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Report on the eel stock, fishery and other impacts in Belgium, 2020–2021

Authors

Claude Belpaire, Research Institute for Nature and Forest (INBO), Dwersbos 28, 1630 Linkebeek, Belgium. Claude.Belpaire@inbo.be

Jan Breine, Research Institute for Nature and Forest (INBO), Dwersbos 28, 1630 Linkebeek, Belgium

Jeroen Van Wichelen, Research Institute for Nature and Forest (INBO), Havenlaan 88/73, 1000 Brussel, Belgium

Billy Nzau Matondo, Université de Liège, UR FOCUS, Unité de Gestion des Ressources Aquatiques et Aquaculture, Laboratoire de Démographie des Poissons et d'Hydroécologie, Quai van Beneden 22, 4020 Liège, Belgium

Michael Ovidio, Université de Liège, UR FOCUS, Unité de Gestion des Ressources Aquatiques et Aquaculture, Laboratoire de Démographie des Poissons et d'Hydroécologie, Quai van Beneden 22, 4020 Liège, Belgium

Pieterjan Verhelst, Ghent University, Marine Biology, Krijgslaan 281, 9000 Ghent (Belgium)

Lies Teunen, University of Antwerp, Systemic Physiological and Ecotoxicological Research group, (SPHERE) Groenenborgerlaan 171, 2020 Antwerp, Belgium

Lieven Bervoets, University of Antwerp, Systemic Physiological and Ecotoxicological Research group, (SPHERE) Groenenborgerlaan 171, 2020 Antwerp, Belgium

Frédéric Dumonceau, Service de la pêche, Direction de la chasse et de la pêche (DCP), Département de la Nature et des Forêts (DNF), Direction générale opérationnelle de l'Agriculture, des Ressources Naturelles et de l'Environnement (DGARNE), Service Public de Wallonie (SPW), avenue Prince de Liège 7, 5100 Jambes (Namur), Belgium.

Kristof Vlietinck, Agency for Nature and Forests, Koning Albert II-laan 20/bus 8, 1000 Brussels, Belgium.

Reporting Period: This report was completed in September 2021, and contains data up to 2021. Some 2021 data are provisional.

1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

The data and stock indicators provided to the Eel Regulation progress report 2018 containing an analysis of escapement biomass and mortality rates for the period 2015-2017 have been presented in provided last year's country report (Belpaire *et al*., 2020b).

In the context of the reporting requirements for the 2021 progress report Belpaire *et al*. (2021) carried out a new assessment on the eel data collected during the 2018-2020 period. 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 watercourses in the eel management plan, including corrections for various factors of natural and anthropogenic mortality. The data is supplied by Flanders' Freshwater Fish Monitoring Network and other monitoring programs carried out by INBO's MHAF team ("Monitoring en Herstel Aquatische Fauna").

The estimated escapement figures for silver eel are 10.1% for the EMU Scheldt and 4.44% for the EMU Meuse (Table 1). Once again, the targets of the EU Eel Regulation (40%) are not being achieved. Compared to the previous reporting period, the figures for EMU Scheldt have even decreased slightly (decrease of 12%). In EMU Meuse, the figures have declined even more drastically (decrease of 76%).

The anticipated positive effects of the applied recovery measures are not visible in the production figures, and current figures are even further away from the objectives. Hence, additional measures will have to be taken if Flanders aims to achieve the objectives of the Eel Regulation.

Table 1. Stock indicators of silver eel escapement, biomass and mortality rates, and assessed habitat area, as reported from Flanders by Belpaire *et al*. (2021).

2021	Water surface (ha)	B_o	B_{best}	ΣF	ΣH	ΣA	$B_{current}$	R	% escapement rate
Flanders	19.796	196,27	23,094	2,403	1,51	3,913	19,181	0	**9,77%**
	Water surface (ha)	**B_o**	**B_{best}**	**ΣF**	**ΣH**	**ΣA**	**$B_{current}$**	**R**	**% escapement rate**
Scheldt EMU	18591	184,323	22,105	2,185	1,27	3,455	18,65	0	**10,12%**
Meuse EMU	1205	11,947	0,989	0,218	0,24	0,458	0,531	0	**4,44%**

	ΣF/B_{best}	ΣH/B_{best}	ΣA/B_{best}
Scheldt	0,10	0,06	0,16
Meuse	0,22	0,24	0,46

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.**

1.2 Recruitment time-series

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

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

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

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

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

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

Figures 1A–D and Tables 2–3 present the time-series of the total annual catches of the dipnet fisheries in the Nieuwpoort ship lock and give the maximum day catch per season. Since the last report the figure has been updated with data for 2020.

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

Fishing effort in **2006** was half of normal, with 130 dipnet hauls during only 13 fishing nights between March 3rd, and June 6th. Catches of the year 2006 were extremely low and close to zero. In fact only 65 g (or 265 individuals) were caught. Maximum day catch was 14 g. These catches are the lowest record since the start of the monitoring (1964).

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

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

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

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

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

In **2012**, fishing effort was higher than previous years with 425 dipnet hauls over 23 fishing nights. The fishing was carried out between and March 2nd and May 1st. Compared to 2010, the number of hauls was 42% higher. Total captured biomass of glass eel amounted 2407.7 g (or 7189 individuals). Maximum day catch was 350 g. Both, the total captured biomass and the maximum day catch are ca. six times higher than in 2010. Overall, the quantity reported in 2012 for the Yser station increased significantly compared to previous years and is similar to the

2007 catches. Still, the 2012 catch represents only 0.47% of the mean catch in the period 1966–1979 (mean = 511 kg per annum, min. 252–max. 946 kg).

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

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

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

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

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

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

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).

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

In 2021, glass eel monitoring started on 20 February and stopped on 23 April and was carried out during 23 fishing nights, with 310 dipnet hauls. Fishing effort was thus quite similar as in 2019. Total captured biomass of glass eel amounted 1095 g (or 2873 individuals). This is a low number compared to the five previous years (and similar to the low 2016 data (which was described as incomplete). Maximum day catch was 128 g, the lowest value since 2010. CPUE (mean catch per haul) was 3.5 g per haul, the lowest value since 2011 (Figures 1A–D, and Tables 2–3). COVID-19 pandemy had no impact on the 2021 data collection.

Table 2. Total year catches (kg) between 1964 and 2021. Data Provincial Fisheries Commission West-Vlaanderen. * The data for 2016 are incomplete and not representative, due to technical problems, and should not be used for statistical purposes, nor for international stock assessment. ** The data for 2020 are incomplete and not representative, due to technical problems and Covid measures, and should not be used for statistical purposes, nor for international stock assessment.

Decade	1960	1970	1980	1990	2000	2010	
Year							2020
0		795	252	218.2	17.85	0.318	0.605**
1		399	90	13	0.7	0.413	1.095
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	

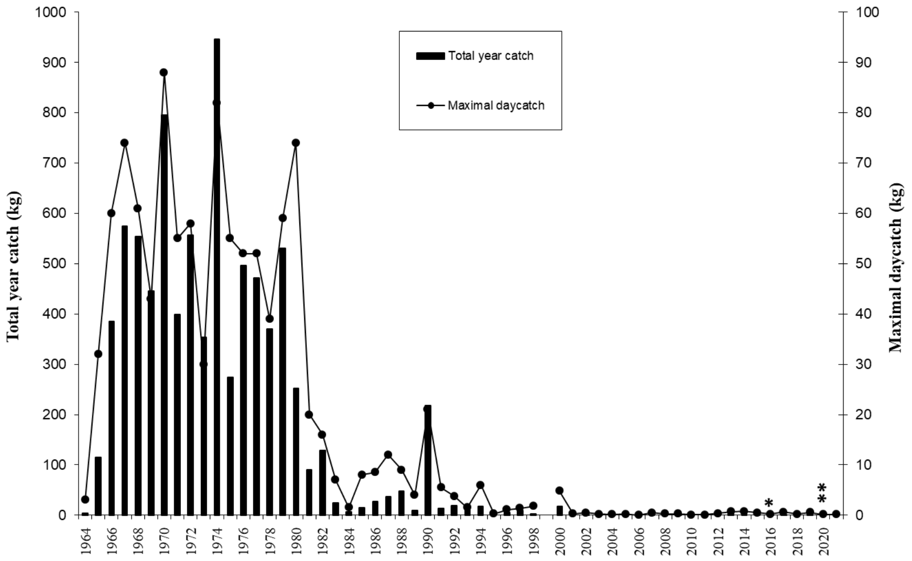


Figure 1A. Annual variation in glass eel catches at river Yser using the dipnet catches in the ship lock at Nieuwpoort (total year catches and maximum day catch per season), data for the period 1964–2021. * The data for 2016 are incomplete and not representative, due to technical problems at the sluices, and should not be used for statistical purposes, nor for international stock assessment. ** The data for 2020 are incomplete and not representative, due to technical problems and Covid measures, and should not be used for statistical purposes, nor for international stock assessment.

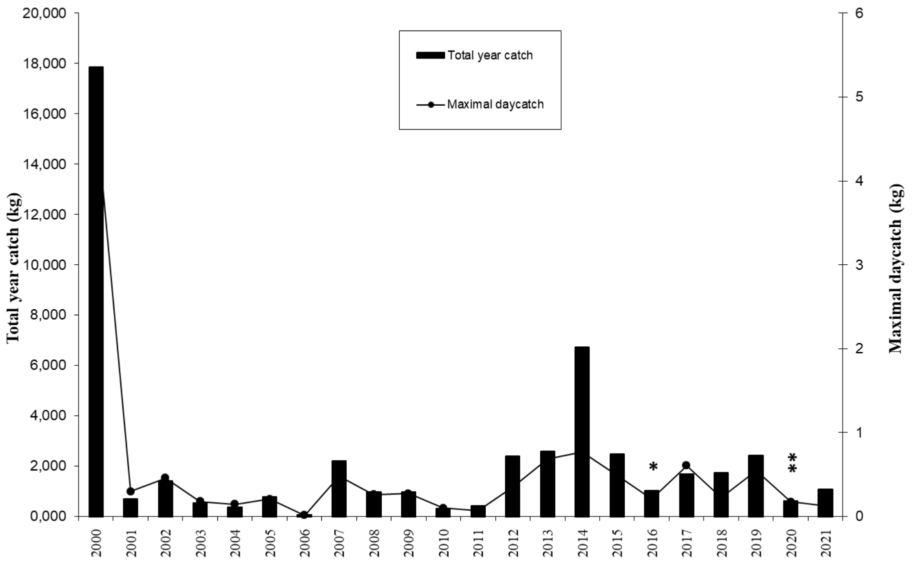


Figure 1B. Annual variation in glass eel catches at river Yser using the dipnet catches in the ship lock at Nieuwpoort (total year catches and maximum day catch per season), data for the period 2000–2021. * The data for 2016 are incomplete and not representative, due to technical problems at the sluices, and should not be used for statistical purposes, nor for international stock assessment. ** The data for 2020 are incomplete and not representative, due to technical problems and Covid measures, and should not be used for statistical purposes, nor for international stock assessment.

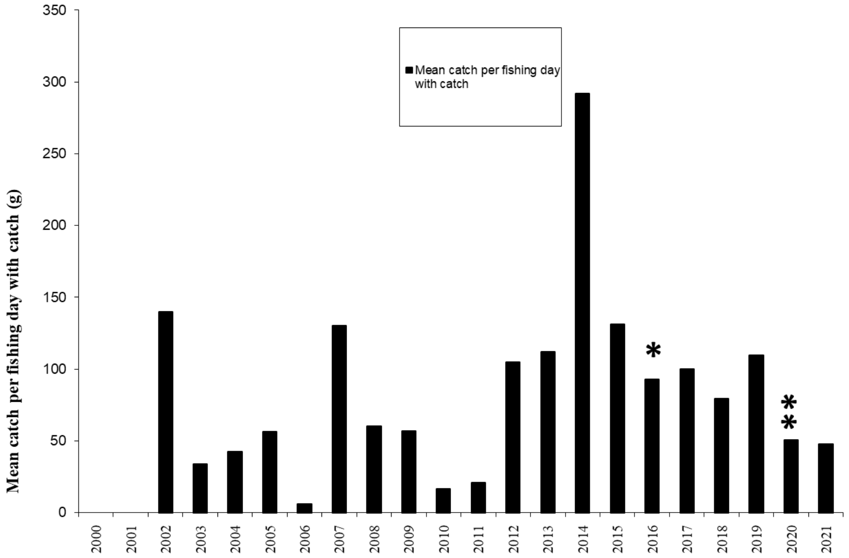


Figure 1C. Annual variation in glass eel catches at river Yser using the dipnet catches in the ship lock at Nieuwpoort) expressed as mean catches per fishing day with catch in g. * The data for 2016 are incomplete and not representative, due to technical problems, and should not be used for statistical purposes, nor for international stock assessment. ** The data for 2020 are incomplete and not representative, due to technical problems and Covid measures, and should not be used for statistical purposes, nor for international stock assessment.

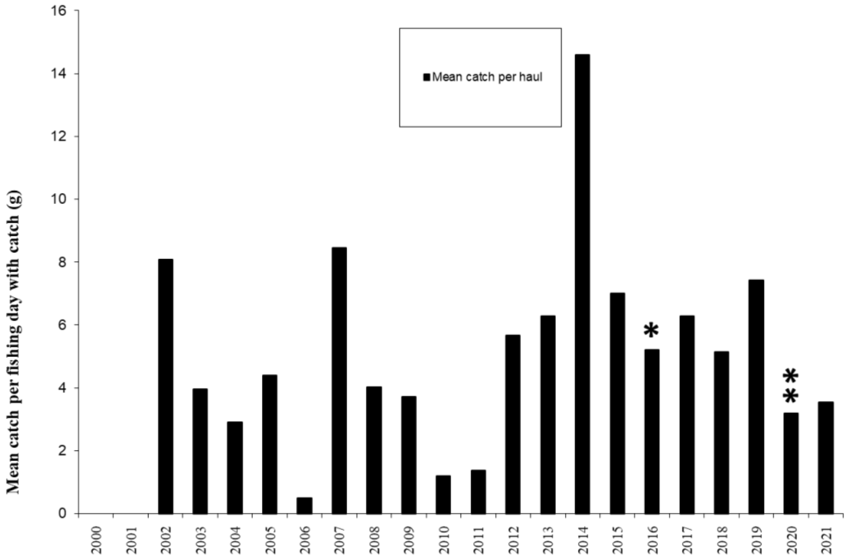


Figure 1D. Annual variation in glass eel catches at river Yser using the dipnet catches in the ship lock at Nieuwpoort), expressed as the mean catches per haul in g. * The data for 2016 are incomplete and not representative, due to technical problems, and should not be used for statistical purposes, nor for international stock assessment. ** The data for 2020 are incomplete and not representative, due to technical problems and Covid measures, and should not be used for statistical purposes, nor for international stock assessment.

Table 3. Temporal trend in catch per unit of effort for the governmental glass eel monitoring by dipnet hauls at the sluices in Nieuwpoort (River Yzer, 2002–2021). CPUE values are expressed as Kg glass eel caught per fishing day with catch and as Kg glass eel per haul. * The data for 2016 are incomplete and not representative, due to technical problems, and should not be used for statistical purposes, nor for international stock assessment. ** The data for 2020 are incomplete and not representative, due to technical problems and Covid measures, and should not be used for statistical purposes, nor for international stock assessment.

Year	Total year catch	Max day-catch	Total year catch/Number of fishing days with catch (Kg/day)	Total year catch/Number of hauls per season (Kg/haul)
2002	1.4	0.46	0.140	0.0081
2003	0.539	0.179	0.034	0.004
2004	0.381	0.144	0.042	0.0029
2005	0.787	0.209	0.056	0.0044
2006	0.065	0.014	0.006	0.0005
2007	2.214	0.485	0.130	0.0085
2008	0.964	0.262	0.060	0.004
2009	0.969	0.274	0.057	0.0037
2010	0.318	0.1	0.017	0.0012
2011	0.412	0.067	0.021	0.0014
2012	2.407	0.35	0.105	0.0057
2013	2.578	0.686	0.112	0.0063
2014	6.717	0.77	0.292	0.0146
2015	2.489	0.487	0.131	0.0070
2016*	1.023*	0.208*	0.093*	0.0052*
2017	1.697	0.607	0.100	0.0063
2018	1.749	0.230	0.080	0.0051
2019	2.415	0.545	0.110	0.0074
2020**	0.605	0.174	0.050	0.0032
2021	1.095	0.128	0.048	0.0035

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 ind. in 2019). Catches are presented in Table 4.

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

In 2021, compared to previous years, the way to report the data was different. From 2021 on, the weight of the glass eel was reported separately from the numbers of pigmented elvers in the trap. Table 4 lists the temporal trend in the data, period 2017 – 2021. Due to the adapted way in reporting data presented in this new table may differ from the data presented in last year’s country report (Belpaire *et al.*, 2020b) (where all captured life stages (glass eels and pigmented elvers), were reported together).

Moreover Van Wichelen *et al.* (2021) published the results on the behaviour of glass eel in this canal after they passed the sluices. See Section 6 for more details.

In 2021, monitoring started on 24 February and stopped on 28 June (147 trapping days). In total (both traps, left and right bank) 17421 g glass eel (in numbers 56195) and 294 g of elvers (in numbers 147) were trapped. There was significantly more glass eel trapped in the trap on the left bank compared to the right bank trap (left 11526 g, right 5895 g), while for elvers it was opposite (left 44 individuals, right 103 individuals). The 2021 glass eel catches were similar as in 2017 and 2019.

Table 4. Temporal trend in catch per unit of effort for the glass eel and pigmented elver monitoring at the at the Veurne-Ambacht pumping station (2017–2021, but see important notice below the table).

Year	Number of trapping days	Total year catch of glass eel (Biomass in Kg)	Total year catch of pigmented elvers (in numbers)
2017	97	19.263	217
2018	89	8.702	73
2019	109	15.692	18
2020*	16	1.417	28
2021	147	17.421	147

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

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

No new information was provided for this year's Country Report.

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

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

Ascending young yellow recruitment series at Lixhe (Meuse basin)

On the Meuse, the University of Liège is monitoring the amount of ascending young eels in a fish pass. From 1992 to 2021 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 2, Table 5). In 2008, 2625 eels were caught. This sudden increase might be explained by the fact that a new fish pass was opened (20/12/2007) at the weir of Borgharen-Maastricht, which enabled passage of eels situated downward the weir in the uncanalized Grensmaas. Nevertheless the number of eels were very low again in 2009 (n=584), 2015 (n = 92) and 2016 (n=21). The figure for 2012 (n= 324) is a bit more than the two previous years. In 2013, 265 eels were caught (size range 19.6-76.5 cm, median 39.1 cm), the data for 2014 are similar with 255 individuals (size range 23.4-69.8 cm, median 40.1 cm). In 2015 92 eels were caught (size range 23.1-85 cm, median 41 cm). In 2016 22 eels were caught (size range 21.1-64.2 cm, median 35.2 cm) which is the lowest number of eels ever recorded since the start of the monitoring (1992, n = 5613). In 2017 up to September 28 yellow eels were recorded (size range 24.0-72.0 cm, median 40.1 cm).

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

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

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

In 2021, from 4 June to 8 July, 406 eels were caught (biomass 16077.6 g). Sizes of eels caught ranged from 6.5 cm to 63.2 cm (median 26.1 cm). Maximum CPUE was 117 individuals per day. This observed number of eels caught has been impacted by the delay in the maintenance cleaning of the fish pass due to the covid-19 pandemic and the fish pass non-functional after 8 July because of the floods that severely affected the Wallonia/Belgium. These data are therefore be incomplete. It includes both the wild eels (n = 344, size range 6.5–34.8 cm, median 25.0 cm) and the eels from restocking carried out in the Belgian Meuse in 2018 and 2019 (n = 62, size range 35.2–63.2 cm, median 41.0 cm).

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).

