-	2007	0.51	0.35	0.63
1981	1.02	-	-	2008	0.42	0.57	0.55
1982	-	-	-	2009	0.44	0.53	1.0
1983	-	-	-	2010	-	0.10	0.53
1984	-	-	-	2011	0.30	0.47	0.38
1985	-	-	-	2012	0.78	0.45	0.43
1986	-	-	-	2013	0.44	0.34	0.61
1987	-	-	-	2014	0.23	0.66	1.87
1988	-	-	-	2015	0.36	0.08	1.11
1989	-	-	-	2016	0.48	0.46	0.96
1990	-	-	-	2017	1.26	0.46	0.94
1991		-	-	2018	0.64	0.61	0.84
1992	-	-	-				

GB_Neag

Samples of ten eel chosen to reflect all size ranges in the catch are removed every week over a 12-week period at Lough Neagh and analysed for age and length. At weekly intervals the previous night's haul is measured for length. The number analysed can vary widely but on average covers at least 400 fish within a nights catch of >1 t. In addition, the weekly silver eel samples are also analysed for length, weight, fat content, sex, prevalence and intensity of *Anguillicola crassus*, stomach contents, and gastrointestinal endohelminths. Sex ratio of the silver eel population is also examined by counting the numbers of individuals contained in the graded (depending upon size) 15 kg boxes. The fishery records the number of boxes of small (male) and large (female) eels sold, and from this, the sex ratio and number of silver eels can be estimated.

5.3 GB_NorE

This EMU was assessed using modified large D ring fykenets for silver eel migration in autumn and winter 2017 and 2018.

IE_NorW*

In the Northwestern EMU, surveys on the migrating silver eel stock on the Erne system began in 2009, as an integral component of a conservation fishery designed to trap and transport silver eels around hydropower plants within this EMU. The results of this survey work are presented in the National Country Report of Ireland.

5.4 Life-history parameters

England and Wales EMUs

Biometric yellow eel data (length in mm, & mass in g) from as early as 1976 onwards for 44 index rivers in England & Wales has been supplied to ICES via the 2019 data call. This information has not been reproduced here.

GB_Scot

Individual growth rates of PIT tagged eels are measured by Marine Scotland Science in two tributaries of the River Dee, GB_Scot. To date, growth rates for eels with more than a season between capture and recapture have ranged from 0.8 to 35.2 $mm.yr^{-1}$, with mean ± s.e growth of 8.85 ± 0.62 $mm.yr^{-1}$ (n = 78). On the Baddoch, the range of growth rates was 0.0–14.5 $mm.yr^{-1}$, with mean ± s.e growth rates of 6.36 ± 0.84 $mm.yr^{-1}$ (n = 26). These may be the lowest growth rates ever reported for the European eel.

Some Fisheries Trusts collect data on the length of eels captured during routine electrofishing surveys targeted at salmonids (1136 eels were measured between 1996 and 2008). Lochaber Fisheries Trust conducted an eel specific survey in 2010, and data are available at http://www.lochaberfish.org.uk/cust_images/Lochaber_eel_re-port_2010[1].pdf.

The sex ratio of silver eels at the Girnock Burn monitoring site has remained broadly stable since the 1960s at about 98% male (Table 5.4). The data comprise two periods: 1966–1981 and 2002–2018. Male eels silvered at shorter lengths during the earlier period (mean 339 mm) than the latter (mean 353 mm), but there is no evidence for an increase in length from 2002 to present (Table 5.4).

Table 5.4 Biological characteristics of silver eels emigrating from the Girnock Burn, GB_Scot. Sex based on assumption that ≥450 mm body length = female.