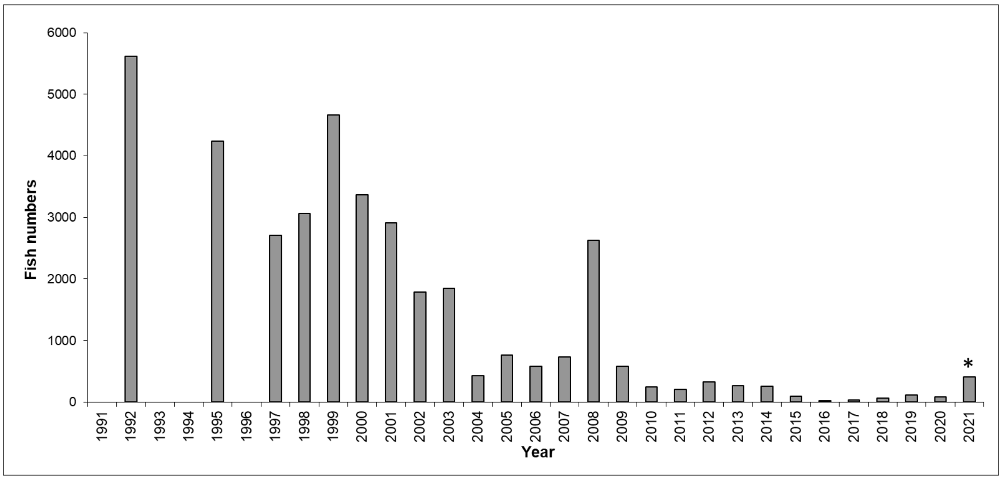


Figure 2. Variation in the number of ascending young yellow eels trapped at the fish trap of the Visé-Lixhe dam between 1992 and 2021. Data from University of Liège (Nzau Matondo *et al.*, 2015; Nzau Matondo and Ovidio, 2016). * Data for 2021 (n=406) include wild eels and restocked eels, and they are 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 2021. 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 2021 (n=406) include wild and restocked eels, and are incomplete.

DECADE				
Year	1990	2000	2010	2020
0		3365	249	84
1		2915	208	406*
2	5613	1790	324	
3		1842	265	
4		423	255	
5	4240	758	92	
6		575	22	
7	2709	731	28	
8	3061	2625	67	
9	4664	584	118	

2 Overview of the national stock and its management

2.1 Describe the eel stock and its management

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

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

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

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

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

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

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

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

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

The data required for the fourth Belgian Progress Report in line with Article 9 of the eel Regulation 1100/2007, was submitted in August 2021.

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 Belgian country report 2018, see Section 2.1 in Belpaire *et al*. (2018).

2.2 Significant changes since last report

Following actions are considered as significant for Belgium compared to last year:

- New estimation of Belgian silver eel escapement in line with the reporting requirements of the Eel Regulation. See Section 4 for more details..
- Glass eel restocking was zero in 2021. See the Section 3.2 for more information about the reason.

- Flanders decided to introduce a catch and release obligation for eel fished by recreational fishermen by January 2023. See Section 3.1.2.
- Significant increase in the number of recreational fishermen in Belgium, due to COVID-19. See Section 3.1.2 for more details.
- Belgium published some new papers related to eel (in the field of glasseel behaviour, eel conservation, restocking, contaminants). See Section 6 for more details.

3 Impacts on the national stock

3.1 Fisheries

3.1.1 Glass eel fisheries

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

There are no recreational glass eel fisheries.

3.1.2 Yellow eel fisheries

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

Recreational fisheries in Flanders

The number of licensed anglers was 60 520 in 2004, 58 347 in 2005, 56 789 in 2006, 61 043 in 2007, 58 788 in 2008, 60 956 in 2009, 58 338 in 2010, 61 519 in 2011, 62 574 in 2012, 64 643 in 2013, 67 554 in 2014, 66 105 in 2015, 64 336 in 2016, 63 545 in 2017, 62 143 in 2018, 57 388 in 2019 and **74 305 in 2020**. The time-series shows a general decreasing trend from 1983 (Figure 3), till 2006. However in 2007 there was again an increase in the number of Flemish anglers until 2014 when the number of anglers was 19% higher than in 2006. Since 2015, numbers are slightly decreasing again. **However, in 2021 there was a significant increase in the number of licensed anglers in Flanders, the increase amounted up to 18.5% compared to the mean number of the five previous years (period 2015-2019). This significant rise was most probably due to COVID-19. Angling was very popular as an individual COVID-safe outdoor activity.**

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

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

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

Belpaire *et al.* (2021) calculated that introducing a release obligation for recreational fishing of eel would contribute to an increase of approximately 10% in the current silver eel escapement figures. For example, the escape percentage of silver eels in the eel management unit of the Scheldt basin would increase from 11.5% to 12.6%. It is clear from this that introducing a catch or take-away ban will not be sufficient to achieve the objectives of the EU Eel Regulation. In their advice, Belpaire *et al.* (2020a) advocated to introduce this ban both to protect the species, but also to protect consumer's health, as eels are most often too contaminated by several contaminants.

In Flanders, measures are now being prepared to introduce a catch and release regulation for eel from 2023 on.

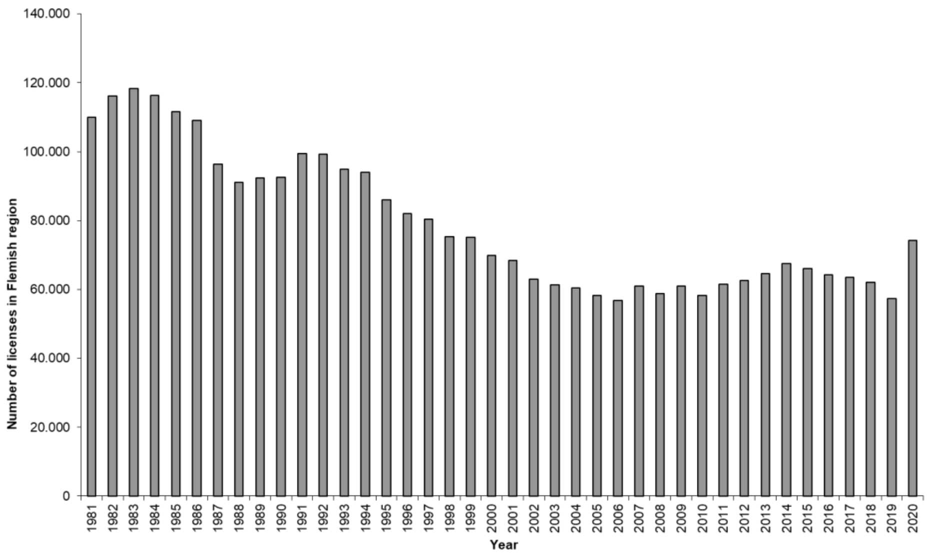


Figure 3. Time-series of the number of licensed anglers in Flanders since 1981 (Data Agency for Nature and Forests).

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

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

Recreational fisheries in Wallonia

In Wallonia, the number of licensed anglers was 65 687 in 2004, 63 145 in 2005, 59 490 in 2006, 60 404 in 2007, 56 864 in 2008, 59 714 in 2009, 54 636 in 2010, 55 592 in 2011, 55 632 in 2012, 55 171 in 2013, 58 379 in 2014, 59 294 in 2015, 57 171 in 2016, 58 284 in 2017, 62 581 in 2018, 62 561 in 2019 and **81 438 in 2021** (Figure 4). 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). **In 2021 there was a very significant increase in the number of licensed anglers in Wallonia, the increase amounted up to 36% compared to the mean number of the five most recent years (period 2015-2019). This significant rise was most probably due to COVID-19. Angling was very popular as an individual COVID-safe outdoor activity.**

The proportion of eel fishermen in Wallonia is not documented, but is probably very small since it is forbidden to fish eels.

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

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

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

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

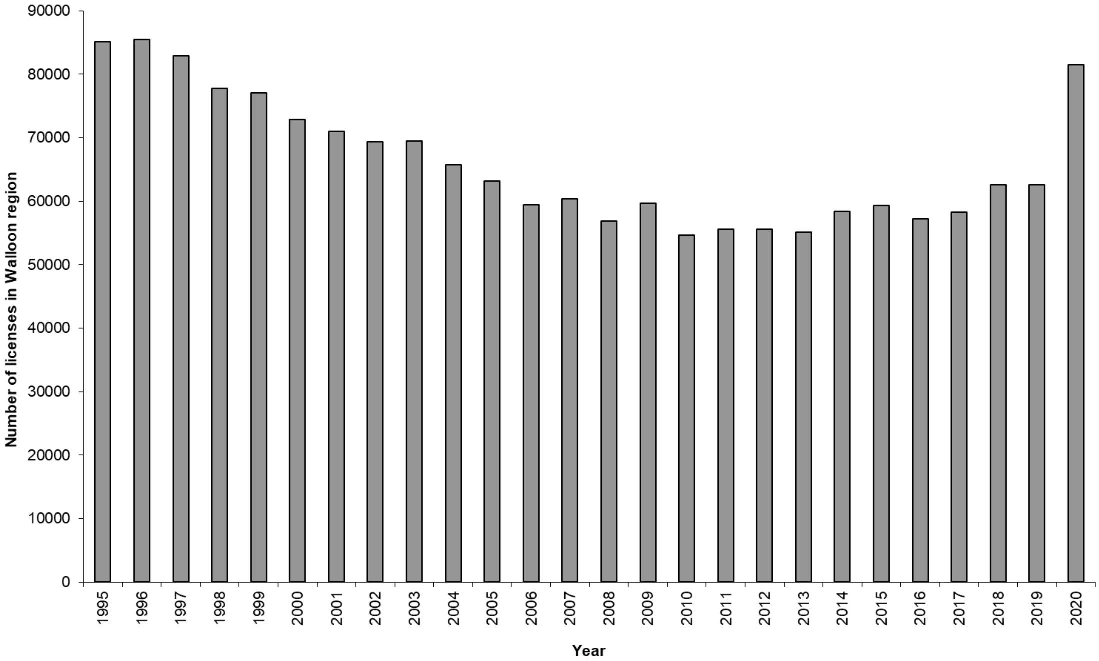


Figure 4. Time-series of the number of licensed anglers in Wallonia since 1995 (Data : Nature and Fish Service of the Nature and Forests Department (DNF – DGARNE - SPW)).

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 5). 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 5 and Table 6). In 2008, 117 kg of glass eel from U.K. origin (rivers Parrett, Taw and Severn) was stocked in Flemish water bodies. In 2009, 152 kg of glass eel originating from France (Gironde) was stocked in Flanders. In 2010 (April 20th, 2010) 143 kg has been stocked in Flanders. The glass eel was originating from France (area 20–50 km south of Saint-Nazaire, small rivers nearby the villages of Pornic, Le Collet and Bouin). A certificate of veterinary control and a CITES certificate were delivered.

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

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

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

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

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

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

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

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

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

In 2020, Flanders bought 300 kg glass eel for stocking in Flemish waters (price 185 €/kg, without taxes). These glass eel were stocked on March, 11th, 2019. Origin of the glass eel was France (EURL AGUIRREBARRENA, Zac Casablanca, 5 rue de la Cotterie – 40230, St Vincent de Tyrosse, France). The cost of the glass eel per kg (including transport but without taxes) is presented in Table 7. Glass eel restocking activities in Flanders are not taking account of the variation in eel quality of the restocking sites.

In 2021, there was no restocking of glass eels in Flanders. Adjusted tidal barrage management (ATBM, leaving sluice doors ajar during tidal rise) is currently applied on several waterways along the Belgian coast as a measure to improve glass eel passage through tidal gates at the salt/freshwater interface. This measures enhances natural recruitment significantly and therefor the fresh water fisheries administration decided to only carry out restocking every two years (instead of yearly) since 2020.

Note however that a Walloon study was published (Nzau Matondo *et al.*, 2021) suggesting that a well-selected habitat/river in a restocking programme can be beneficial for the species and recommends restocking practice as a management tool to achieve eel conservation goals (See Section 6).

Trend in restocking in Flanders is presented in Figure 5 and Table 6.

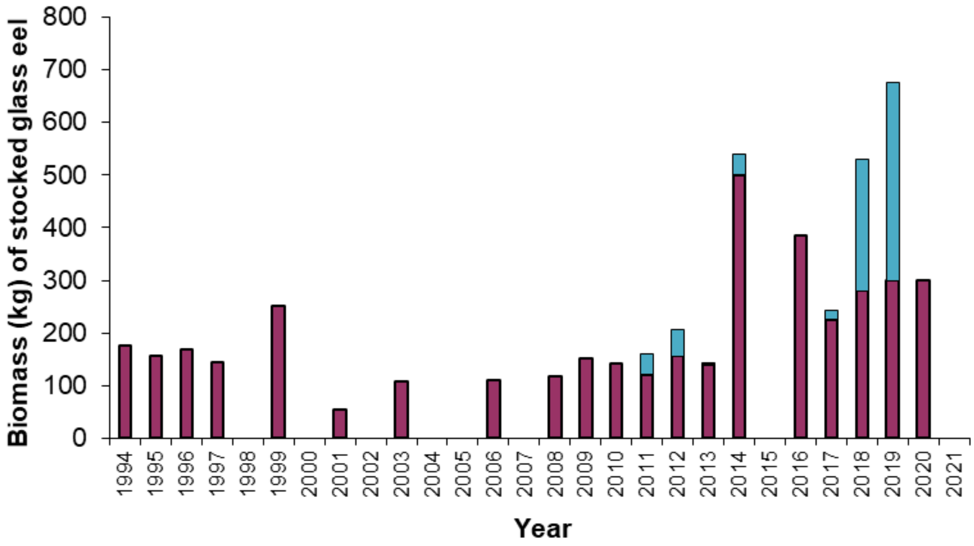


Figure 5 and Table 6. Restocking of glass eel in Belgium (Flanders and Wallonia) since 1994, in kg of glass eel. Flanders is represented in red and Wallonia in blue in the figure. * left Flanders/right Wallonia.

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

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

Year	Cost (€/kg)
2008	510
2009	425
2010	453
2011	470 (Flanders) 520 (Wallonia)
2012	416 (Flanders) 399 (Wallonia)
2013	460 (Flanders) 400 (Wallonia)
2014	128 (Flanders) 128 (Wallonia)
2015	190 (Flanders)(not supplied) 128 (Wallonia) (not supplied)
2016	180 (Flanders)
2017	233 (Flanders) 350 (Wallonia)
2018	265 (Flanders) 292 (Wallonia)
2019	180 (Flanders) 178 (Wallonia)
2020	185 (Flanders) 299 (Wallonia)(but not supplied)
2021	No restocking

Stocking in Wallonia

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

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

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

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

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

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

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

In 2020, Wallonia ordered on 12 March 2020 to an eel trading company (UK Glass Eels Ldt, Gloucester, UK) 220 kg glass eel for stocking in Walloon waters (price 299 €/kg, without taxes).

However, the supplier was not able to provide the glass eel due to the lockdown as a measure for the Covid-19 pandemic. As a result, no glass eel could be stocked in Wallonia in 2019 but this order remains valid, probably for 2021.

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. Two new studies were published by Nzau Matondo *et al*. (2020; 2021) on the evaluation of restocking practices (see below Chapter 6 for more details for Nzau Matondo *et al*. (2021). **Nzau Matondo *et al*. (2021) studied the fitness of restocked eels and concluded that restocking programme can be beneficial for the species and recommends restocking practice as a management tool for eel conservation. (See Section 6).**

There was no restocking in European eels in Wallonia in 2021. The United Kingdom-based supplier has not been able to provide the glass eels ordered because of Brexit.

Trend in restocking in Wallonia is presented in Figure 5 and Table 6.

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

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

Year	Region	Origin	Amount (kg)
2018	Flanders	France	280
	Wallonia	France	250
2019	Flanders	France	300
	Wallonia	France	376
2020	Flanders	France	300
	Wallonia***	UK	0
2021	Flanders		No restocking
	Wallonia		No restocking

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

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

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

3.3 Aquaculture

There is no aquaculture production of eel in Belgium.

3.4 Entrainment

No changes compared to the last Belgian country report (Belpaire *et al.*, 2020b).

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

Significant progress has been made in quantifying impacts of migration barriers such as turbines and fish locks on eel migration in canals (see the items under Chapters 5.2 and 6 in Belpaire *et al*., 2020b).

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 major changes compared to the 2015 Belgian country report (Belpaire *et al*., 2016a). We refer to this report for details.

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

4 National stock assessment

4.1 Description of method

The data regarding national stock assessment refer to the silver eel escapement assessment for the progress report 2018 and 2021 of the EU Regulation as described in Belpaire *et al*. (2018; 2021) and the 2018 and 2021 Belgian Eel Progress Tables.

We refer to these documents for detailed information.

4.1.1 Data collection

Flanders (Belpaire *et al*., 2018; 2021)

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 and 2021 reporting are based on data collected in 2015-2017 and 2018-2020, respectively.

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").

Wallonia

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

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

4.1.2 Analysis

Flanders (Belpaire *et al*., 2018; 2021)

The method used by Belpaire *et al*. (2018) for calculating the silver eel escapement rate was adjusted from the calculation models used in the previous reports (Stevens en Coeck, 2013, Belpaire *et al*., 2015). In this new model, conversion of catch data to expected number per ha have been optimized, and the mortality figures from recreational fisheries and cormorants have been calculated in a different way. Mortalities due to pumps and turbines were now integrated over the stratum *River Basin* on the basis of a different allocation key (in casu the proportion of the basin drained by pumps)). For cases without CPUE data within the stratum *River Type * River Basin*, a zero-inflated negative binomial model was used to estimate the number of eels per hectare. Furthermore, the fresh, brackish and salt tidal waters (types Mlz and O1) were considered together as one river type. The R script developed during the previous report was further adapted according to the refinement of the calculation model. The changes in the calculation model are considered to have a significant influence on the results. The same method has been used in Belpaire *et al*. (2021).

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 assessments for the periods 2015–2017 and 2018-2020 for Flanders have been reported in Belpaire *et al*. (2018) and Belpaire *et al*. (2021) respectively.

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; 2021)

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.

During the evaluation of the reports provided by the European member states, ICES (International Commission for the Exploration of the Sea) expressed concerns about the accuracy of the final figures due to among others insufficient data for some water types (ICES, 2019). Electrofishing data for large bodies of water such as canals and large estuaries are not considered fully suited as data source. ICES suggests that direct monitoring of migrating silver eels in experimental (sub)basins, coupled with a set of indicators, may be a better alternative.

Flanders has not (yet) followed these recommendations, and the present report calculates the silver eel escapement rate for the 2021 report in the same way as in the previous report.

Wallonia

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

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

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

No new information was made available for the 2021 Country Report.

4.2 Trends in Assessment results

Flanders (Belpaire *et al*., 2021)

The latest estimated escapement figures for silver eel (period 2018-2020) are 10.1% for the EMU Scheldt and 4.44% for the EMU Meuse. Once again, the targets of the EU Eel Regulation (40%) are not being achieved. Compared to the previous reporting period, the figures for EMU Scheldt have even decreased slightly (decrease of 12%). In EMU Meuse, the figures have declined even more drastically (decrease of 76%).

Belpaire *et al*. (2021) back calculated escapement indicators for the last three periods (2011-2014 (‘2015’), 2015-2017 (‘2018’) and 2018-2020 (‘2021’) using the identical calculation methodology as in the 2018 report (Belpaire *et al.*, 2018). The figures for net production of silver eel and percentage escapement are given in Figures 6-7.