	MALES			FEMALES		
Year	%	Mean L (mm)	Mean Wt (g)	%	Mean L (mm)	Mean Wt (g)
1966	98.7	330.9	NC	1.3	550	NC
1967	98.4	331	NC	1.6	510	NC
1968	96.8	337.5	NC	3.2	540.8	NC
1969	98	335.6	NC	2	606.7	NC
1970	99.2	342.2	NC	0.8	475	NC
1971	99.4	339.2	NC	0.6	520	NC
1972	99.1	337.8	NC	0.9	660	NC
1973	99.1	335.9	NC	0.9	575	NC
1974	99.3	338.9	NC	0.7	490	NC
1975	97.9	338.1	NC	2.1	627.5	NC
1976	99.7	341.2	NC	0.3	450	NC
1977	99.2	334.3	NC	0.8	572.5	NC
1978	99.4	339.9	NC	0.6	660	NC
1979	98.6	342.2	NC	1.4	490	NC
1980	95.9	346.8	NC	4.1	561.7	NC
1981	99.3	349.8	NC	0.7	550	NC
2002	100	356.8	73	0	NP	NP
2003	97.7	350.4	68.3	2.3	535	232.9
2004	98.3	359.8	74.4	1.7	488	74.4
2005	99.1	361.3	76.1	0.9	450	76.1
2006	100	353.4	71.4	0	NP	71.4
2007	94.9	354.3	74.4	5.1	529.7	74.4
2008	100	355.5	72.5	0	NP	72.5
2009	96.5	350	71.5	3.5	509.5	71.5
2010	94.1	355.1	74.3	5.9	500	74.3
2011	100	358.2	74.6	0	NP	74.6
2012	96.7	356	75.5	3.3	511.7	75.5
2013	96.5	344.8	64.2	3.5	549.5	64.2
2014	90.9	354.8	69.9	9.1	629.5	69.9
2015	100	345.2	67.4	0	NP	67.4
2016	98.5	347.5	66	1.5	465	66
2017	98.2	348.3	68.3	1.8	485.7	68.3
2018	98.8	349	69.2	1.2	468	69.2

Eel otoliths (about 100 pairs) have been collected (by SEPA) and read (by Marine Scotland Science) from a number of sites around GB_Scot, see Oliver *et al*. (2015) for some further details.

Historical data are available for age (estimated from otoliths) and length composition at a variety of sites in Scotland from a survey conducted in the early 1970s (Williamson, 1975).

In 2018, a new national electrofishing scheme has been implemented in Scotland deploying a generalised random tessellation stratified sampling design. Length and weight data for eels will be collected at 801 sites.

GB_Neag

The sex ratio of the silver eel population is estimated by counting the numbers of individuals contained in the graded 15 kg boxes which the Fishery use. Eels are graded as small (males) and large (females), based on a length–sex key derived from previous sampling. Sex ratios in the silver eels in 2004 to 2005 were numerically close to 1:1, but changed in 2006 and 2007 to 63% and 62% females (Table 5.5). However, in 2008, 2009 and 2010, this trend has reverted to close to 1:1 (48, 52 and 47% females) and continues up to 2018 with 53% females. Taking account of differing sizes and weights of males and females, 70% of the recorded silver eel biomass is now female.

Table 5.5. Biological characteristics of silver eels emigrating from Lough Neagh, GB_Neag. Note; mean ages of males and females for 2005 and 2006 have been revised in light of additional data.

	MALES				FEMALES			
Year	%	Mean L (cm)	Mean Wt (g)	Age	%	Mean L (cm)	Mean Wt (g)	Age
1927	0				100		567	
1943	27				73			
1946	40				60			
1956	61				39			
1957	62				38			
1965	10		180		90		330	
2004	51	40.6	122	11.0	49	58.6	386	18.0
2005	52	41.4	126	11.4	48	58.1	393	18.2
2006	37	40.1	117	12.3	63	59.5	368	18.7
2007	38	40.2	121	11.0	62	62.3	370	18.4
2008	52	40.3	122	12.0	48	59.5	367	18.0
2009	54	40.9	128	11.7	46	61.7	378	17.7
2010	54	40.1	117	12.3	46	56.7	365	17.8
2011	57	40.2	118	12.2	43	61.4	375	20.1*
2012	54	38.4	117	11.9	46	61.2	396	19.6*
2013	51	41.1	125	12.8	49	61.4	372	18.1
2014	53	39.6	120	11.8	47	58.1	342	17.6
2015	51	40.3	121	11.1	49	62.3	380	16.9
2016	46	40.5	121	10.9	54	63.5	379	n/a
2017	4357	39.7	120	n/a	57	61.3	374	n/a
2018	47	40.4	118	N/A	53	61.7	388	N/A

***age data to be QA verified.**

5.5 Diseases, Parasites and Pathogens or Contaminants

5.5.1 Parasites and Pathogens

GB_Neag

- No evidence of anguillid herpes virus in any life-history stage of the wild European eel population of Lough Neagh.
- Eel virus European (EVE) and Eel virus European X (EVEX) were found but at a very low prevalence, suggesting that the presence of these diseases has not reached levels of concern to the population's health status (Evans *et al*., 2018).
- The infection parameters of yellow and silver eels are recorded annually from Lough Neagh (Table 5.6).

Table 5.6. *A. crassus* infection parameters.

Year	YELLOW			SILVER		
	prev (N)	mean int	range	prev (N)	mean int	range
2003	24.4 (340)	2.2	1–9	57 (100)	2.5	1–9
2004	69 (300)	3.6	1–47	90 (100)	4.3	1–47
2005	92.5 (190)	7.7	1–60	100 (100)	7.8	1–56
2006	78.2 (153)	12.9	1–54	89 (100)	16.6	1–129
2007	70.4 (340)	7.0	1–52	76 (100)	11.4	1–66
2008	67.3 (290)	6.4	1–67	86 (100)	13.0	1–73
2009	55.8 (280)	4.4	1–27	73 (100)	8.4	1–32
2010	48.8 (280)	4.4	1–28	80.7 (100)	9.9	1–143
2011	56.7 (290)	3.9	1–32	74 (100)	6.6	1–32
2012	40.5 (285)	3.7	1–17	55 (100)	5.0	1–34
2013	50.9 (290)	3.5	1–32	70 (100)	7.6	1–37
2014	52.6 (250)	4.1	1–21	76 (100)	10.1	1–32
2015	54.1 (320)	4.5	1–38	69 (100)	6.9	1–47
2016	49.1 (270)	4.6	1–29	76 (100)	7.3	1–39
2017	61.3 (240)	4.4	1–22	86 (100)	10.0	1–44
2018	58.4 (260)	3.8	1–21	78 (100)	9.7	1–51

England

Herpes virus anguillae (HVA) was detected during disease investigations of European eel, *Anguilla anguilla* L. at two still-water fisheries in central England. These represent the first records of HVA from UK eels. Both mortalities were eel specific and took place during August 2009 and July 2010 at water temperatures between 17° and 19.4°C. Pathological changes consistent with HVA infection included haemorrhaging in the fins, skin lesions and necrosis within the gills and liver. Transmission electron microscopy revealed active virion replication within the gill tissue. An initial assessment of risk is presented, indicating that HVA represents a high disease risk to UK eel stocks. However, further studies are required to establish the distribution of HVA before a reliable assessment of impact may be obtained. Until then, the detection of HVA hold important implications for eel conservation and management, in particular eel stocking activity.

In 2017, 61.3% of yellow eels (N= 320) and 86% of silver eels (N=100) were found to be infected with the nematode *A. crassus*, the highest infection parameters observed since 2008. As noted in

previous Country Reports, the mean intensity of individual worms per infected eel remains significantly higher in silver eels with on average ten worms per fish compared to four in yellow eels.

European eel health and disease investigations

Eel health and diseases in England and Wales are monitored through mortality investigations, targeted surveillance and screening of eels prior to restocking.

Since 2013, two eel-specific mortalities have been reported from-still water fisheries in England. Field investigations and detailed post-mortem examinations confirmed the primary cause for these losses to be Anguillid herpesvirus 1 (AngHV-1). These events, combined with previous outbreaks reported in 2009 and 2010 (Armitage *et al*., 2013), bring the total number of mortalities associated with this virus in England to four.

All four outbreaks of AngHV-1 have involved large eels, measuring between 70 and 120 cm in length. These fish had estimated ages of between 17 and 29 years and many eel examined showed morphological characteristics of silvering. Affected eels were lethargic and unresponsive with signs of external haemorrhaging, skin lesions and severe gill necrosis. Histopathological examinations revealed marked necrosis, haemorrhage and inflammatory changes within the gills, kidney, skin, liver and spleen.