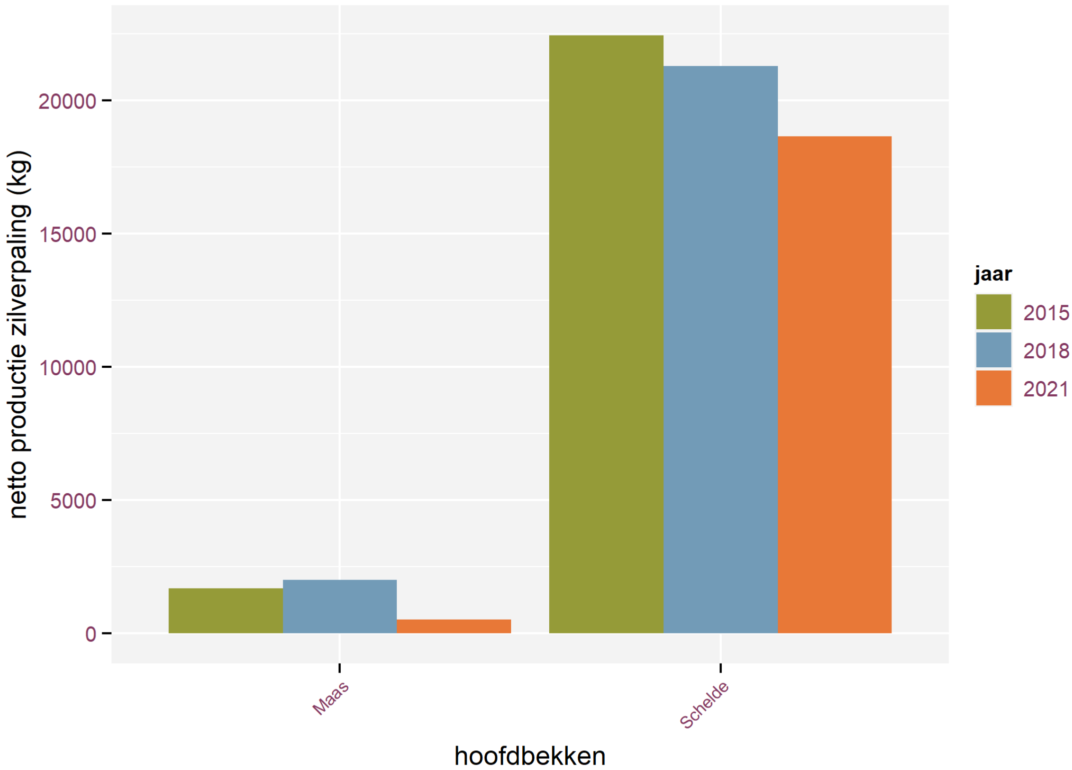


Figure 6. Silver eel production in EMU Maas and EMU Schelde. Comparison between the periods 2011-2014 (‘2015’), 2015-2017 (‘2018’) and 2018-2020 (‘2021’)(Belpaire *et al.*, 2021)

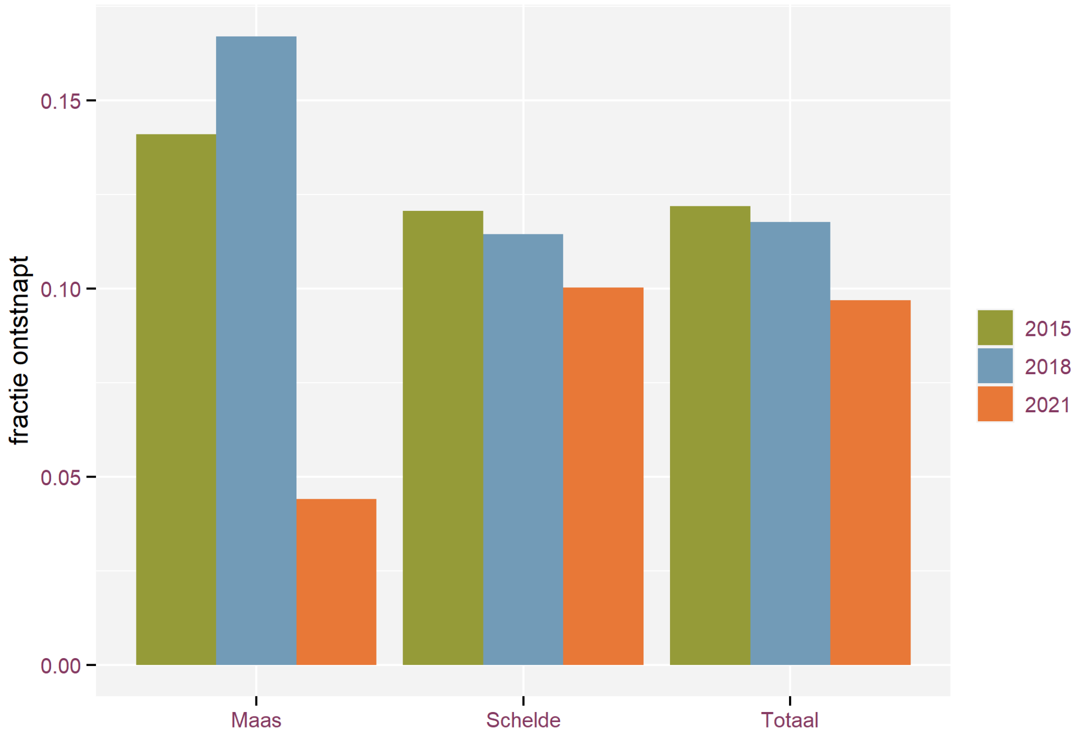


Figure 7. Percentage escapement in EMU Maas and EMU Schelde. Comparison between the periods 2011-2014 ('2015'), 2015-2017 ('2018') and 2018-2020 ('2021')(Belpaire *et al.*, 2021)

The anticipated positive effects of the applied recovery measures are not visible in the production figures, and current figures are even further away from the objectives. Hence, additional measures will have to be taken if Flanders aims to achieve the objectives of the Eel Regulation.

Wallonia

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

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

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

5 Other data collection for eel

5.1 Yellow eel abundance surveys

Trend analysis of eel catches in the Flemish Fish Monitoring Network

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

Later, trend analyses of catches collected during of electrofishing and fyke-fishing, have been performed on a regular basis in the framework of the elaboration of progress reports for the EU eel Regulation. The most recent analysis being for the 2021 progress report for the EU Eel Regulation (Belpaire *et al*., 2021). 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

For technical reasons this series could not be updated for year's country report.

A fish monitoring network by INBO has been put in place to monitor fish stock in the Scheldt estuary using paired fykenets (Figure 8). 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 9–11) 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 & Van Thuyne, 2015; Breine *et al*., 2019b). Data are presented until autumn 2019.

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

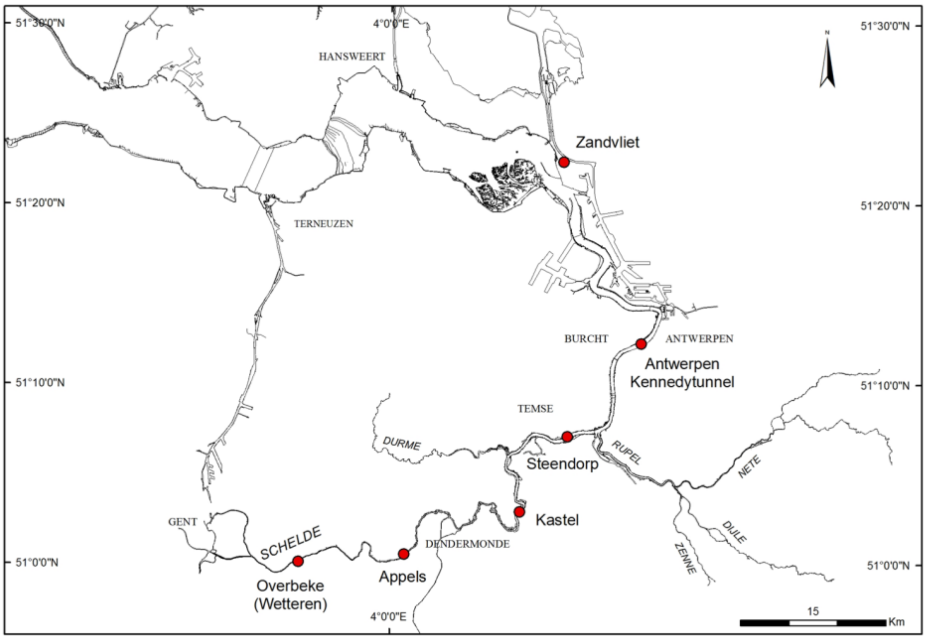


Figure 8. Locations sampled in the Zeeschelde estuary.

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).

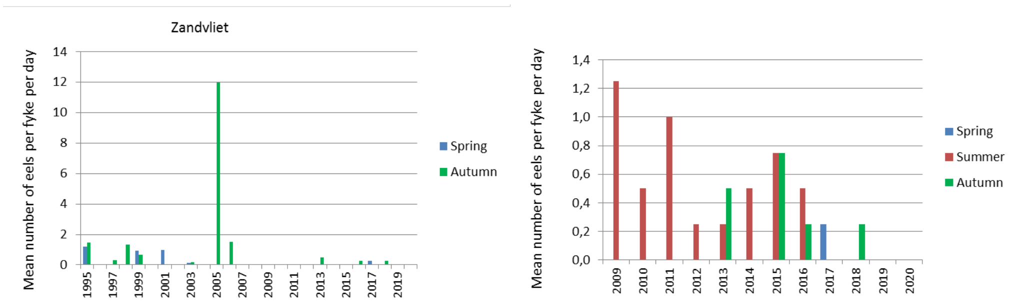


Figure 9. Time trend of fyke catches of eel in Zandvliet. Numbers are expressed as mean number of eels per fyke per day. Left, data are split up in spring catches and fall catches (1995–2019) while right, summer catches are added (2009–2019). Years without monitoring data are excluded from the X-axis.

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.

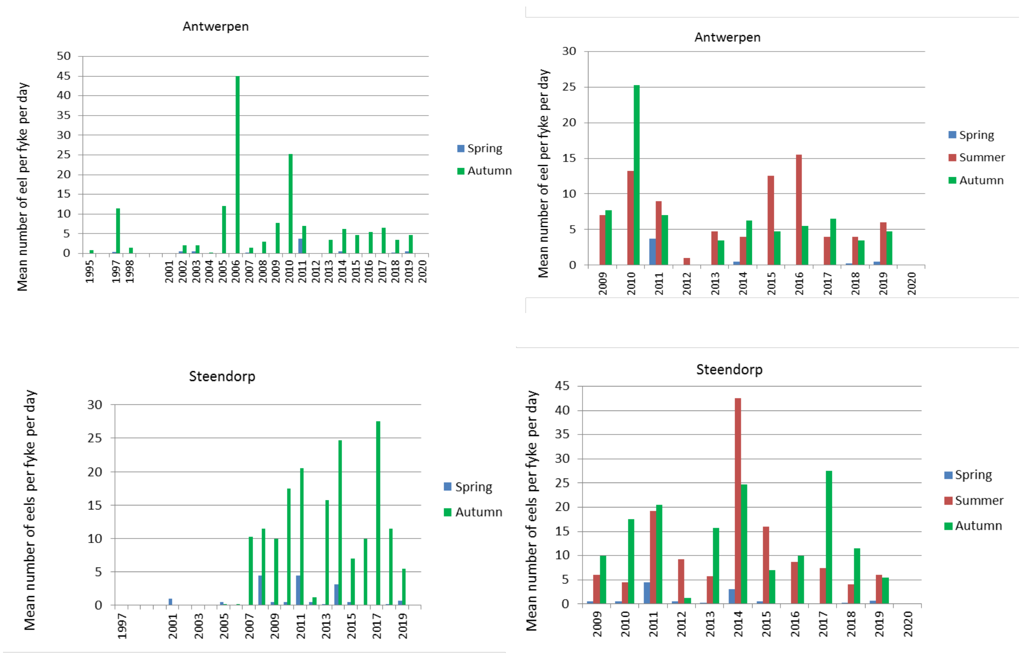


Figure 10. Time trend of fyke catches of eel in Antwerpen and Steendorp. Numbers are expressed as mean number of eels per fyke per day. On the left, data are split up in spring catches and fall catches (1995–2019) while on the right, summer catches are added (2009–2019). Years without monitoring data 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.

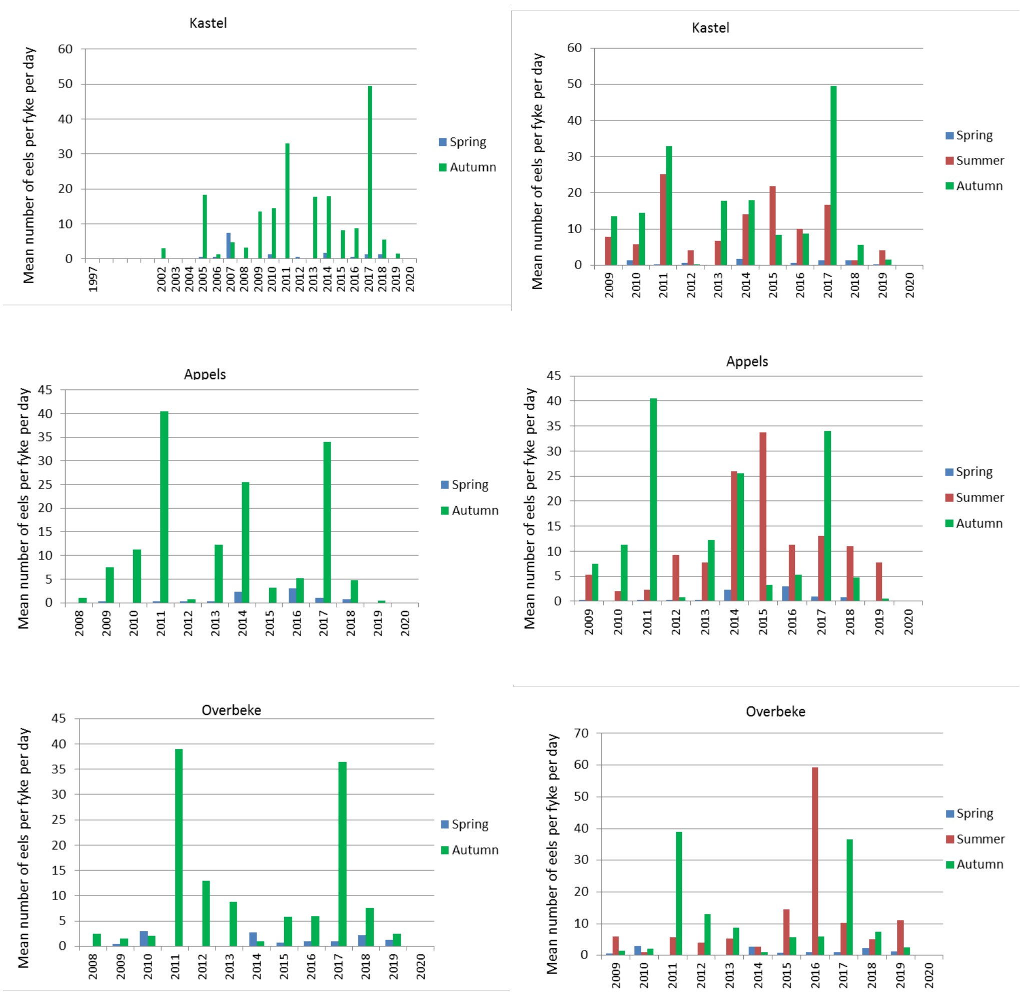


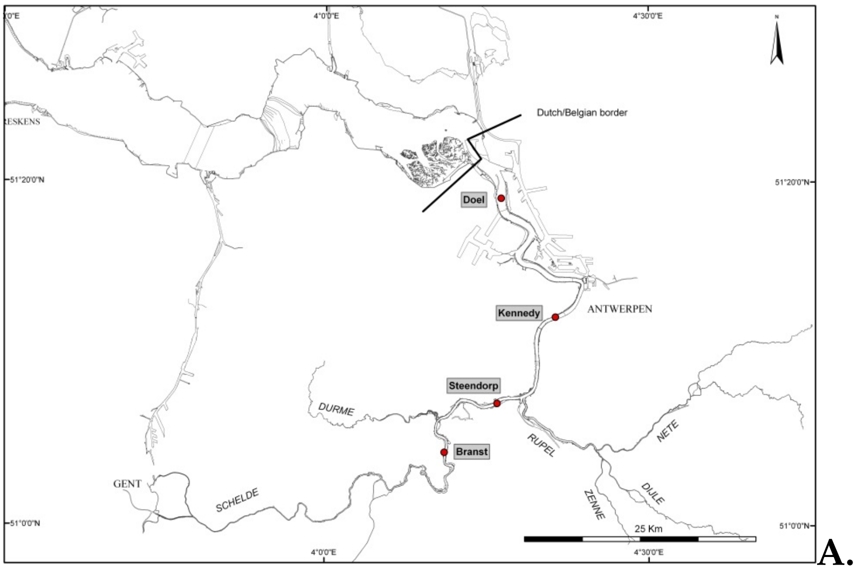
Figure 11. Time trend of fyke catches of eel in Kastel, Appels and Overbeke. Numbers are expressed as mean number of eels per fyke per day. On the left, data are split up in spring catches and fall catches (1997 or 2008–2019) while on the right, summer catches are added (2009–2019). Years without monitoring 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 summer 2021 are shown in Figure 12. The data are expressed as number of eels per hour.

Compared to last year's report the data for 2020 and data for spring and summer 2021 have been now included. The data show overall low densities for the last 3 years, with in 2021 a slight increase of catches at Steendorp in the summer.



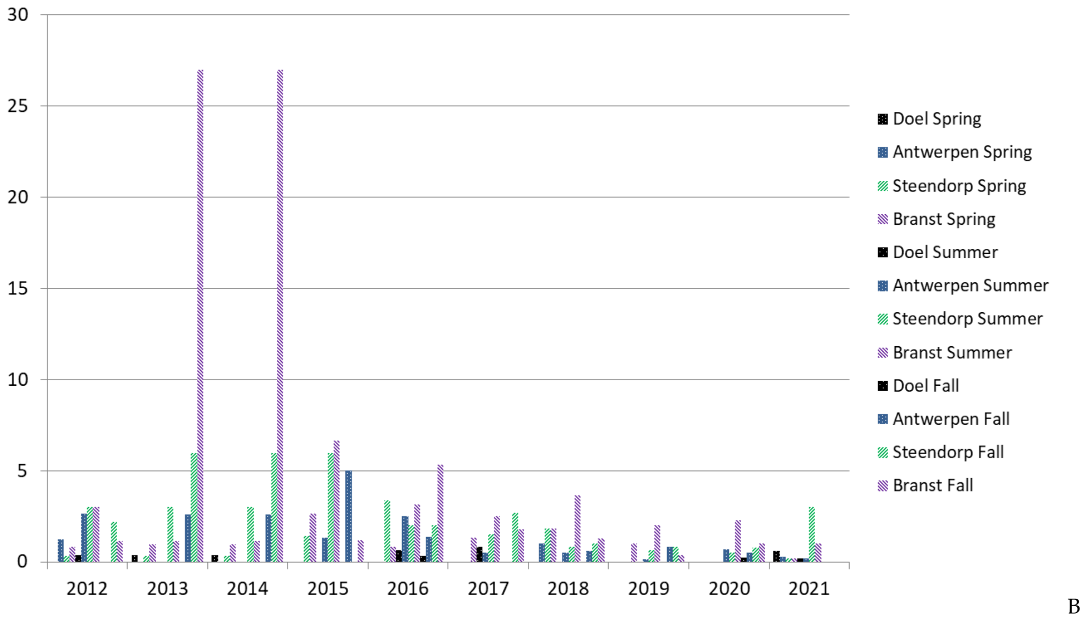


Figure 12. A. Location of the anchor net monitoring sites B. Time trend of catches of eel in a mid-water beam trawl from an anchored boat in Doel, Antwerpen, Steendorp and Branst along the Scheldt River. Numbers are expressed as mean number of eels per hour. Catch data of spring, summer and fall fishing is presented. Data source Jan Breine, INBO, unpublished.

Yellow eel abundance surveys in the Walloon Fish Monitoring Network

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

No update for this project was available for the 2021 Country Report.

5.2 Silver eel escapement surveys

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

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

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

No update for this project was available for the 2021 Country Report.

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

See under Section 6 for details or preliminary results.

Meta-analysis on European silver eel migration

See under Section 6 for details or preliminary results.

Silver eel migration from the Baltic Sea into the North Sea

See under Section 6 for details or preliminary results.

Silver eel tagging experiments in the Albert Canal (Flanders)

The Belgian Country Reports 2018-2020 reported on results from tagging and migration studies at the Albert Canal connecting the Meuse River to the Scheldt Estuary (Belpaire *et al.*, 2018; 2019, 2020).

No update for this project was available for the 2021 Country Report.

Silver eel tracking

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

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

No update for this project was available for the 2021 Country Report.

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

Assessment of the silver eel escapement in Flanders

Belpaire *et al*. (2021) estimated the biomass of silver eels escaping from Flanders in the framework of the 2021 progress report for the EU Regulation. See for more details Chapter 4.

Silver eel tagging in the River Meuse

No update for this project was available for the 2021 Country Report.