Post-mortality sampling suggested that up to 70% of the eel populations were lost from these waters. It is proposed that the onset of silvering, with associated physiological changes and migration pressure, were triggers for these disease events, which so far have all occurred in still waters with barriers to escapement. Further sampling is underway to assess the prevalence, persistence and impact of the virus within these waters.

Since 2011, efforts have been made to establish the distribution of AngHV-1 in wild eels in England and Wales. This collaborative study between the Environment Agency and Cefas, has involved taking blood samples from live eels captured and returned during routine monitoring activities. To date, 685 eels, from 36 rivers in eleven EMUs have been tested for antibodies to AngHV-1. An additional 429 glass eels have been tested, from 14 sites in five EMUs. This work has confirmed that AngHV-1 has a relatively widespread distribution, but exists at a low prevalence (~5%) in most of the rivers sampled. This work will help inform existing disease risk assessments for this virus. Efforts are also underway to assess the presence and distribution of other eel viruses in England.

Since 2013, yellow eel from two rivers and glass eels from three rivers have been screened for parasites and disease prior to movement/stocking. *Anguillicola crassus* was found in all of the yellow eel samples at a prevalence of between 50 and 93%. Within these populations mean intensity of infection ranged from six to seven parasites respectively. Of the glass eels examined, only one of the samples revealed infections of *A. crassus*, at a prevalence of 37% and intensity of 1–7 nematodes (mean 2.4). These data are consistent with historic surveys of this nematode, now widely distributed throughout England and Wales. It is thought that a small number of catchments and some isolated rivers in North Wales and Northern England remain either sparsely infected or tentatively free of the parasite. No other parasites or diseases of concern were recorded during these examinations.

In May of both 2015 and 2016, dead eels were reported in parts of the river Dee catchment, GB_Scot. In 2016, some of these were identified at the Girnock monitoring site, and the Fish Health Inspectorate isolated *Flavobacterium psycrophilum* from moribund specimens.

A number of collaborative projects are underway to progress understanding of European eel health interactions. This includes development of a standardised protocol to harmonise assessments of eel spawner quality and maximise retrieval of data from UK monitoring activities (Lewin *et al.,* 2014).

A study in collaboration with Southampton and Cardiff Universities was also conducted to assess the influence of parasites on the behaviour and passage of silver eels in freshwater. This involved observations of 150 silver eels in response to a range of flow regimes within flume facilities. It has been shown that infections of *A. crassus* alters the behaviour of silver eels, causing avoidance of high flow velocities, in turn delaying downstream migration (Newbold *et al.,* 2015). This could have important implications for eel passage, escapement and eel spawner quality.

The effect of *Anguillicola crassus*, *Pseudodactylogyrus bini* and *Pseudodactylogyrus anguillae* infection on the behaviour of downstream migrating adult European eels as they encountered accelerating water velocity, common at engineered structures where flow is constricted (e.g. weirs and bypass systems), was evaluated in an experimental flume. The probability of reacting to, and rejecting, the velocity gradient was positively related to *A. crassus* larval, adult and total abundance. High abundance of *Pseudodactylogyrus* spp. reduced this effect, but *A. crassus* was the strongest parasitic factor associated with fish behaviour, and abundance was positively related to delay in downstream passage. Delayed downstream migration at hydraulic gradients associated with riverine anthropogenic structures could result in additional energetic expenditure for migrating *A. anguilla* already challenged by *A. crassus* infection (Newbold *et al.,* 2015).

In Lough Neagh, the glass eel/elvers are monitored for the presence of *Anguillicola crassus*, and the weekly samples of yellow eels are also examined for length, weight, fat content, sex, age, stomach contents, the prevalence and intensity of *A. crassus,* and gastrointestinal endohelminths. In 2015, the prevalence of *A. crassus* in yellow and silver eels was 52% and 71%, respectively.

5.5.2 Contaminants

GB_Neag

Levels of contaminants were generally extremely low, and in many cases, among the lowest recorded in similar studies. Concentrations of those contaminants regulated by the European Commission (2006) with regard to human health (Pb, Cd, Hg, dioxins and PCBs) were all within current limits (2011; 2015). Concentrations of whole-body heavy metal burdens were generally very low in Lough Neagh eels, and in most cases were significantly lower than the average reported from studies conducted on eels elsewhere in Europe.

Analysis for 2018 for combined sample of 20 silver eels also recorded that all results were less than the maximum permitted by current legislation (Table 5.7).

Table 5.7. Levels of contaminants in 20 silver eels from Lough Neagh.

CONTAMINANT	VALUE	
Sum of Dioxins	0.37pg/g	(Limit is 3.5pg/g)
Sum of Dioxin & Dioxin like PCB's	1.28pg/g	(Limit is 10.0pg/g)
Sum of PCB's	14ng/g	(Limit is 300ng/g)
Arsenic	0.10mg/Kg	(No MRL)
Cadmium	0.04mg/Kg	(Limit 0.05mg/Kg)
Lead	0.05mg/Kg	(Limit 0.3mg/Kg)
Mercury	0.085mg/Kg	(Limit is 1.0mg/Kg)

GB_Scot

A comparison of recent lipid and pollutant levels in Scottish yellow eel tissue with data from 1980 showed lipid levels were notably higher in the more recent eel samples (Oliver *et al.,* 2015).

6 New Information

UK lead Eel Research Projects for 2018/2019.

1. REDEEM project: research and development of fish and eel entrainment mitigation at pumping stations

As well as abiding with the requirements of the EC Eel Regulation (1100/2007), the UK has specific legislation (Eels (England and Wales) Regulations 2009) for screening intakes, including pumping stations. Water is frequently pumped from or into rivers for flood protection, water level management, domestic supply, agriculture, industry and hydropower generation. Fish and eels can be entrained in pumps and water intakes, especially adult silver eels during downstream migration; providing flood protection and safe eel passage is a particular problem. However, the extent of the problem is not fully understood and gaps in our knowledge prevent identification of adequate, cost-effective mitigation measures.

This research consortium will focus on understanding fish and eel behaviour to assess the effectiveness of existing and new technologies for minimising entrainment at pumping stations and develop innovative measures to provide applied outcomes. Specifically, the research will focus on understanding the spatial distribution of fish and eels in pumped catchments, the processes that lead to entrainment and the effectiveness of altered operating regimes, fish-friendly pumps and novel downstream bypass channels for minimising entrainment.

Funding has been provided by Environment Agency (EA), EU European Marine and Fisheries Fund (ENG2130), Internal Drainage Boards, Association of Drainage Authorities and the University of Hull (UoH). The research cluster will bring together knowledge and expertise in state-of-the-art acoustic telemetry (under Home Office Licence), multibeam imaging sonar, eDNA and flow modelling techniques performed by staff and researchers across the EA, UoH and the Institute of Zoology (ZSL), to make major advances in the field and maximise research quality.

The knowledge arising from this strategic, inter-disciplinary and international applied research investigation is anticipated to inform and revise guidance for mitigating fish and eel entrainment at pumping stations and water intakes at national, European and global levels.

For more information about the project, please contact Jon Bolland (UoH research lead; J.Bolland@hull.ac.uk) or Ros Wright (EA research lead; ros.wright@environment-agency.gov.uk)

2. Azores Eel Project Summary

The EU Eel Regulation (EC 1100/2007) has obligated Member States to implement eel management plans (EMPs) to increase the biomass of eels leaving EU waters on their way to the spawning area in the Sargasso Sea. However, these eels still have about 4000–6000 km to migrate across the ocean before spawning so EU targets cannot guarantee to increase the actual spawning stock and ensure stock recovery.

Locating where eels spawn is critical for understanding the reasons for their decline and conserving this globally important species. Many factors could influence migratory success, both in freshwater and in the marine environment. The fundamental questions of where do the eels spawn and how do they get there need to be answered before we can address questions about factors affecting migratory and spawning success and managing these factors to support stock recovery.