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

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

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

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

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

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

5.3 Life-history parameters

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

Belpaire *et al*. (2021) calculated the length–weight relationship for 3561 eels captured through electrofishing and fyke fishing in Flanders in the period 2018–2020 (Figure 13). The L/W relationship was:

$$W = 0{,}000877\ L^{3{,}176} \text{ with } r^2 = 0{,}9826\ (N = 3561)$$

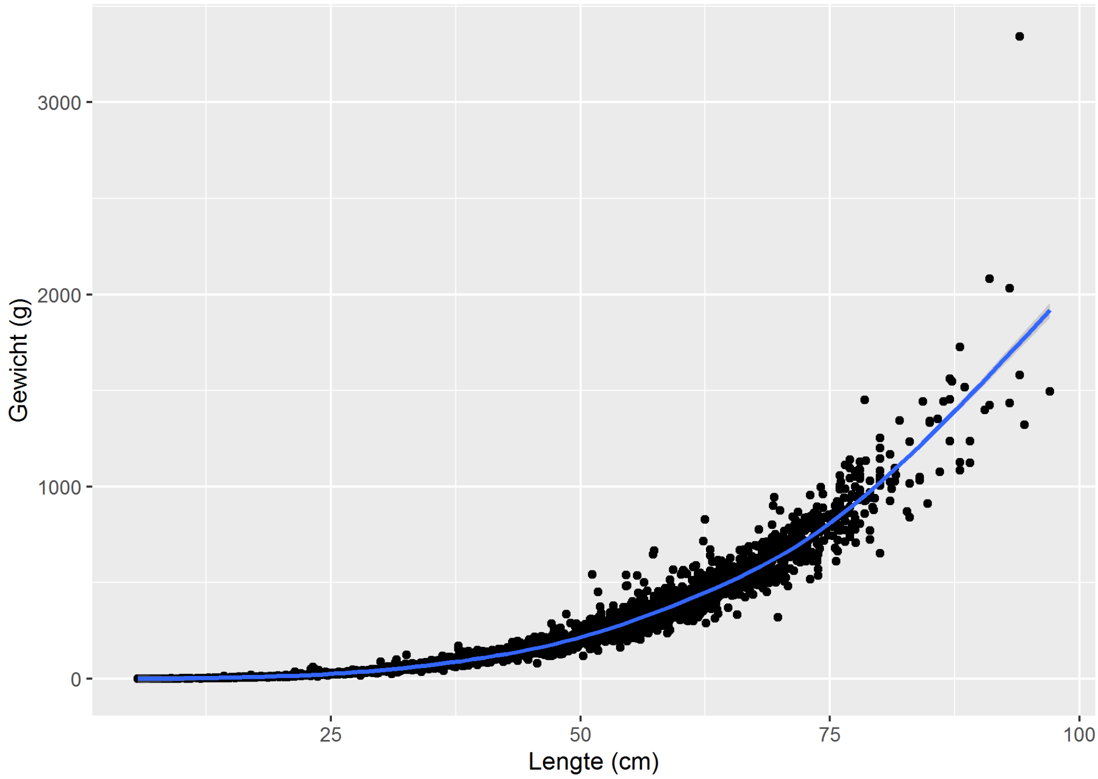


Figure 13. Length–weight relationship of 3561 eels captured through electrofishing and fyke fishing in Flanders in the period 2018–2020.

5.4 Diseases, Parasites and Pathogens or Contaminants

Diseases, parasites and pathogens

With respect to diseases and parasites no new information is available, apart from some data on eels from Italy published in Capoccioni *et al.*, 2020 (see Section 6)

Contaminants

In 2021 a few new publications were issued on the status of chemical pollution in eel. They are listed here, but more information is provided under Section 6, and the papers are made available on the WGEEL Sharepoint.

Teunen *et al*. (2021a) measured PFOS and PFAS compounds in eel and other organisms in Flanders and concluded that eel PFAS concentrations did pose a human health risk. European standard for PFOS was exceeded in eel at 44% of the sampling locations.

Teunen *et al*. (2021b) measured accumulated mercury concentrations in muscle and liver tissue of European eel (*Anguilla anguilla*) collected at 26 sampling locations in Flemish (Belgian) waterbodies, allowing an interpretation of a variety of environmental situations. We found no correlation of accumulated mercury with length in eel. Liver tissue showed higher concentrations than muscle tissue. Health risk analyses revealed that only frequent consumption of local eel (> 71 g day^{-1}) could pose risks to humans.

Teunen *et al*. (2021c) studied the effects of abiotic factors and environmental concentrations in water and sediment on the bioaccumulation of persistent organic and inorganic compounds to freshwater fish (including eel) and mussels.

Capoccioni *et al*. (2020) investigated silver eel from two Italian lagoons for a broad range of contaminants Concentrations showed a general low contamination pattern. Overall, a good quality status of escaping silver eels, for both lagoons, was highlighted by the use of integrative Indexes. The study proposed as a tool to identify sites yielding high quality eel spawners in the Mediterranean region, in order to set up suitable management frameworks.

Righton *et al*. (2021) listed and reviewed important questions to progress science and sustainable management of anguillid eels, including the question on how pollution affects the viability of eel stocks.

Below we also copied the information presented in the 2020 Country Report as it may be relevant for the work of Subgroup 5 of the WGEEL 2021 session.

Contaminants in silver eel

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

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

Measuring contaminants in eel for implementation of the Water Framework Directive

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

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

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

PBDE (97%) and mercury (100%; Figure 14) exceeded their respective biota EQS in almost all sample locations. Furthermore, many exceedances were recorded for PFOS (76%) and dioxins in eel (69%). As for HCBz, HBCD, HCBd, heptachlor (0%>LOQ) and dioxins in perch less than 1% exceedances were detected. The human consumption standards for PCBs and dioxins in eel were exceeded in respectively 51 and 37.5% of the Flemish waterbodies.

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

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

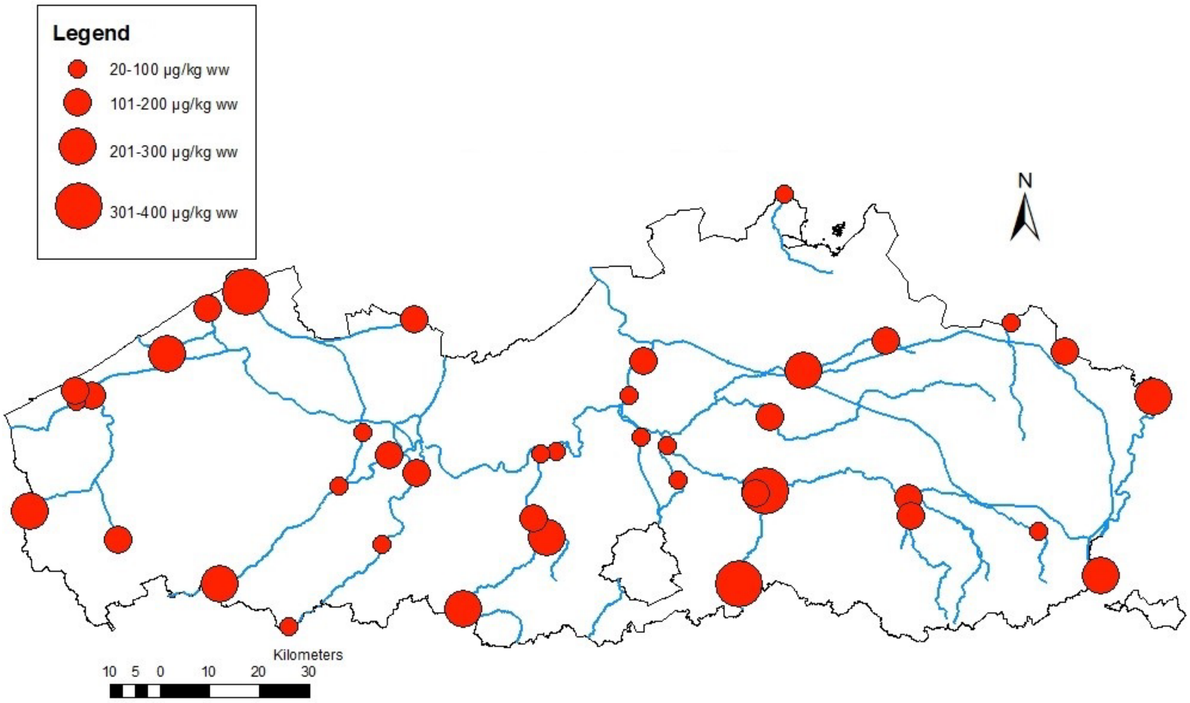


Figure 14. Map with exceedance of the biota EQS for Hg in eel on different sampling locations in Flanders (Belgium). The size of the red dots indicates the range of concentrations measured at that specific location. The biota EQS for Hg equals 20 µg kg-1 ww.

Contaminants in eel versus otter restoration

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

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

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

6 New information

Impacts of flooding

In July 2021 heavy floods occurred throughout Belgium, the Netherlands and Germany causing many human casualties and enormous damages. The situation in Flanders was less catastrophic compared to the Walloon region, however had enormous impact on several water courses in Flanders. End of July, the river Demer and her affluents suffered from almost complete anoxia over a 50 kms stretch during 2-3 weeks, and 80-90% of the fish populations is believed to have died. Among other species, thousands of dead eels have been observed.

New papers published

New paper. **Nzau Matondo, B., Benitez, J.P., Dierckx, A., Renardy, S., Rollin, X., Colson, D., Baltus, L., Ro-main, V.R.M., Ovidio, M., 2021. What are the best upland river characteristics for glass eel restocking practice? Science of the Total Environment 784 (2021) 147042. https://doi.org/10.1016/j.scitotenv.2021.147042**

The fitness of restocked European eel (*Anguilla anguilla*), an endangered fish species, was studied in relation to the environmental variables of habitats in six upland rivers that are typologically different in terms of their hydromorphological and physicochemical characteristics, food resources and fish communities. These rivers received a total of 76,370 imported glass eels in 2017. During a three-year period, we monitored eels with respect to total length, annual growth rate, condition factor and density using capture-mark-recapture experiments to understand the effects of the characteristics of receiving rivers on restocking success levels. Our results showed the survival of the restocked eels in the six rivers and revealed significant differences between them in terms of total length, condition factor and density. Better performance in eel yield variables was observed in a eutrophic alkaline river with greater roughness of riverbed substrates, dominant pool- and riffle-type flow facies and lower brown trout density. The variables conductivity and total hardness had higher explanatory power and were strongly associated with increased eel density. This study suggests that a well-selected habitat/river in a restocking programme can be beneficial for the species and recommends restocking practice as a management tool to achieve eel conservation goals.

New paper. **Van Wichelen J., Verhelst P., Buysse D., Belpaire C., Vlietinck K., Coeck J., 2021. Glass eel (*Anguilla anguilla* L.) behaviour after artificial intake by adjusted tidal barrage management. Estuarine, Coastal and Shelf Science 249 (2021) 107127**

Tidal barrages on water ways constitute a major threat for diadromous fish species such as the critically endangered European eel (*Anguilla anguilla* L.). An unobstructed migration route between the spawning area in the Sargasso Sea and the freshwater growth habitats in Europe is crucial for the European eels' long-term survival. Every spring however, millions of glass eels arrive at the European coast to find their inland migration route blocked. Adjusted tidal barrage management (ATBM), i.e. setting the tidal sluice doors ajar during tidal rise, is one of the mitigation measures to enhance glass eel colonisation. Although this management substantially improves the number of incoming glass eels, the fate of these migrants, confronted with abruptly shifting conditions upon sluice passage, remains un-investigated. Glass eel upstream dispersion after sluice passage by means of ATBM was investigated in a drainage canal connecting a small estuary with an adjacent polder area in Belgium. Large numbers of glass eel caught with eel ladders installed at a pumping station about 800 m upstream the tidal barrage indicate that glass eels were well able to switch to an active counter current swimming behaviour to continue upstream dispersion. On the other hand, some glass eels did not initiate active migration but settled in artificial substrates placed in the canal instead. These residents however appeared very successful in using the canal as feeding ground and in time substantially increased their overall fitness. The appearance of both migration strategies (switch to active migration or successful settlement) in this canal shows the potential of ATBM as a valuable tool for the management and restoration of the European eel population and calls for a wide application of this cost-efficient mitigation measure.

New paper. **Teunen, L., Bervoets, L., Belpaire, C., De Jonge, M., Groffen, T. (2021a) PFAS accumulation in indigenous and translocated aquatic organisms from Belgium, with translation to human and ecological health risk.** ***Environ Sci Eur 33*****, 39.** **https://doi.org/10.1186/s12302-021-00477-z**

Despite specific restrictions on their production and use, per- and polyfluoralkyl substances (PFAS) are still omnipresent in the environment, including aquatic ecosystems. Most biomonitoring studies have investigated the PFAS concentrations in indigenous organisms, whereas active biomonitoring has only been used sporadically. In the present study, accumulated PFAS concentrations were measured in indigenous fish, European perch (*Perca fluviatilis*) and European eel (*Anguilla anguilla*) and in translocated freshwater mussels (*Dreissena bugensis* and *Corbicula fluminea*) at 44 sampling locations within the main water basins of Flanders, the northern part of Belgium. Finally, both human health risk and ecological risk were assessed based on accumulated concentrations in fish muscle. Among locations, ΣPFAS concentrations ranged from 5.73 – 68.8 ng/g ww (median: 22.1 ng/g ww) in eel. Concentrations of PFOA and PFTeDA were higher in mussels compared to fish, whereas for PFDA and PFUnDA the opposite was true. A comparison of concentrations on a wet weight basis between both fish species showed significantly higher PFDoDA, PFTrDA, PFTeDA and PFOA concentrations in eel compared to perch and significantly higher concentrations of PFDA and PFOS in perch. In mussels, PFAS profiles were dominated by PFOA and showed a higher relative contribution of short-chained PFAS, while PFAS profiles in fish were dominated by PFOS. Furthermore, all mussel species clearly occupied a lower trophic level than both fish species, based on a stable isotope analysis. Biomagnification of PFDA, PFUnDA and PFOS and biodilution of PFOA and PFTeDA were observed. Translocated mussels have been proven suitable to determine which PFAS are present in indigenous fish, since similar PFAS profiles were measured in all biota. Finally, mean PFAS concentrations in fish did pose a human health risk for eel, although tolerable daily intake values for perch were close to the reported daily consumption rates in Belgium and exceeded them in highly contaminated locations. Based on the ecological risk of PFOS, the standard was exceeded at about half of the sampling locations (44% for eel and 58% for perch).

New paper. **Teunen, L., Belpaire, C., De Boeck, G., Blust, R., Bervoets, L. (2021b). Mercury accumulation in muscle and liver tissue and human health risk assessment of two resident freshwater fish species in Flanders (Belgium): a multilocation approach.** ***Environ Sci Pollut Res.*** **https://doi.org/10.1007/s11356-021-16215-0**

Detrimental effects of chemical pollution - primarily caused by human activities - on aquatic ecosystems, have increasingly gained attention. Because of its hydrophobic qualities, mercury is prone to easily bioaccumulate and biomagnify through the food chain, decreasing biodiversity and eventually also affecting humans. In the present study, accumulated mercury concentrations were measured in muscle and liver tissue European eel (*Anguilla anguilla*) collected at 26 sampling locations in Flemish (Belgian) waterbodies, allowing an interpretation of a variety of environmental situations. Furthermore, effects of size and weight have been assessed, expected to influence accumulation and storage of pollutants. Mercury concentrations in eel ranged between 0.07 and 1.3 µg g^{-1} dw (median: 0.39 µg g^{-1} dw) in muscle tissue and between 0.08 and 1.4 µg g^{-1} dw (median: 0.55 µg g^{-1} dw) in liver tissue. We found no correlation of accumulated mercury with length in eel. Liver tissue showed higher concentrations than muscle tissue. These findings were further considered with concentrations corrected for lipid content, excluding the fat compartment, which is known to hold a negligible portion of the total and methyl mercury concentrations. This resulted in the absence of a significant difference between muscle and liver concentrations. Finally, health risk analyses revealed that only frequent consumption of local eel (> 71 g day^{-1}) could pose risks to humans.

New paper. **Teunen, L., De Jonge, M., Malarvannan, G., Covaci, A., Belpaire, C., Focant, J.F., Blust, R., Bervoets, L. (2021c). Effect of abiotic factors and environmental concentrations on the bioaccumulation of persistent organic and inorganic compounds to freshwater fish and mussels.** ***Science of The Total Environment*****, *799*,149448. https://doi.org/10.1016/j.scitotenv.2021.149448.**

Many aquatic ecosystems are under persistent stress due to influxes of anthropogenic chemical pollutants. High concentrations can harm entire ecosystems and be toxic to humans. However, in case of highly hydrophobic compounds, their low water solubility precludes direct measurement in water, and thus alternative monitoring strategies are needed. In the present study, we investigated the extent to which bioaccumulated concentrations of persistent compounds can be predicted by concentrations in environmental compartments (water and sediment). Due to their high biomagnification potential, Hg and PFOS were included in this analysis as well. At 44 field locations in Flanders (Belgium), we monitored the concentrations of 11 priority compounds and their derivatives, included in the Water Framework Directive, in both sediment and water (where feasible) and European eel. Besides, some sediment (i.e. total organic carbon (TOC) and clay content) and water characteristics were measured (i.e. pH, oxygen level, conductivity, nitrate, nitrite and dissolved organic carbon (DOC)). Measurements of HCB, HCBD, cis-heptachlorepoxide, HBCD and PFOS in sediment and ∑PCB in water showed a lower detection frequency than in eel samples. While PCB profiles were comparable between all matrices, for PBDE clear differences were detected between sediment and eel profiles, with BDE99 contributing the most for sediment (34%) and BDE47 for fish (≥44%), followed by BDE100 (25%). Water concentrations for PFOS and benzo(a)pyrene were predictive of respective bioaccumulated concentrations. HCB, ∑PCB and ∑PBDE, concentrations in fish were dependent on sediment concentrations and negatively related to organic compound levels ($p<0.05$). Furthermore, pH and nitrite were negatively associated with accumulated concentrations in eel for HCB and PFOS, respectively ($p<0.05$). Strong relationships between bioaccumulation and sediment and/or water concentrations strengthened the basis for surrogate monitoring methods.

New paper. **Verhelst P, Reubens J., Buysse D., Goethals P., Van Wichelen J. , Moens T., 2021. Toward a roadmap for diadromous fish conservation: the Big Five considerations.** ***Front Ecol Environ*** **doi:10.1002/fee.2361.**

Increasing habitat fragmentation is a major contributing factor to dramatic reductions in populations of migratory species worldwide. Diadromous fish species in particular are affected by this anthropogenic disturbance, resulting in historically low population abundances. Despite a plethora of management measures and considerable investment, desired results are often lacking. Here, we highlight five important considerations –the "Big Five" –for diadromous species management: removal of barriers to migration, installation of fish passages, habitat restoration, restocking, and fisheries management. We review current management measures and their effectiveness, and propose a way forward. Current management of diadromous fish populations largely focuses on mitigation of migration barriers, but management will likely fail if other fundamental aspects of diadromous species' life cycles are overlooked or disregarded. We therefore propose an integrated management strategy that takes into account the five major factors influencing diadromous fish species, with the ultimate goal of restoring their populations.

<u>New paper.</u> **Capoccioni, F., Leone, C., Belpaire, C., Malarvannan, G., Poma, G., De Matteis, G., Tancioni, L., Contò, M., Failla, S., Covaci, A., Ciccotti, E., 2020. Quality assessment of escaping silver eel (Anguilla Anguilla L.) to support management and conservation strategies in Mediterranean coastal lagoons. Environ Monit Assess (2020) 192:570**

Silver eel samples, collected from the lagoons of Fogliano and Caprolace (Italy), were investigated for a broad range of contaminants (29 polychlorinated biphenyls, 9 polybrominated diphenyl ethers, 5 dichlorodiphenyltrichloroethane, 5 chlordanes, hexachlorobenzene, 3 hexachlorocyclohexane, and 5 metals). Concentrations of targeted compounds stand for a general low contamination pattern. Infestation by Anguillicola crassus and virus infections were also examined. No parasite infestation was found, while infected silver eels had a low prevalence for EVEX, and, for the first time in the Mediterranean area, for AngHV-1. Overall, a good quality status of escaping silver eels, for both lagoons, was highlighted by the use of integrative Indexes. A quality assessment of the ecological status of the two lagoons was carried out developing an expert judgment approach, in order to characterize the habitat of eel stocks.
A Final Pressure Index was derived, whose values showed an overall limited global anthropogenic impact acting on both lagoons. Results stand for the suitability of an integrated approach to assess lagoon habitats and eel local stocks quality. This could be proposed as a tool to identify sites yielding high quality eel spawners in the Mediterranean region, in order to set up suitable management frameworks, providing elements to appraise and discuss the potential of coastal lagoons in the Mediterranean region towards the recovery of the eel global stock.

<u>New paper.</u> **David Righton, Adam Piper, Kim Aarestrup, Elsa Amilhat, Claude Belpaire, John Casselman, Martin Castonguay, Estibaliz Díaz, Hendrik Dörner, Elisabeth Faliex, Eric Feunteun, Nobuto Fukuda, Reinhold Hanel, Celine Hanzen, Don Jellyman, Kenzo Kaifu, Kieran McCarthy, Michael J. Miller, Thomas Pratt, Pierre Sasal, Robert Schabetsberger, Hiromi Shiraishi, Gaël Simon, Niklas Sjöberg, Kristen Steele, Katsumi Tsukamoto, Alan Walker, Håkan Westerberg, Kazuki Yokouchi, Matthew Gollock, 2021. Important questions to progress science and sustainable management of anguillid eels. Fish and Fisheries. 2021; 22: 762– 788. https://doi.org/10.1111/faf.**

Anguillid eels are found globally in fresh, transitional and saline waters and have played an important role in human life for centuries. The population status of several species is now of significant concern. The threats to populations include direct exploitation at different life stages, blockages to migratory routes by dams and other structures, changes in river basin management that impact habitat carrying capacity and suitability, pollution, climate change, diseases and parasites. While much has been done to understand eel biology and ecology, a major challenge is to identify the key research and management questions so that effective and targeted studies can be designed to inform conservation, management and policy. We gathered 30 experts in the field of eel biology and management to review the current state of knowledge for anguillid eel species and to identify the main topics for research. The identified research topics fell into three themes: (a) Lifecycle and Biology; (b) Impacts and (c) Management. Although tropical anguillid eels are by far the least well understood, significant knowledge gaps exist for all species. Considerable progress has been made in the last 20 years, but the status of many species remains of great concern, particularly for northern temperate species. Without improved engagement and coordination at the regional, national and international level, the situation is unlikely to improve. Further, adaptive management mechanisms to respond to developments in science, policy and our knowledge of potential threats are required to ensure the future of these important and enigmatic species.