Several attempts have been made to monitor migrating silver eels from Europe. The waters around the Azores are the last point to which an eel has been tracked using satellite tags. A scoping study carried out by volunteers from EA, ZSL and Defra in December 2017 confirmed

the presence of European eel populations on several islands within the Azores archipelago - which means there is the chance to track eels from a point closer to their speculative spawning area which greatly increases the chance of success using current technology. It is proposed to develop an international partnership project with the specific objective to track the migration routes and behaviours of eel from the Azores to their spawning area. Should this satellite tagging study reveal the spawning area of the European eel, and the behaviour of the species in this region, a high impact publication will result.

For further information on this project, contact Ros Wright (ros.wright@environment-agency.gov.uk) who is the overall lead and project co-ordinator, responsible for project organisation, funding, project team co-ordination, and liaison with the University of Azores.

England and Wales EMUs

Data quality audit on Catch and CPUE data.

Following some data discrepancies identified during the writing of the 2018 EMP progress report, we conducted a data quality audit of the yellow and silver eel catch return data from the period 2014–2017. The data discrepancies were attributed to some missing fishermen's catch returns being submitted late and also due to some catch return landings being recorded against the wrong EMU. The corrected dataset was used in the EMP 2018 report and the corrected data was uploaded into the ICES database at the workshop in Poland in 2018. However, due to changes in reporting format, there has not be an opportunity until now to add these amendments to the UK country report. This section holds the amended EMU catch data and the subsequently amended CPUE figures, see Table 6.1.

Table 6.1. Silver and Yellow eel catch returns and CPUE as reported to the Environment Agency over the period 2014–2018 (amended version).

EMU	Year	Life Stage	Landings (kg)	CPUE	Landings (T)	Life Stage	Landings (kg)	CPUE	Landings (T)
GB_Angl	2018	Silver	2258.0	0.035	2.258	Yellow	11795.9	0.131	11.796
GB_Dee	2018	Silver	19.2	0.065	0.019	Yellow	122.6	0.175	0.123
GB_Humb	2018	Silver	1115.0	0.188	1.115	Yellow	4838.0	0.893	4.838
GB_Nort	2018	Silver	NP	NP	NP	Yellow	NP	NP	NP
GB_NorW	2018	Silver	220.0	0.016	0.220	Yellow	154.0	0.039	0.154
GB_Seve	2018	Silver	NP	NP	NP	Yellow	0.0	NP	0.000
GB_Solw	2018	Silver	NP	NP	NP	Yellow	0.0	NP	0.000
GB_SouE	2018	Silver	79.0	0.545	0.079	Yellow	216.0	0.028	0.216
GB_SouW	2018	Silver	1342.0	0.012	1.342	Yellow	13347.0	0.917	13.347
GB_Tham	2018	Silver	133.5	0.070	0.134	Yellow	1971.0	0.133	1.971
GB_Wale	2018	Silver	0.0	0.000	0.000	Yellow	0.0	0.000	0.000
GB_Angl	2017	Silver	2109.0	0.038	2.109	Yellow	6129.0	0.251	6.129
GB_Dee	2017	Silver	21.0	0.053	0.021	Yellow	333.0	0.149	0.333
GB_Humb	2017	Silver	22.0	0.002	0.022	Yellow	1542.0	0.764	1.542
GB_Nort	2017	Silver	NP	NP	NP	Yellow	NP	NP	NP
GB_NorW	2017	Silver	254.0	0.216	0.254	Yellow	326.0	0.560	0.326
GB_Seve	2017	Silver	NP	NP	NP	Yellow	NP	NP	NP
GB_Solw	2017	Silver	NP	NP	NP	Yellow	NP	NP	NP