Ongoing or new projects

Meta-analysis on European silver eel migration (ongoing)

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

Pop-off data storage tags to reveal marine migration routes of European eel (ongoing, update of 2020 report)

The migration routes of European eel have mainly been deduced and studied in freshwater and estuarine systems, yet, their routes in marine environments remain elusive. Nonetheless, improving our knowledge on that front could reveal important aspects of the life cycle since the largest part of their migration is fulfilled in the marine environment. Tracking silver eels from the Southern North Sea into the Atlantic will expose how eels handle the dynamic hydrology of the English Channel. For instance, if eels apply selective tidal stream transport as they do in estuaries or already start with diel vertical migration. Data is obtained via the tagging of eels with pop-off data storage tags in the Veurne-Ambacht Canal (Nieuwpoort, Belgium) and the Rivers Elbe and Eider (Germany) with an additional two datasets from pop-off satellite archival tags from the River Eider. In Belgium, 238 eels have been tagged from 2018 to 2020. In Germany 82 eels were tagged in 2011 and 2012. This study is a collaboration between Ghent University (Belgium), Centre for Environment, Fisheries and Aquaculture Science (UK), Flanders Marine Institute (Belgium), the Research Institute for Nature and Forest (Belgium), Swedish University of Agricultural Sciences (Sweden), Institute of Inland Fisheries Potsdam Sacrow (Germany) and the Thünen Institute of Fisheries Ecology (Germany).

Silver eel migration from the Baltic Sea into the North Sea (ongoing, update of 2020 report)

DTU Denmark (Professor Kim Aarestrup and Dr Martin Lykke Kristensen) and Ghent University have tagged 70 silver eels with acoustic transmitters and pop-off data storage tags in 2019 and 40 in 2020 to identify the migration routes and behaviour of eels migrating from the Baltic Sea into the North Sea. Not only will the results illustrate how the eels change behaviour when moving from the relative shallow, hydrologically low-dynamic Baltic Sea into the deeper waters along the coast of southern Sweden and Norway, information may be revealed on the capture rate by commercial fishing. Additionally, since eels were single (either acoustic or pop-off data storage tag) or double tagged (acoustic and pop-off data storage tag) a comparative study can be conducted on the effect of external pop-off data storage tag attachment on the progression speed by the eels.

New upcoming research by INBO on migration potential of land-locked stocked eels

In many reservoirs like lakes and ponds, European eels have been stocked either unintentionally or intentionally, for instance for recreational fishing purposes. Since these reservoirs are not connected to rivers, eels are unable to migrate to the sea for spawning. In this study, we investigate if large eels from a reservoir still migrate to the sea when transported to an estuary. Therefore, we will tag and track the eels upon release into the Scheldt Estuary and the Belgian part of the North Sea using acoustic telemetry. If the eels would still migrate to the sea, this can obviously have repercussions for management such as the stimulation of a trap-and-transport system of land-locked eels to lotic, barrier-free systems. (Verelst *et al*).

7 References

Agentschap voor Natuur en Bos, 2013. Officieuze coördinatie van de visserijreglementering. 19 April 2013.

Agentschap voor Natuur en Bos, 2016. Enquête bij hengelaars op openbaar water. 11 april 2016. ANB-VF/2015/4. M.A.S. – Market Analysis & Synthesis, 63p.

Baeyens, R. &, I. S. Pauwels, D. Buysse, A. M. Mouton, I. Vergeynst, J. Papadopoulos, N. De Maerteleire, S. Pieters, E. Gelaude, K. Robberechts, P. Verhelst, L. Vermeersch, S., Vandamme, & J. Coeck, 2019. Monitoring van de effecten van de pompinstallatie en waterkrachtcentrale te Ham op het visbestand in het Albertkanaal. Brussels, Belgium.

Belpaire C., Verschelde P., Maes Y., Stevens M., Van Thuyne G., Breine J., Coeck J. (2015). Berekening van het ontsnappingspercentage van zilverpaling ten behoeve van de 2015 rapportage voor de Palingverordening. Rapporten van het Instituut voor Natuur- en Bosonderzoek 2015 (INBO.R.2015.9679951). Instituut voor Natuur- en Bosonderzoek, Brussel.

Belpaire C., Verschelde P., Maes Y., Van Thuyne G., Van Wichelen J., Buysse D., Breine J., Verreycken H. (2018). Berekening van het ontsnappingspercentage van zilverpaling ten behoeve van de 2018 rapportage voor de Palingverordening. Rapporten van het Instituut voor Natuur- en Bosonderzoek 2018 (65). Instituut voor Natuur- en Bosonderzoek, Brussel. DOI: doi.org/10.21436/inbor.14744967

Belpaire C., Verschelde P., Maes Y., Van Thuyne G., Van Wichelen J., Buysse D., Breine J., Verreycken H. (2021, in prep). Berekening van het ontsnappingspercentage van zilverpaling ten behoeve van de 2021 rapportage voor de Palingverordening. Rapporten van het Instituut voor Natuur- en Bosonderzoek, in prep.

Belpaire, C. 2002. Monitoring of glass eel recruitment in Belgium. In: Dekker W. (Ed.) Monitoring of glass eel recruitment. Netherlands Institute of Fisheries research, report C007/02-WD, Volume 2B, pp. 169–180.

Belpaire, C. 2006. Report on the eel stock and fishery in Belgium 2005. In FAO European Inland Fisheries Advisory Commission; International Council for the Exploration of the Sea. Report of the 2006 session of the Joint EIFAC/ICES Working Group on Eels. Rome, 23–27 January 2006. EIFAC Occasional Paper. No. 38, ICES CM 2006/ACFM:16. Rome, FAO/Copenhagen, ICES. 2006. 352p., 217–241.

Belpaire, C. and Coussement, M. 2000. Nota omtrent het uitzetten van paling in de Vlaamse openbare waters. [Note on the restocking of glass eel in Flandrian public waters]. Advice for the High Fisheries Council (March 20, 2000). Institute for Forestry and Game Management, Vlaamse Vereniging van Hengelsport Verbonden, IBW.Wb.V.ADV.2000.070 (in Dutch).

Belpaire, C., Adriaens, D., Breine, J., Buysse, D., Geeraerts, C., Ide, C., Lebel, A., Philippart, J.C., Stevens, M., Rollin, X., Vlietinck, K. 2011. Report on the eel stock and fishery in Belgium 2010/'11. 44 pages.

Belpaire, C., Breine, J., Buysse, D., Coeck, J., Pauwels, I., Schneiders, A., Van Wichelen, J., 2020a Advies over de toestand van de Europese paling in Vlaanderen. Advice INBO Brussels, INBO.A.4905

Belpaire, C., Breine, J., Buysse, D., Van Wichelen, J., Coeck, J., Ovidio, M., Nzau Matondo, B., De Meyer, J., Bouilliart, M., Adriaens, D., Verhelst, P., Roland, K., Kestemont, P., Bervoets, L., Darchambeau, F., Rollin, X., Vlietinck, K., 2016a. Report on the eel stock and fishery in Belgium 2014/'15. In: ICES. 2016. Report of the Joint EIFAAC/ICES/GFCM Working Group on Eel (WGEEL), 24 November–2 December 2015, Antalya, Turkey. ICES CM 2015/ACOM:18. 130 pp.

Belpaire, C., Breine, J., Van Wichelen, Nzau Matondo, B., Ovidio, M., Vergeynst, J., Verhelst, P., Teunen, L., Bervoets, L., Rollin, X., Vlietinck, K., 2019. Report on the eel stock, fishery and other impacts, in Belgium, 2019. In: ICES. 2019. Joint EIFAAC/ICES/GFCM Working Group on Eels (WGEEL). ICES Scientific Reports. 1:50. 177 pp. http://doi.org/10.17895/ices.pub.5545

Belpaire, C., Breine, J., Van Wichelen, Pauwels, I., Baeyens, R., Coeck, J., Nzau Matondo, B., Ovidio, M., Vergeynst, J., Verhelst, P., De Meyer, J., Adriaens, D., Teunen, L., Bervoets, L., Sony, D., Rollin, X., Dumonceau, F., Vlietinck, K., 2020b. Report on the eel stock, fishery and other impacts in Belgium, 2019-2020. In: ICES. 2020. Joint EIFAAC/ICES/GFCM Working Group on Eels (WGEEL). ICES Scientific Reports. 2:85.

Belpaire, C., Breine, J., Van Wichelen, Pauwels, I., Nzau Matondo, B., Ovidio, M., De Meyer, J., Vergeynst, J., Verhelst, P., Adriaens, D., Teunen, L., Bervoets, L., Rollin, X., Vlietinck, K., 2018. Report on the eel stock, fishery and other impacts, in: Belgium, 2018. In: ICES. 2018. Report of the Joint EIFAAC/ICES/GFCM Working Group on Eels (WGEEL), 5–12 September 2018, Gdańsk, Poland. ICES CM 2018/ACOM:15. 152 pp.

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

Belpaire, C., Van Thuyne, G., Breine, J., Buysse, D., Van Wichelen, J., Coeck, J., Ovidio, M., Nzau Matondo, B., De Meyer, J., Bouilliart, M., Adriaens, D., Verhelst, P., Rees J.F., Rollin, X., Vlietinck, K., 2016b. Report on the eel stock, fishery and other impacts, in: Belgium, 2016. In: ICES. 2016. Report of the Working Group on Eels (WGEEL), 15–22 September 2016, Cordoba, Spain. ICES CM 2016/ACOM:19. 107 pp.

Benitez, J.P., Dierckx, A., Nzau Matondo, B., Philippart, J.C., Mandiki, R., Erraud, A., Kestemont, P., Ovidio, M. (2019). Rapport final annuel 2019 au Service Public de Wallonie (DGARNE/DNF-SP) de la Subvention 2018-2019 relative au suivi scientifique de la réhabilitation du saumon atlantique dans le bassin de la Meuse. Université de Liège et Université de Namur, 159 pages.

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

Breine, J., L. Galle, I. Lambeens, Y. Maes, T. Terrie & G. Van Thuyne; (2019b). Opvolgen van het visbestand in het Zeeschelde-estuarium. Viscampagnes 2018. Rapporten van het Instituut voor Natuur- en Bosonderzoek 2019 (27). 81 pp.

Breine, J., L. Galle, I. Lambeens, Y. Maes, T. Terrie en G. Van Thuyne (2019a). Monitoring van de visgemeenschap in het Zeeschelde-estuarium. Ankerkuilcampagnes 2018. Rapporten van het Instituut voor Natuur- en Bosonderzoek 2019 (7). 68pp.

Breine, J., Van Thuyne, G., 2015. Opvolging van het visbestand in de Zeeschelde: Viscampagnes 2014. INBO.R.2015.6977363. Rapporten van het Instituut voor Natuur- en Bosonderzoek 2015. 65 pp.

Buysse, D., Mouton, A.M., Bayens, R., Coeck, J., 2015. Evaluation of downstream migration actions for eel at an Archimedes screw pump pumping station. Fisheries Management and Ecology 22, 286 – 294.

Buysse, D., Mouton, A.M., Stevens, M., Van den Neucker, T., Coeck, J., 2014. Mortality of European eel after downstream migration through two types of pumping stations. Fisheries Management and Ecology, 21, 13-21 online doi: 10.1111/fme.12046

Capoccioni, F., Leone, C., Belpaire, C., Malarvannan, G., Poma, G., De Matteis, G., Tancioni, L., Contò, M., Failla, S., Covaci, A., Ciccotti, E., 2020. Quality assessment of escaping silver eel (*Anguilla anguilla* L.) to support management and conservation strategies in Mediterranean coastal lagoons. Environ Monit Assess (2020) 192:570

de Canet, L., Briand, C., Beaulaton, L., Roland, K., Kestemont, P., 2014. Eel density analysis (EDA 2.0), Silver eel (*Anguilla anguilla*) escapement in the Meuse basin (DRAFT). Draft Report Université de Namur, EPTB-Vilaine, ONEMA.

Eel Management Plan for Belgium 2009. 172 pages.

Nzau Matondo B., Ovidio M. (2018). Decreased stock entering the Belgian Meuse is associated with the loss of colonisation behaviour in yellow-phase European eels. *Aquatic Living Resources* 2018, 31, 7. https://doi.org/10.1051/alr/2017047

Nzau Matondo, B., Benitez, J. P., Dierckx, A., Rollin, X., Ovidio, M., 2020. An evaluation of restocking practice and demographic stock assessment methods for cryptic juvenile European eel in upland rivers. Sustainibility 12, 1124; DOI : 10.3390/su12031124.

Nzau Matondo, B., Benitez, J.P., Dierckx, A., Renardy, S., Rollin, X., Colson, D., Baltus, L., Romain, V.R.M., Ovidio, M., 2021. What are the best upland river characteristics for glass eel restocking practice? Science of the Total Environment 784 (2021) 147042. https://doi.org/10.1016/j.scitotenv.2021.147042.

Nzau Matondo, B., Benitez, J-P., Dierckx, A., Philippart, J-C., Ovidio, M., 2014. Arrival of European eel in Belgian part of the Meuse: who and how are they? Proceedings of the 10th International Conference on Ecohydraulics, Trondheim, Norway http://hdl.handle.net/2268/170392

Nzau Matondo, B., J. P. Benitez, A. Dierckx, J. C. Philippart, M. Ovidio, 2017. Assessment of the entering stock, migration dynamics and fish pass fidelity of European eel in the Belgian Meuse River. River Res. Applic. 33:292-301. DOI: 10.1002/rra

Nzau Matondo, B., Ovidio, M., 2016. Dynamics of upstream movements of the European eel *Anguilla anguilla* in an inland area of the River Meuse over the last 20 years Environ Biol Fish (2016) 99:223–235 DOI 10.1007/s10641-016-0469-x

Nzau Matondo, B., Philippart, J.C., Dierckx, A., Benitez, J.P, Rimbaud, G. & Ovidio, M. 2015. Estimation de l'abondance du stock des anguilles recrutées par migration de remontée dans la Meuse en Wallonie et réalisation des essais de repeuplement en juvéniles. Rapport final du projet financé par le Fonds européen pour la Pêche (Code projet: 32-1102-002) et Service Public de Wallonie, Département de la Nature et des Forêts. Laboratoire de Démographie des Poissons et d'Hydroécologie de l'Université de Liège, 135 pages.

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.

Ovidio, M., Tarrago-Bès, F., Nzau Matondo, B., 2015. Short-term responses of glass eels transported from UK to small Belgian streams. Ann. Limnol. - Int. J. Lim. 51:219-226. DOI : 10.1051/limn/2015016

Pauwels, I. S., R. Baeyens, G. Toming, M. Schneider, D. Buysse, J. Coeck, & J. A. Tuhtan, (n.d.). Multi-species assessment of injury, mortality and physical conditions during downstream passage through a large Archimedes hydrodynamic screw (Albert canal, Belgium). Sustainability .

Pauwels, I., Van Wichelen, J., Vandamme, L., Vught, I., Van Thuyne, G., Auwerx, J., Baeyens, R., De Marteleire, N., Gelaude, E., Picavet, B., Pieters, S., Robberechts, K., Belpaire, C., Coeck, J. (2016). Wetenschappelijke onderbouwing en ondersteuning van het visserijbeleid en het visstandbeheer - onderzoeksprogramma visserij 2015: eindrapport. Rapporten van het Instituut voor Natuur- en Bosonderzoek 2016. Instituut voor Natuur- en Bosonderzoek, Brussel.

Philippart, J.C., Rimbaud G., 2005 L'efficacité de la nouvelle grande échelle à poissons du barrage de Visé-Lixhe sur la Meuse. Eléments du suivi scientifique 1999–2004. [Efficiency of the new large fish pass at the Visé-Lixhe dam on the river Meuse. Follow-up 1999–2004]. Draft report: 50 years of Fonds Piscicole.

Philippart, J-C., 2006. *L'érosion de la biodiversité: les poissons*. Dossier Scientifique réalisé dans le cadre de l'élaboration du rapport analytique 2006–2007 sur l'état de l'environnement Wallon. Université de Liège. 306 pp.

Righton, David, Adam Piper, Kim Aarestrup, Elsa Amilhat, Claude Belpaire, John Casselman, Martin Castonguay, Estibaliz Díaz, Hendrik Dörner, Elisabeth Faliex, Eric Feunteun, Nobuto Fukuda, Reinhold Hanel, Celine Hanzen, Don Jellyman, Kenzo Kaifu, Kieran McCarthy, Michael J. Miller, Thomas Pratt, Pierre Sasal, Robert Schabetsberger, Hiromi Shiraishi, Gaël Simon, Niklas Sjöberg, Kristen Steele, Katsumi Tsukamoto, Alan Walker, Håkan Westerberg, Kazuki Yokouchi, Matthew Gollock,

2021. Important questions to progress science and sustainable management of anguillid eels. Fish and Fisheries. 2021; 22: 762– 788. https://doi.org/10.1111/faf.

Rollin, X., Graeven, C., 2016. Bilan du Plan Police Pêche en Wallonie : Période 2010-2015. Rapport interne du Département Nature et Forêt, DGO3, Service Public de Wallonie, 18 p.

Stevens M., Coeck M., 2013. Berekening van het ontsnappingspercentage van zilverpaling in Vlaanderen. Wetenschappelijke ondersteuning voor de eerste rapportering over de opvolging van het palingbeheerplan. Rapporten van het Instituut voor Natuur- en Bosonderzoek 2013 (18). Instituut voor Natuur- en Bosonderzoek, Brussel.

Teichert, N.; Tétard, S.; Trancart, T. ; Feunteun, E. ; Acou, A. ; De Oliveira, E. 2020. Resolving the trade-off between silver eel escapement and hydropower generation with simple decision rules for turbine shutdown. *Journal of Environmental Management* **261**, 110212.

Teunen L., Belpaire C., Dardenne F., Blust R., Covaci A. en Bervoets L. 2020. Veldstudies naar monitoring van biota in het kader van de rapportage van de chemische toestand voor de Kaderrichtlijn Water 2015-2018 (algemene trends en relaties). Universiteit Antwerpen (UA) in samenwerking met het Instituut voor Natuur- en Bosonderzoek (INBO), in opdracht van de Vlaamse Milieumaatschappij (VMM). Antwerpen, België, 99 blz.

Teunen, L., Belpaire, C., De Boeck, G., Blust, R., Bervoets, L. (2021b). Mercury accumulation in muscle and liver tissue and human health risk assessment of two resident freshwater fish species in Flanders (Belgium): a multilocation approach. *Environ Sci Pollut Res*. https://doi.org/10.1007/s11356-021-16215-0

Teunen, L., Bervoets, L., Belpaire, C., De Jonge, M., Groffen, T. (2021a) PFAS accumulation in indigenous and translocated aquatic organisms from Belgium, with translation to human and ecological health risk. *Environ Sci Eur 33*, 39. https://doi.org/10.1186/s12302-021-00477-z

Teunen, L., De Jonge, M., Malarvannan, G., Covaci, A., Belpaire, C., Focant, J.F., Blust, R., Bervoets, L. (2021c). Effect of abiotic factors and environmental concentrations on the bioaccumulation of persistent organic and inorganic compounds to freshwater fish and mussels. *Science of The Total Environment*, *799*,149448. https://doi.org/10.1016/j.scitotenv.2021.149448.

Van Den Berge K., Belpaire C., Maes D., Van Thuyne G., Gouwy J., Geeraerts C., Pauwels I., De Bruyn L., Vandamme L. (2019). Onderzoek naar habitatkwaliteit voor de otter in België; Potentieel leefgebied voor de otter in Vlaanderen. Rapporten van het Instituut voor Natuur- en Bosonderzoek 2019 (58). Instituut voor Natuur- en Bosonderzoek, Brussel. DOI: doi.org/10.21436/inbor.17664371

Van Wichelen J., Verhelst P., Buysse D., Belpaire C., Vlietinck K., Coeck J., 2021. Glass eel (*Anguilla anguilla* L.) behaviour after artificial intake by adjusted tidal barrage management. Estuarine, Coastal and Shelf Science 249 (2021) 107127

Vandamme L., Belpaire C., Gelaude E., Gouwy J., Robberechts K., Van Thuyne G., Galle L., Maes Y., Lambeens I., Terrie T., Breine J., Bervoets L., Teunen L., Malarvannan G., Covaci A., Van Den Berge K. (2019). Onderzoek naar potentieel habitat voor de otter in de Benedenschelde; 2019. Habitatkwaliteit en knelpunten gedetailleerd in kaart. Rapporten van het Instituut voor Natuur- en Bosonderzoek 2019 (59). Instituut voor Natuur- en Bosonderzoek, Brussel. DOI: doi.org/10.21436/inbor.17665371

Vergeynst, J., I. Pauwels, R. Baeyens, A. Mouton, T. De Mulder, & I. Nopens, 2020. Shipping canals on the downstream migration route of European eel (Anguilla anguilla): Opportunity or bottleneck?. Ecology of Freshwater Fish 1–15.

Vergeynst, J., I. Pauwels, R. Baeyens, J. Coeck, I. Nopens, T. De Mulder, & A. Mouton, 2019. The impact of intermediate-head navigation locks on downstream fish passage. River Research and Applications 35: 224–235.

Verhelst P, Reubens J., Buysse D., Goethals P., Van Wichelen J. , Moens T., 2021. Toward a roadmap for diadromous fish conservation: the Big Five considerations. *Front Ecol Environ* doi:10.1002/fee.2361.

Verhelst, P., Baeyens, R., Reubens, J., Benitez, J.-P., Coeck, J., Goethals, P., Ovidio, M., Vergeynst, J., Moens, T., Mouton, A., 2018. European silver eel (*Anguilla anguilla* L.) migration behaviour in a highly regulated shipping canal. Fisheries Research 206, 176 – 184.

Verhelst, P., Bruneel, S., Reubens, J., Coeck, J., Goethals, P., Oldoni, D., Moens, T., Mouton, A., 2018. Selective tidal stream transport in silver European eel (*Anguilla anguilla* L.) – Migration behaviour in a dynamic estuary. Estuarine, Coastal and Shelf Science 213, 260–268.

Verhelst, P., Buysse, D., Reubens, J., Pauwels, I., Aelterman, B., Van Hoey, S., Goethals, P., Coeck, J., Moens, T., Mouton, A., 2018a. Downstream Migration of European Eel (*Anguilla anguilla* L.) in an Anthropogenically Regulated Freshwater System : Implications for Management. Fisheries Research 199: 252–262.

Verhelst, P., R. Baeyens, J. Reubens, J. P. Benitez, J. Coeck, P. Goethals, M. Ovidio, J. Vergeynst, T. Moens, & A. Mouton, 2018. European silver eel (Anguilla anguilla L.) migration behaviour in a highly regulated shipping canal. Fisheries Research Elsevier 206: 176–184, https://doi.org/10.1016/j.fishres.2018.05.013.

Vlietinck, K. et al., 2012. Nature and Forest Agency, Groupe de travail pour l'anguille européenne coordonné par le Service de la pêche du Service public de Wallonie. Council Regulation (EC) No 1100/2007 of 18 September 2007 establishing measures for the recovery of the stock of European eel. Eel Management Plan for Belgium. First report to be submitted in line with Article 9 of the eel Regulation 1100/2007. June 2012.

Vlietinck, K., Rollin, X., 2015. Council Regulation (EC) No 1100/2007 of 18 September 2007 establishing measures for the recovery of the stock of European eel. Eel Management Plan for Belgium. Second report to be submitted in line with Article 9 of the eel Regulation 1100/2007. Nature and Forest Agency, Nature and Forest Department (SPW). June 2015.

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

Denmark

2020/2021

Note to the reader - this document accompanies a series of spreadsheet tables that provide the bulk of the data in a format most suitable for the working practices of the WGEEL. Summaries of these data are provided in this document.

Authors

Michael Ingemann Pedersen, Technical University of Denmark, National Institute of Aquatic Resources, DTU-Aqua, Vejlsøvej 39, DK-8600 Silkeborg, Denmark. Direct +45 89213128

mip@aqua.dtu.dk

Martin Lykke Kristensen, Technical University of Denmark, National Institute of Aquatic Resources, DTU-Aqua, Vejlsøvej 39, DK-8600 Silkeborg, Denmark. +45 89213100

makri@aqua.dtu.dk

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Table of Contents

1 Summary of national and international stock status indicators

1.1 Escapement, biomass and mortality rates

Year	EMU_code	Assessed Area (ha)	B_0 (kg)	B_{curr} (kg)	B_{best} (kg)	Bcurr/B_0 (%)	∑A	∑F	∑H
2020	Dk_inla	60.000	1.110.000	122.300	144.700	11.0	0.168	0.101	0.005

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, was 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.

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 is available during several year but the trap was in operation again in 2019 and 2020.

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 DENSITY EEL/M^2		YEAR	TANGE	HARTE	VESTER VEDSTED BROOK DENSITY EEL/M^2		YEAR	TANGE	HARTE	VESTER VEDSTED BROOK DENSITY EEL/M^2	
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	Na	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	97	1350	0.5	0.6
1982	257	239	-	-	2001	239	11	0.6	0.8	2020	28,8	1,4	0,2	0,3
1983	146	164	-	-	2002	278	17	0.5	0.6	2021	NA	NA	0,3	0,5
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. This trap was established as 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 in the lake. 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.

Year	Number
2011	638
2012	162
2013	804
2014	87
2015	1380
2016	1793
2017	782
2018	1094
2019	2650
2020	1132

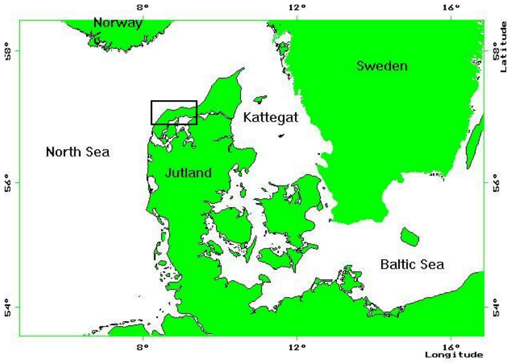
Table 1.2.3 Ascending elvers measured in Hellebaekken.

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 EU Water Frame Directive. Monitoring young eel recruitment the traditionally way, using eel pass traps, has become 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 or three 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.



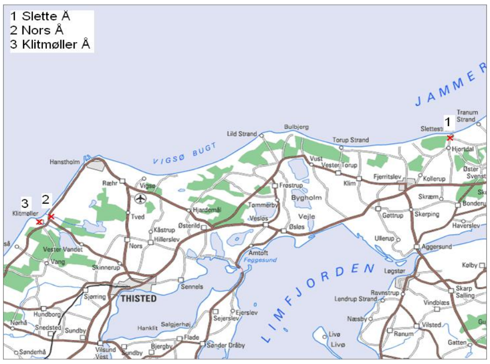
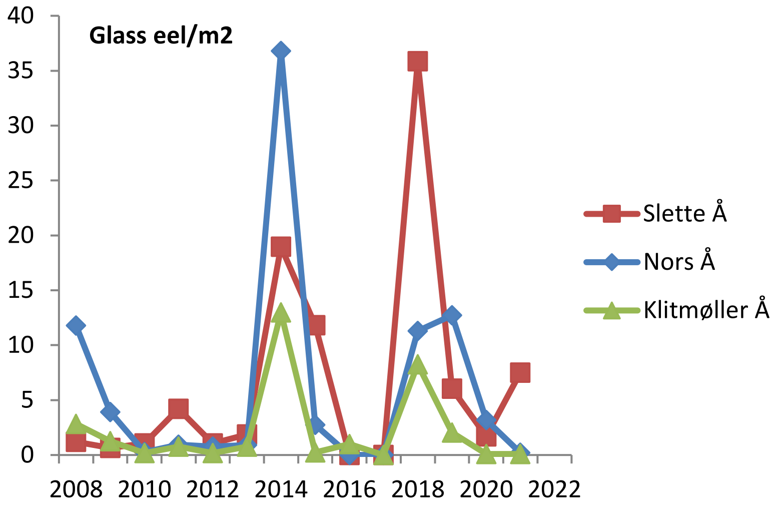


Figure 1.2.2 Map with glass eel monitoring sites (1, 2 and 3) in the North Sea.

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
2020	1.7	2.1	3.2	3.8	0.1	0.3
2021	7.5	9.7	0.2	0.5	0.1	0.1

Figure 1.2.3 Monitoring data. 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.



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 fyke nets or six hook lines but in a reduced period of the year. Fishing is closed from the 10th of May to 31. 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 month (1.aug and 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 3 month closing period for commercial and recreational eel fisheries. The closing period will be from 1. Dec 2020 until 1. Marts 2021.

2.2 Significant changes since last report

There are no significant changes in eel management since the last country report.

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)

3.1.4 Silver eel fisheries

3.3 Silver eel landings

3.3.1 Commercial

Data on separate landings of yellow and silver eel in fresh and salt water are given below. Data origin is landing reports by commercial fishers reported to the ministry. From medio 2009 landings was 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	**1981**	-	-	140	**2002**	5	27	27
1961	-	-	235	**1982**	-	-	163	**2003**	2	21	24
1962	-	-	215	**1983**	-	-	116	**2004**	4	12	15
1963	-	-	238	**1984**	-	-	126	**2005**	3	10	14
1964	-	-	223	**1985**	-	-	111	**2006**	7	8	14
1965	-	-	205	**1986**	-	-	120	**2007**	5	6	11
1966	-	-	211	**1987**	-	-	90	**2008**	5	4	9
1967	-	-	243	**1988**	-	-	119	**2009**	8	5	13
1968	-	-	258	**1989**	-	-	114	**2010**	10	3	13
1969	-	-	254	**1990**	-	-	107	**2011**	11	4	15
1970	-	-	249	**1991**	-	-	99	**2012**	9	4	13
1971	-	-	183	**1992**	-	-	109	**2013**	10	3	13
1972	-	-	200	**1993**	-	-	57	**2014**	12	3	15
1973	-	-	201	**1994**	-	-	60	**2015**	9	6	15
1974	-	-	163	**1995**	-	-	52	**2016**	10	3	13
1975	-	-	260	**1996**	-	-	34	**2017**	12	5	16
1976	-	-	178	**1997**	-	-	39	**2018**	6.5	5	11.5
1977	-	-	179	**1998**	-	-	40	**2019**	5.9	4.0	9.9
1978	-	-	157	**1999**	-	-	30	**2020**	3.6	1.6	5.4
1979	-	-	78	**2000**	4	24	28	**2021**	Na	Na	Na
1980	-	-	147	**2001**	2	34	36	**2020**			

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	**1981**	897	1190	1947	**2002**	365	217	555

Year	Silver	Yellow	Total	Year	Silver	Yellow	Total	Year	Silver	Yellow	Total
1961	2098	1777	3640	**1982**	1003	1375	2215	**2003**	437	188	601
1962	2132	1775	3692	**1983**	884	1119	1887	**2004**	343	187	516
1963	1837	2091	3690	**1984**	830	915	1619	**2005**	372	149	506
1964	1417	1865	3059	**1985**	793	726	1408	**2006**	427	154	567
1965	1498	1699	2992	**1986**	818	734	1432	**2007**	411	115	515
1966	1829	1861	3479	**1987**	538	651	1099	**2008**	364	93	448
1967	1673	1763	3193	**1988**	799	960	1640	**2009**	367	87	454
1968	2063	2155	3960	**1989**	785	797	1468	**2010**	304	105	409
1969	1552	2072	3370	**1990**	834	734	1461	**2011**	271	84	355
1970	1470	1839	3060	**1991**	724	642	1267	**2012**	226	78	304
1971	1490	1705	3012	**1992**	687	655	1233	**2013**	243	100	343
1972	1662	1567	3029	**1993**	523	500	966	**2014**	251	80	331
1973	1697	1758	3254	**1994**	509	631	1080	**2015**	202	65	267
1974	1378	1436	2651	**1995**	408	432	788	**2016**	178	74	251
1975	1534	1691	2965	**1996**	381	336.5	684	**2017**	170	70	240
1976	1477	1399	2698	**1997**	375	383	719	**2018**	88	82	170
1977	1141	1182	2144	**1998**	306	251	517	**2019**	95	79	173
1978	1187	1148	2178	**1999**	380	307	657	**2020**	101	76	177
1979	887	939	1748	**2000**	382	218	572	**2021**	Na	Na	Na
1980	911	1230	1994	**2001**	446	225	635	**2022**			

3.3.2 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 Table 3.3.2.1 is 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 fishers from both the marine and fresh water. The data should be treated with care and it is believed especially the freshwater catch may be biased.

Tabel 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
2019	8.5	101.5	110.0
2020	8.0	90.9	98.9

3.2 Restocking

In 2021 a total of 1,238,700 2-5 gram eels were stocked. In freshwater 908,700 eel and in marine waters 330,000 were stocked (Table 3.5.1 below). The stocked eels are foreign source glass eel imported from France, England or 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 fresh waters from 1987–2021. 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	**2005**	0.24	0.06	0	0.3
1988	0.11	0.24	0.4	0.75	**2006**	1.15	0.35	0.1	1.6
1989	0	0.24	0.17	0.42	**2007**	0.59	0.21	0.02	0.83

1990	2.46	0.49	0.51	3.47	**2008**	0.52	0.19	0.04	0.75
1991	2.3	0.44	0.32	3.06	**2009**	0.55	0.20	0.05	0.81
1992	2.94	0.81	0.11	3.86	**2010**	0.30	0.57	0.67	1.55
1993	2.97	0.76	0.23	3.96	**2011**	0.20	0.77	0.59	1.56
1994	6.12	0.61	0.67	7.4	**2012**	0.25	0.64	0.64	1.53
1995	6.83	0.72	0.9	8.44	**2013**	0.25	0.66	0.61	1.52
1996	3.58	0.58	0.44	4.6	**2014**	0.26	0.71	0.63	1.60
1997	2.02	0.29	0.22	2.53	**2015**	0.13	0.79	0.61	1.53
1998	2.35	0.53	0.1	2.98	**2016**	0.13	0.69	0.71	1.53
1999	3.38	0.56	0.18	4.12	**2017**	0.13	0.69	0.71	1.52
2000	3.02	0.55	0.25	3.83	**2018**	0.13	0.67	0.31	1.11
2001	1.2	0.38	0.12	1.7	**2019**	0.18	0.88	0.75	1.81
2002	1.66	0.47	0.3	2.43	**2020**	0.15	0.56	0.64	1.34
2003	1.54	0.49	0.22	2.24	**2021**	0.33	0.52	0.38	1.23
2004	0.52	0.18	0.06	0.75					

3.3 Aquaculture

Aquaculture production of eel in Denmark started in 1984. The production takes currently 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.

Table. 3.3.1. Annual aquaculture eel production.

	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	2007	9	1617
1989	40	430	2008	9	1740
1990	47	586	2009	9	1707

1991	43	866	2010	9	1537
1992	41	748	2011	8	1156
1993	35	782	2012	8	1093
1994	30	1034	2013	8	824
1995	29	1324	2014	6	842
1996	28	1568	2015	5	1234
1997	30	1913	2016	5	1072
1998	28	2483	2017	3	561
1999	27	2718	2018	3	455
2000	25	2674	2019	3	490
2005	9	1700	2020	3	659
2006	9	1900	2021	3	NA

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

2020	Kg	Number
Imported glass eel	1.013	2.525.000
Stocking in Dk or abroad	19.301	1.106.000
Large eel consumption	599.379	
Large eel export	7.000	
Dead biomass	33.600	
Total production	659.280	

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 kg. 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 3-8 month and eel for consumption is 18 month or more.

3.4 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 capasity of hydroelectric power units at present.

We have measured a loss of silver eel between 0 and 58 % at two particular hydro power plants. Measured using telemetry. 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 work 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 yaers and the eels by pass the screens that were supposed to prevent eels and other species to nenter the 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 10 have systems for recirculation of water. To prevent fish from entering the trout farms a screen with a max. 6 mm bar distance is obligatory at the point of the water inflow and a max. 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 6mm 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).

3.5 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 on quantity and quality is available since 2006.

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

3.6 Other impacts

Covid-19 affected the number of eel stocked this year see section restocking section 3.2.

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 was used (Bohlin et al. 1989) 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 index river systems are used to calculate the total silver eel escapement from the Danish freshwater territory. The count was repeated every third year. 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.

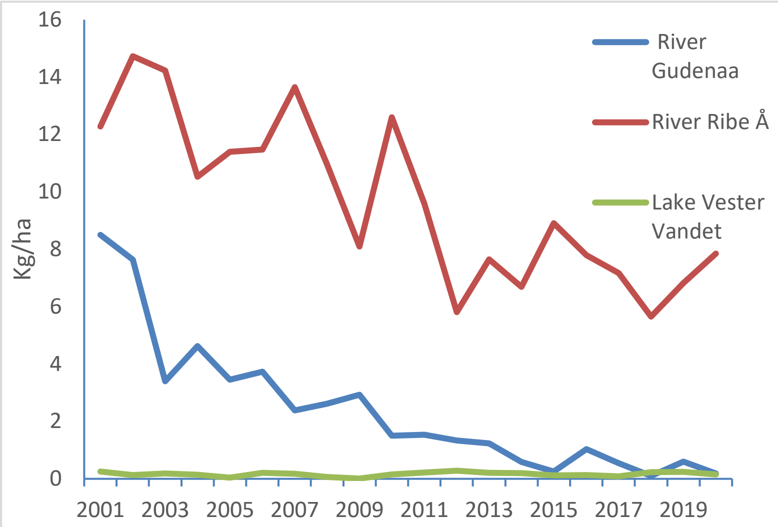


Figure 4.2: The production of silver eel (kg/ha) from three index systems from 2001-2020.

5 Other data collection

5.1 Recruitment time series

Glass eel surveys are described in 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 & Pathogens

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 1987–2018 at all three locations.

Table 11.2. Anguillicola monitoring data.

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 analyzing 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.

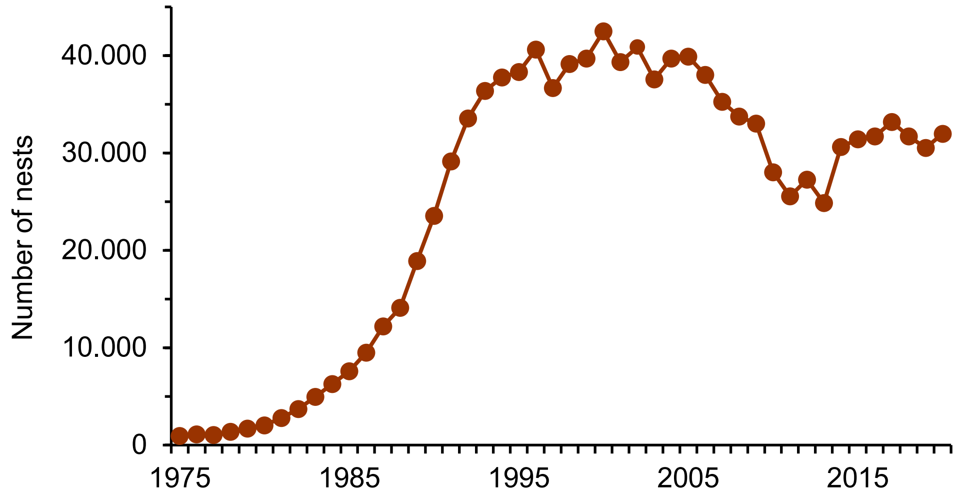


Figure 5.6. Number of cormorant nests in Denmark 1971–2017. Data from NERI. University of Århus.

6 New Information

New studies - DK

In August 2019, DTU Aqua initiated a study with acoustic telemetry that will

1. Investigate silver eel migration behaviour and determine when and where out migrating eels leave the Baltic Sea.
2. Estimate the efficiency of coastal based commercial silver eel fisheries in Denmark.

For the study, silver eels were tagged with an acoustic tag that emits a unique ID. The study attempts to have full acoustic receiver coverage at transects across the exits from the Baltic Sea (Fig. X) to see when and where each individual eel leaves the Baltic Sea. To investigate the efficiency of commercial fisheries, receivers have also been mounted at four commercial fisheries located close to the receiver transects. This enables the study to estimate the proportion of acoustically tagged eels caught by the fishermen versus the proportion that are detected at the receiver transects and considered to have escaped the Baltic Sea.