EMU	Year	Life Stage	Landings (kg)	CPUE	Landings (T)	Life Stage	Landings (kg)	CPUE	Landings (T)
GB_SouE	2017	Silver	30.2	0.004	0.030	Yellow	364.3	0.068	0.364
GB_SouW	2017	Silver	1117.0	0.011	1.117	Yellow	11167.5	1.257	11.168
GB_Tham	2017	Silver	14.0	0.038	0.014	Yellow	2264.0	0.161	2.264
GB_Wale	2017	Silver	0.0	0.000	0.000	Yellow	0.0	0.000	0.000
GB_Angl	2016	Silver	3664.0	0.039	3.664	Yellow	12273.0	0.131	12.273
GB_Dee	2016	Silver	23.9	0.027	0.024	Yellow	73.2	0.082	0.073
GB_Humb	2016	Silver	49.0	0.061	0.049	Yellow	155.0	0.192	0.155
GB_Nort	2016	Silver	NP	NP	NP	Yellow	NP	NP	NP
GB_NorW	2016	Silver	33.0	0.031	0.033	Yellow	187.0	0.175	0.187
GB_Seve	2016	Silver	NP	NP	NP	Yellow	NP	NP	NP
GB_Solw	2016	Silver	NP	NP	NP	Yellow	NP	NP	NP
GB_SouE	2016	Silver	252.2	0.010	0.252	Yellow	825.2	0.033	0.825
GB_SouW	2016	Silver	946.9	0.023	0.947	Yellow	10261.0	0.247	10.261
GB_Tham	2016	Silver	152.1	0.011	0.152	Yellow	2473.3	0.182	2.473
GB_Wale	2016	Silver	150.0	0.011	0.150	Yellow	1345.0	0.098	1.345
GB_Angl	2015	Silver	3759.0	0.028	3.759	Yellow	8378.8	0.028	8.379
GB_Dee	2015	Silver	31.0	0.039	0.031	Yellow	73.6	0.039	0.074
GB_Humb	2015	Silver	741.5	0.064	0.742	Yellow	1381.0	0.064	1.381
GB_Nort	2015	Silver	NP	NP	NP	Yellow	NP	NP	NP
GB_NorW	2015	Silver	56.0	0.141	0.056	Yellow	92.7	0.141	0.093
GB_Seve	2015	Silver	NP	NP	NP	Yellow	NP	NP	NP
GB_Solw	2015	Silver	NP	NP	NP	Yellow	NP	NP	NP
GB_SouE	2015	Silver	106.9	0.013	0.107	Yellow	957.0	0.013	0.957
GB_SouW	2015	Silver	907.0	0.019	0.907	Yellow	16828.0	0.019	16.828
GB_Tham	2015	Silver	201.5	0.015	0.202	Yellow	2696.0	0.015	2.696
GB_Wale	2015	Silver	0.0	0.000	0.000	Yellow	0.0	0.000	0.000
GB_Angl	2014	Silver	5021.0	0.050	5.021	Yellow	16875.0	0.167	16.875
GB_Dee	2014	Silver	29.9	0.005	0.030	Yellow	415.4	0.073	0.415
GB_Humb	2014	Silver	479.5	0.024	0.480	Yellow	3522.3	0.173	3.522
GB_Nort	2014	Silver	NP	NP	NP	Yellow	NP	NP	NP
GB_NorW	2014	Silver	27.7	0.110	0.028	Yellow	86.6	0.345	0.087
GB_Seve	2014	Silver	NP	NP	NP	Yellow	NP	NP	NP
GB_Solw	2014	Silver	NP	NP	NP	Yellow	NP	NP	NP
GB_SouE	2014	Silver	754.0	0.281	0.754	Yellow	284.0	0.106	0.284
GB_SouW	2014	Silver	1166.6	0.053	1.167	Yellow	10116.8	0.464	10.117
GB_Tham	2014	Silver	383.6	0.032	0.384	Yellow	3222.1	0.272	3.222
GB_Wale	2014	Silver	NP	NP	NP	Yellow	NP	NP	NP

A new glass eel monitoring site was established at Strangford Lough to replace the River Quoile site in 2012 and is now part of a longer term monitoring programme for this EMU (Table 6.2). Once the collection of this dataset has progressed beyond a continual 10-year standard (2021), this information will be registered as a new index site within the ICES datacall database.

Table 6.2. Annual cumulative totals from weekly counts at new glass eel monitoring site, Strangford Lough, Northern Ireland (GB_NorE). Method: 2 x standard settlement samplers at tidal barrier.

Year	2012	2013	2014	2015	2016	2017	2018	2019
Total glass eel	150	362	3290	2256	9282	1231	481	349
Weight (kg)	0.048	0.058	1.053	0.539	0.723	0.394	0.178	0.131

***2012 values refer to trialling methods (estimate).**

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