The study has been joined by research institutions from Sweden (SLU Aqua), Estonia (Estonian University of Life Sciences), Germany (Thünen-Institute), Belgium (Ghent University), Lithuania (Lithuanian Nature Research Centre), Finland (Luke Natural Resources Institute) and Latvia (Institute of Food Safety, Animal Health and Environment). The research institutes contribute to the study with tags, eels and/or receivers. A total of 860 silver eels have been or will be tagged throughout the Baltic region during 2019-2021, and the majority of these eels are expected to be included in the study. The different research institutes will also use the generated data from the tagged eels to assess a number of other hypothesis.

DTU Aqua is working on making the receiver transects in the belts and sounds permanent, which will allow future research on eel migration behaviour to use this infrastructure.

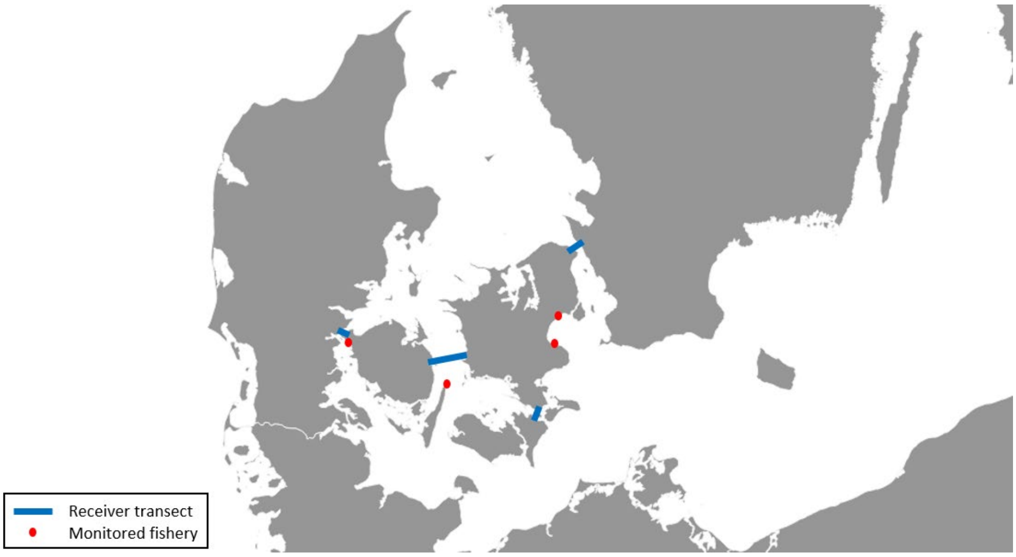


Figure X. Location of receiver transects (blue lines) and monitored fisheries (red dots) in the Danish belts and sounds.

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 fresh water, 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. & G. H. Rasmussen 2018. Fisheries regulation on European eel (*Anguilla anguilla*) for 2018; how big is the effect? Journal of fisheries Research. Vol 2 p 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.

7 References:

Danish EMP (2008). Danish Eel Management Plan December 2008. In accordance with COUNCIL REGULATION (EC) No 1100/2007 of 18 September 2007.

Hald, P. (2007). Skarvernes Fødevalg ved Hirsholmene i årene 2001-2003. http://www.sns.dk/publikat/2001/hirsholmen_skarv_2001_2003.pdf

Jepsen, N.• R. Klenke, P • Sonnesen, T. Bregnballe (2010). The use of coded wire tags to estimate cormorant predation on fish stocks in an estuary. Marine end freshwater Research. Volume 61, Issue 3, pp. 320-329.

Pedersen M.I. (2002). Monitoring of glass eel recruitment in Denmark. In: Dekker W. (ed) 2002, Monitoring of glass eel recruitment. Netherlands Institute of Fisheries Research, report C007/02-WD, 256 pp. ISBN 90-74549-06-3

Pedersen, M.I., J.S. Mikkelsen (2011). Udvandring af blankål fra Ribe Å i 2010. DTU Aqua-rapport nr. 241-2011, 10 p.

Pedersen M. I., N. Jepsen, K. Aarestrup, A. Koed, S. Pedersen and F. Økland (2011). Loss of European silver eel passing a hydropower station. J. Appl. Ichthyol. 28, 189-193.

Pedersen M. I., N. Jepsen (2012). Passage for ål ved dambrug og kraftværk i Gudenåen og Kongeåen. DTU Aqua-rapport nr. 259-2012

Pedersen, M. I., Rasmussen, G.H., (2015). Yield per recruit from two different sizes of stocked eel (*Anguilla anguilla*) in brackish Roskilde Fjord. ICES Journal of Marine Science 73: 158-164.

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.

Sonnesen, P. (2007). Skarvens prædation omkring Ringkøbing Fjord – en undersøgelse af sammenhænge mellem fødevalg og fiskebestandenes sammensætning. DTU Aqua Specialerapport pp. 76 + bilag.

Sparrevohn C. R. og M. Storr-Paulsen (2010). DTU Aqua-rapport nr. 217-2010. Åle- og torskefangst ved rekreativt fiskeri i Danmark.

Contents

i Report on the eel stock, fishery and other impacts in Estonia, 2020–2021

Authors

Priit Bernotas*, Paul Teesalu, Maidu Silm

Estonian University of Life Sciences, Chair of Hydrobiology and Fisheries

pbernotas@emu.ee, paul.teesalu@emu.ee, maidu.silm@emu.ee

+37256501622*

Reporting Period: This report was completed in September 2021, and contains data up to 2020

1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

In 2020 the Bcurr/B_0 value stayed similar to previous year due to new data being included to ∑F calculation (Table 1). In 2019-2020 a telemetry study was carried out within EE_Narv freshwater system which indicates additional fishing pressure on both yellow- and silver eels which are moving outside of the original waterbodies of restocking. This includes also recreational fisheries. It has to be kept in mind that true fishing mortality is probably higher due to under-reporting 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 and ∑A values for previous periods probably higher.

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	1887800	90000	86563	101839	96	0.05	**0.12**	0.16
2017	EE_Narv	1887800	90000	64681	77001	72	0.06	**0.12**	0.18
2018	EE_Narv	1887800	90000	52341	64547	58	0.09	**0.12**	0.21
2019	EE_Narv	1887800	90000	65779	82658	73	0.08	**0.12**	0.20
2020	EE_Narv	1887800	**90000**	**66952**	**93616**	**74**	**0.16**	**0.12**	**0.28**
2016	EE_West	3650000	x	x	x	x	x	x	x
2017	EE_West	3650000	x	x	x	x	x	x	x
2018	EE_West	3650000	x	x	x	x	x	x	x
2019	EE_West	3650000	x	x	x	x	x	x	x
2020	EE_West	3650000	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 fyke nets 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 fyke nets in the coastal fisheries has been reduced by 50%.

Commerical eel fisheries in Estonia are roughly divided in two:

1. Freshwater eel fishery (10-35 t/year, 2006-2020) – 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, 2006-2020) – occurs in the coastal waters of Estonia. Eel is not targeted by the fishery and mostly registered as bycatch in fyke nets. Eels both of natural and restocked origin are being fished.

Long lines 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.

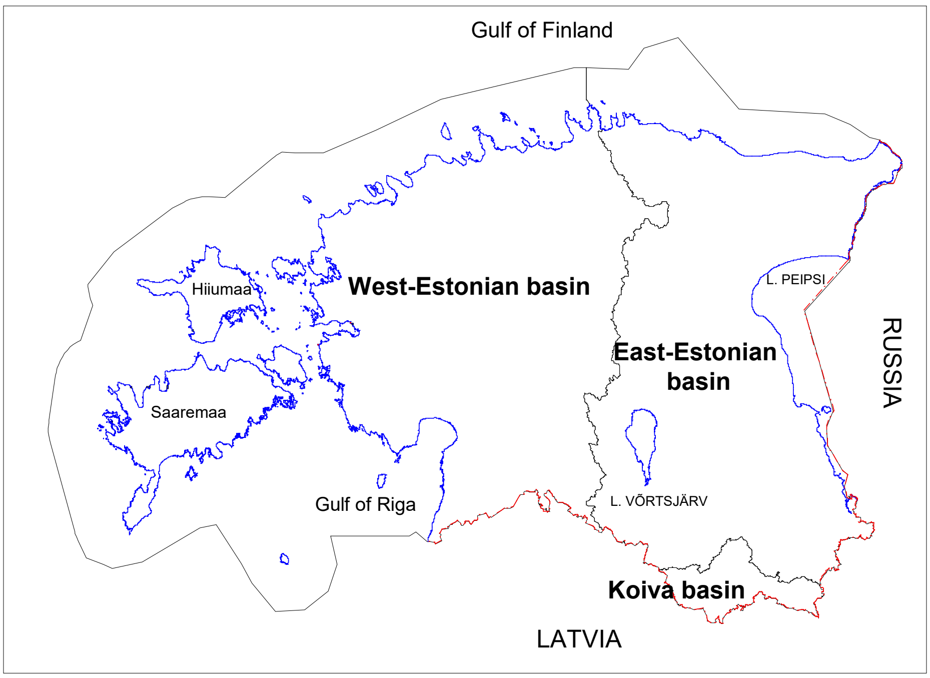


Figure 1. Map of basins. Note that East-Estonian basin and West-Estonian basin correspond to Narva RBD and West-Estonian RBD according to Estonian Eel Management Plan.

According to ordinance of government (RT I 2004, 48, 339) and Water Framework Directive the territory of Estonia is divided into 3 basins (Figure 1) and 9 sub-basins. Basins and sub-basins 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 ∑F and ∑A. See paragraphs 1.1 and 4.2 for details.

3 Impacts on the national stock

3.1 Fisheries

The total capacity of the coastal fishery in 2020 was 1117 commercial fishermen/companies. 128 commercial fishermen/companies of the coastal fishery reported eel (average catch per fisherman/company = 11.9 kg/year; CPUE per gear/night = 0.1 kg) in their catch in 2020. The total capacity of the freshwater fishery in 2020 was 359 commercial fishermen/companies. 85 commercial fishermen/companies of the freshwater fishery reported eel in their catch. In the freshwater fishery 96% (35.8 t) of the eel was caught from Lake Võrtsjärv by 48 fishermen/companies (averaging 745.1 kg per company/fisherman, CPUE per gear/night = 0.8 kg). This information is collected by the Estonian Ministry of Rural Affairs. Register is updated every year and available online at https://pta.agri.ee/ettevotjale-tootjale-ja-turustajale/kutseline-kalapuuk/puugiload-ja-voimalused and https://pta.agri.ee/ettevotjale-tootjale-ja-turustajale/kutseline-kalapuuk/puugi-statistika (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.

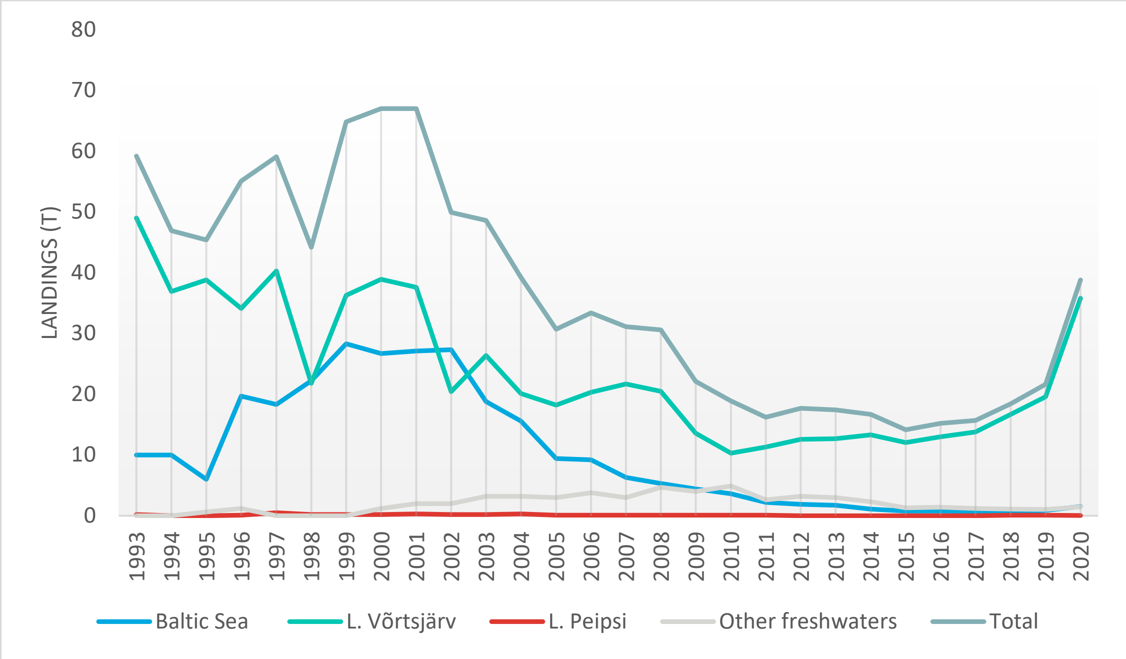


Figure 2. Eel landings (tons) in different water bodies of Estonia in the period 1993-2020.

Table 2. Eel landings (tons) in different water bodies of Estonia in the period 1993-2020 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
2019	0.9	19.6	0.1	1.0	21.6	96
2020	1.5	35.8	0.04	1.45	38.79	96

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 is available.

Long lines 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 2005-2020 is brought out in Figure 3. 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.

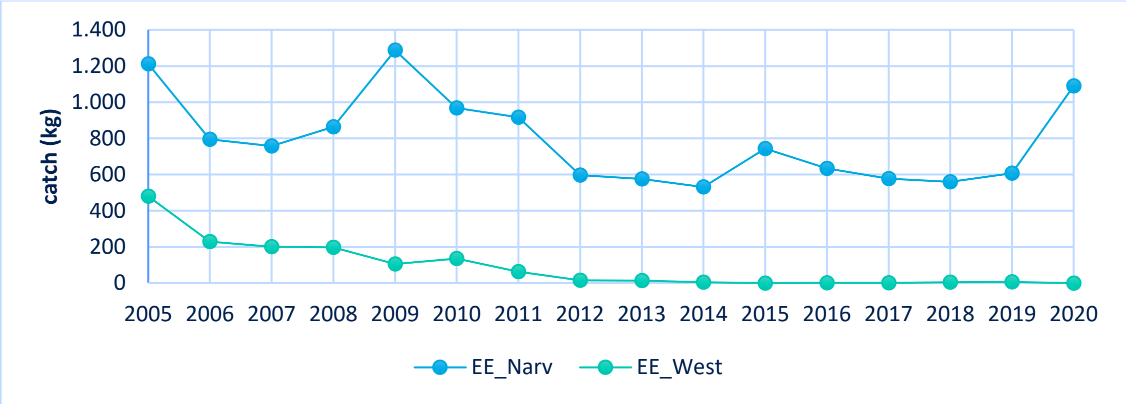


Figure 3. Recreational catch during period 2005-2020 in the Estonian Eel Management Units.

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 2020 2.03 million glass eels (676.3 kg) were restocked into water bodies of Narva RBD. Restocking activities took place in two parts and in January and February (due to extremely warm winter). Glass eels were provided by Eurl Aguirrebarrena from France. Restocking material was transported to Estonia in live fish tanks of a truck and relased to waterbodies using boats (Figure 4).

Table 3. Restocking of glass eel and ongrown eel in Estonia (in 10⁶).

	1950		1960		1970		1980	
year	glass eels	elver	glass eels	elver	glass eels	elver	glass 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		2020	
year	glass eels	elver	glass eels	elver	glass eels	elver	glass eels	elver
0			1.1			0.21	2.03	
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	1.58			

Figure 4. Restocking of glass eels in L. Võrtsjärv on 08/01/2020.

3.3 Aquaculture

NO DATA AVAILABLE

3.4 Entrainment

See 2019 Country Report.

3.5 Habitat Quantity and Quality

See 2020 Country Report

3.6 Other impacts

NO DATA AVAILABLE

4 National stock assessment

4.1 Description of Method

4.1.1 Data collection

Data is collected by regular fyke nets and an enclosure fyke net system in Narva RBD.

Data is collected annually during the fishing season (may-september). 100-200 specimens are collected from commercial fishermen to measure length and weight. Up to 3 regular fyke nets (mouth opening 1-3 m, mesh size in the cod end > 18mm) set in different locations in L. Võrtsjärv are used for collecting scientific samples.

Enclosure fyke net system was used on the small lakes of Narva RBD in 2018. The methodology was modified after Ubl & 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 fyke nets were used for annual monitoring. 6 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 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 fyke nets. Otoliths are collected for age reading and micro-chemical analyses.

4.1.2 Analysis

Enclosure fyke net system (Ubl & 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 fyke net 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 fyke net 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. Data on recreational fisheries exists only for fishers who use gear that requires a fishing card (long lines and harpoons), other recreational catches go unreported.

4.2 Trends in Assessment results

The biomass estimators (B_{curr} and B_{best}) in Narva RBD stayed similar to 2019 however the ∑F indicator increased due to new data available (Figure 5). The number of restocked specimens increased during the period 2011-2015 compared to the first decade of 2000s and this also reflects in the increased biomass estimators. In Lake Võrtsjärv, most of the eels restocked are glass eels, which have a faster growth in comparison with elvers (Silm et al, 2017). This has also an effect on the distribution of age groups in the commercial catches where prevailing age class is 7. We have determined that eels in either FIV or FV silvering stage have an average age of 9 years (with a mean weight of 704 g) which can be counted as the mean age for the start of migration from the lake. As the assessment depends on the data of commercial landings which are under-reported an overestimation of B_{curr} appears affecting also the value of ∑A. However it is difficult to assess the proportion of over-estimation as the dimension of under-reporting in unknown.

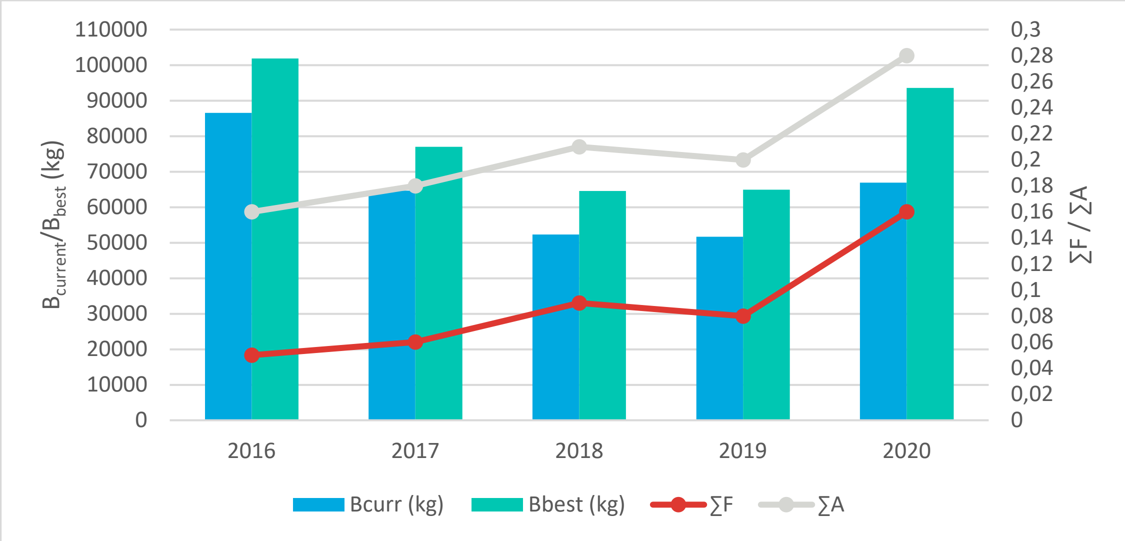


Figure 5. Changes in the amount of silver eel biomass that currently escapes to the sea to spawn (in the assessment year; $B_{current}$), the amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the current stock (B_{best}), ∑F = mortality due to fishing, summed 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 2016-2020.

4.3 Yellow eel abundance surveys

See ICES, 2018.

4.4 Silver eel escapement surveys

See chapter 4.1.2

4.5 Life-history parameters

In 2020 a Cross Border Cooperation Programme (https://estoniarussia.eu/) project ESTRUSEEL was continued on Lake Peipsi and Lake Lämmi. The main objective of the project is to assess the distribution and origin of the eels residing in the shared water bodies of Estonia and Russia (most notably Lake Peipsi and Narva Reservoir). In total, Lake Peipsi was fished for 73 nights from 12 different sampling spots while Lake Lämmi was fished for 7 nights in 2 different sampling spots. Additionally project Russian partners fished on Narva River on the Russian side for 47 nights from 5 different sampling spots and Narva Reservoir for 43 nights from 5 different spots. 28 eels were caught from Lake Peipsi and none from Lake Lämmi. Half of the caught eels were migrating males and other half mostly FIII and FV stage eels (Figure 6) As there is no restocking program for Lake Peipsi, all these eels originate from either Lake Võrtsjärv or the small lakes in the area where annual restocking programs are implemented.

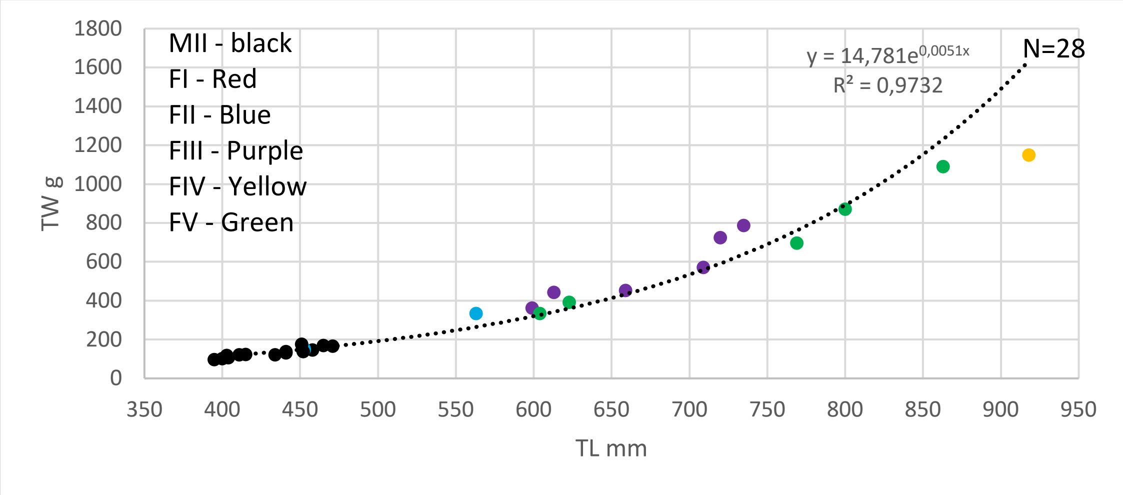


Figure 6. Total length and total weight of eels (N=28) caught from Lake Peipsi in 2020. Silvering stages are marked with different colours (key on the figure).

In 2020 a total of 131 eels were caught using Estonian University of Life Sciences experimental fyke nets on Lake Võrtsjärv. 93% of the caught specimens were in legal size (TL≥55cm; Figure 7). The average total length of the eels was TL = 61.7 cm and the weight TW = 478.3 g. Compared to 2019 the average length stayed the same while weight rose slightly (+ 3%). The average Fulton index was K = 0.20, which characterizes Lake Võrtsjärv as a stable living environment.

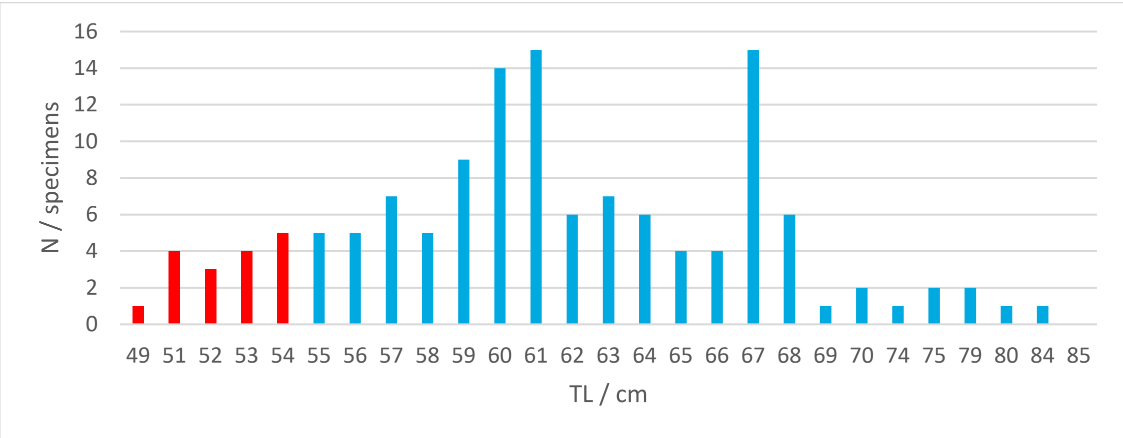


Figure 7. Overview of eel length distribution in Lake Võrtsjärv in 2020. Red bars indicate specimens shorter than the legal size (under TL=55cm).

Most numerous age class in the fyke net catch was 7 making up 35% of total (Figure 8).

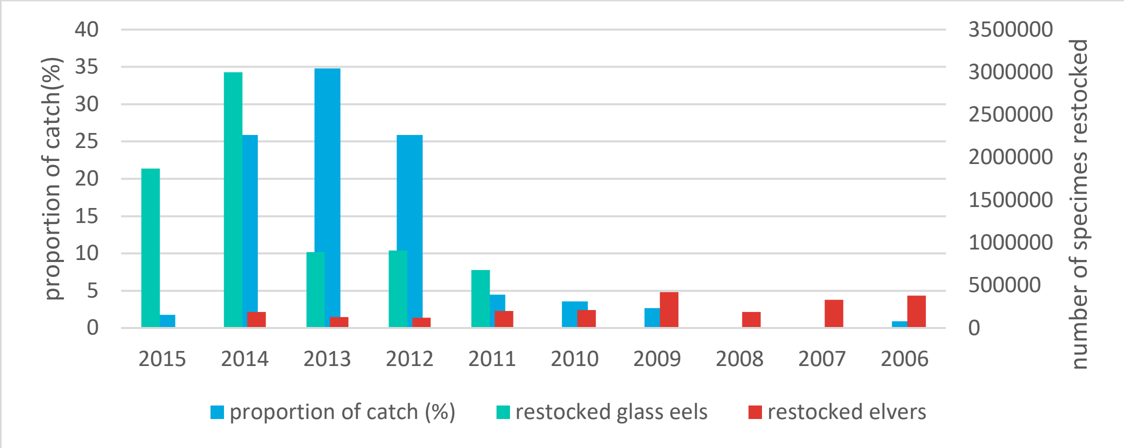


Figure 8. Proportion of different eel generations in the 2020 fyke net catch in Lake Võrtsjärv. Blue bars denote the proportion of age class in the catch and correspond to the scale on left. Light blue and red bars correspond to the scale on left and denote which stage of eel was restocked.

Among the catch, yellow eels of stage FII were the most numerous (53%), silver eels of stage FIII and FV accounted for 42% and 4% of the catch, respectively. As in the previous year, there were no FI stage eels caught.

Of the age groups, the highest number of individuals were 6-8 years old, in the length range of TL = 55-69 cm (Figure 9). 16% of the aforementioned age groups were restocked as elvers. It is interesting that in the period 2013-2015, ongrown eels accounted for only 6% of specimens restocked, so it may reflect that the mortality of farmed eels in the first years of the lake is significantly lower than that of glass eels.

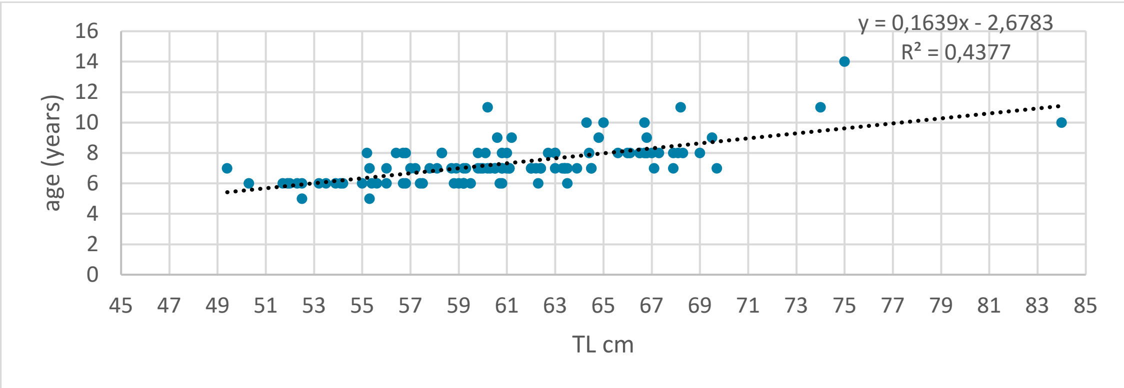


Figure 9. Total length of eels (N=111) according to age groups in Lake Võrtsjärv in 2020.

In West-Estonian RBD the CPUE of survey fyke nets has been increasing slowly compared to the lowest point in 2016 (R. Eschbaum, *unpublished data*, Figure 10). In the last 3 years the most productive sampling area in terms of fyke net CPUE is near island of Vilsandi on the western edge of Estonia.

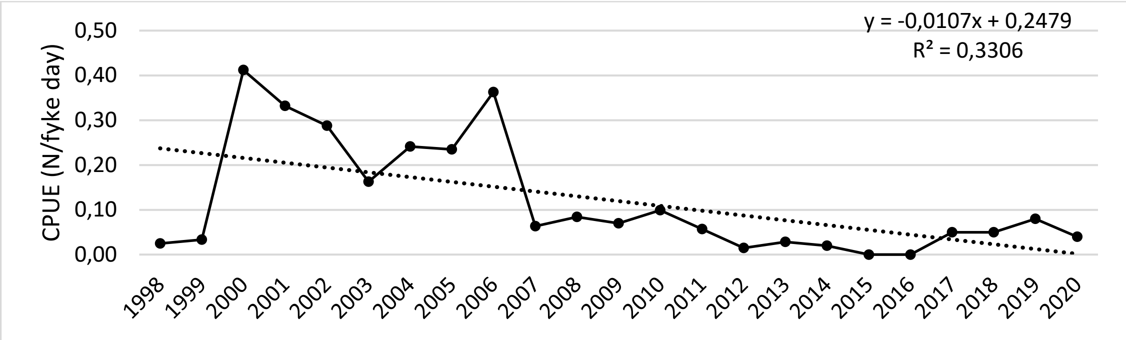


Figure 10. Eel CPUE of small fyke nets set in coastal monitoring areas from period 1998-2020 (R. Eschbaum, *unpublished data*).

4.6 Diseases, Parasites & Pathogens or Contaminants

61% (N=71) of the eels analyzed (N=116) were infected with the swimbladder parasite *Anguillicoloides crassus*. The average intensity of infection was 8 parasites per fish, which is 20% less than in 2019. The average length of infected eels was TL=61.8 cm, while that of uninfected individuals was 59.9 cm. Fulton condition factors were virtually the same in both groups ($K_{infected}$=0.197 and K=0.199 respectively). It is also known from the literature that infected fish can have a longer length and weight, mainly due to a higher nutritional activity (and thus a higher probability of infection) compared to uninfected fish.

5 New Information

Studies

A telemetry study was carried out in Narva RBD from 2019-2020 to observe the migration patterns of FIII-FV stage eels. New knowledge about the migration patterns of silver eels deriving from Lake Võrtsjärv in River Emajõgi, Lake Peipsi and River Narva system were obtained during the 2 year period of the project. The migration pattern on this journey of at least 240 km proved to be very complex, with rapid movements towards the sea, but also longer and shorter stops and movements in the opposite direction within the freshwater system.

As expected, some fish showed a clear pattern, during which they moved towards the sea – downstream along River Emajõgi, through Lake Peipsi and along River Narva to the Baltic Sea. Some specimens had the capacity to make such a migration as fast as within three weeks. However, the proportion of such fish in the study was surprisingly small - less than a tenth. Some of the eels that did migrate to River Narva by the end of the project stayed in Lake Peipsi for a considerable time, about one year. However some eels that migrated to Lake Peipsi are still in Lake Peipsi 1.5 years later, some in the area near the mouth of the River Emajõgi. The return of relatively large number of eels migrating back to River Emajõgi from Lake Peipsi and the completion of extensive upstream migrations were particularly unexpected - the migrations even extended back to Lake Võrtsjärv.

We observed that some of the eels were caught by fishermen during the migratory phase. About 2% of the tagged fish were caught on River Emajõgi, 6% of the eels on Lake Peipsi. 9% of the tagged eels died when passing through the Narva Hydroelectric Power Plant.

How to assess such a migration pattern and mortality in the context of silver eel escapent from Lake Võrtsjärv depends on several factors. Mortality at the Narva hydroelectric power plant is unacceptably high, measures must be taken to reduce it in the future. Stopping in Lake Peipsi, despite moderate mortality, may increase the escaping silver eel biomass through resuming feeding during the pause in migration that is if the growth rate of individuals stopping in Lake Peipsi is fast due to favorable conditions (good feeding conditions, low densities etc). While there has been a lack of eel growth related data from Lake Peipsi, there is an ongoing project ESTRUSEEL that fills this gap which is scheduled to conclude in February of 2022.

Articles

Tambets, M., Kärgenberg, E., Järvalt, A., Økland, F., Kristensen, M.L., Koed, A. and Bernotas, P., 2021. Migrating silver eels return from the sea to the river of origin after a false start. Biology Letters, 17(9), p.20210346.

The European eel's singular spawning migration from European waters towards the Sargasso Sea remains elusive, including the early phase of migration at sea. During spawning migration, the movement of freshwater resident eels from river to sea has been thought to be irreversible. We report the first recorded incidents of eels returning to the river of origin after spending up to a year in the marine environment. After migrating to the Baltic Sea, 21% of the silver eels, tagged with acoustic transmitters, returned to the Narva River. Half returned 11–12 months after moving to the sea, with 15 km being the longest upstream movement. The returned eels spent up to 33 days in the river and migrated to the sea again. The fastest specimen migrated to the outlet of the Baltic Sea in 68 days after the second start—roughly 1300 km. The surprising occurrence of returning migrants has implications for sustainable management and protection of this critically endangered species.

Rohtla, M., Silm, M., Tulonen, J., Paiste, P., Wickström, H., Kielman-Schmitt, M., Kooijman, E., Vaino, V., Eschbaum, R., Saks, L. and Verliin, A., 2021. Conservation restocking of the imperilled European eel does not necessarily equal conservation. ICES Journal of Marine Science, 78(1), pp.101-111.

To stop the decline of the European eel population, one of the measures taken is translocating eels for restocking, despite its conservational value being largely unknown. We aimed to contribute to this knowledge gap by (i) investigating the origin of eels caught in coastal waters of Estonia and Finland using otolith microchemistry and (ii) directly estimating restocked eel escapement from Narva River Basin District (NRBD), which is part of the primary Eel Management Unit in Estonia. In Estonia, 74% of the sampled eels (n = 140) were natural recruits and 26% were restocked. In Finland, 27% of the sampled eels (n = 235) were natural recruits and 73% were restocked. Only 1% of all the coastally collected eels were originally restocked to NRBD. These new data together with the reported commercial landings from the escapement route conflict with the current silver eel escapement estimation for NRBD and question the accuracy and value of such indirect calculations compiled for most Eel Management Units throughout the European Union. It is concluded that restocking eels to freshwaters may be futile as a conservation measure in some situations, and better escapement is likely achieved in restocking eels to coastal waters or undammed freshwater systems with a direct connection to the sea.

6 References

Bernotas, P., Vetemaa, M., Saks, L., Eschbaum, R., Verliin, A., & Järvalt, A. 2016. Dynamics of European eel landings and stocks in the coastal waters of Estonia. ICES Journal of Marine Science: Journal Du Conseil . http://doi.org/10.1093/icesjms/fsv245

ICES. 2009. Workshop on Age Reading of European and American Eel (WKAREA), 20-24 April 2009, Bordeaux, France. ICES CM 2009\ACOM: 48. 66 pp.

ICES. 2018. Report of the Joint EIFAAC/ICES/GFCM Working Group on Eels (WGEEL), 5–12 September 2018, Gdańsk, Poland. ICES CM 2018/ACOM:15. 152 pp. Annex "Report on the eel stock, fishery and other impacts, in: Estonia 2018"

Järvalt, A. 2008. Eel management plan. Report. 26 pp. Ministry of Environment. http://www.envir.ee/sites/default/files/elfinder/article_files/kavajaheakskiitmiseotsus03.12.2009.pdf

Pihu, E. & Haberman, J. (eds) 2001. Lake Peipsi – Flora and Fauna. Institute of Zoology and Botany. Tartu, Sulemees publishers.

Report of the implementation of Estonian National Eel Management Plan. 2015. Estonian Ministry of the Environment. Report. Tallinn 2015. 25pp.

Silm, M; Bernotas, P; Haldna, M; Järvalt, A; Nõges, T, 2017. Age and growth of European eel, *Anguilla anguilla* (Linnaeus, 1758), in Estonian lakes. Journal of Applied Ichthyology, 33 (2), 236−241.jai.13314.

Ubl, C. & Dorow, M. 2015. A novel enclosure approach to assessing yellow eel (Anguilla anguilla) density in non-tidal coastal waters. Fisheries Research 161, 57–63. http://dx.doi.org/10.1016/j.fishres.2014.06.009

Contents

i Report on the eel stock, fishery and other impacts, in Finland, 2020-2021

Authors

Jouni Tulonen, Research Scientist, Natural Resources Institute Finland, jouni.tulonen@luke.fi

Sami Vesala, Specialist, Natural Resources Institute Finland, sami.vesala@luke.fi

Reporting Period: This report was completed in September 2021, and contains data up 2020 and some provisional data for 2021

Acknowledgments:

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 is not available data to provide stock indicators of silver eel escapement biomass and mortality rates. In Finland eels are on their North-Eastern 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 has 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 1970's. 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. Because of the Brexit the glasseels into the Swedish quarantine were imported in 2021 from the River Garonne in France.

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:

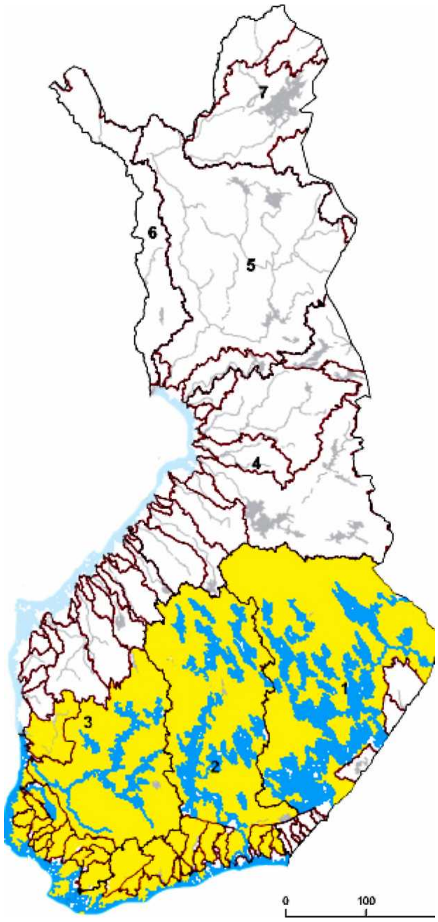
-outlet of the river basin is in Finland's national territory

-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:

a) 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.

b) 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 20509 km². No management actions take place in this area.

The management actions are directed towards the free migration area complex (Ab, 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 eleven years almost 1,8 million eels have been stocked in total. In the beginning 40-60% of the stockings were paid by private water owners mainly to benefit the local fisheries in the sea or in the freshwaters. Later on the motivation of restockings have changed to help the recovery of the eel in Europe. In last three years Natural Resources Institute Finland have restocked 220 000 quarantined glasseels in the coastal area from Vaasa to Vironlahti and lower reaches of small waterways below the lowest dams to improve the stock.

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 programs. It is possible to get limited number of eel samples from the fyke-net fisheries bycatch.

3.1.1 Glass eel fisheries

There is no glass eel fisheries in Finland as glass eels doesn’t exist there.

3.1.2 Yellow eel fisheries

There is no specific data on yellow eel fisheries. During 2008-2020 the total professional marine eel landings (yellow and silver together) have varied between 202-2300 kg/year. In 2019 the catch was radically redused to 299 kg, mainly due to the four months closure of fisheries. In 2020 the trend was still downwards, the landings were only 202 kg. Landings in the professional fisheries are based in the sea on annual logbook data and in freshwaters until year 2016 on questionnaires made every second year to professional and semi-professional fishermen. In freshwater commercial fisheries the number of fishermen grew when a new logbook based registry was implemented form 2016 onwards. As a result the landings of commercial fisheries were 49 kg in 2016, 36 kg in 2017, 31 kg in 2018 and 95 kg in 2019. Landings for 2020 will be officially available in October 2021 but most probably they will be of the same magnitude as in previous years. During 2008-2018 in recreational fisheries the landings in freshwater have varied between 2000-11000 kg/year and in the sea from almost zero to13000 kg/year. In recreational fisheries landings are based on data collected by questionnaires every second year. Data is collected with a postal survey. The sample is taken from the population information system maintained by the Population Register Centre. Data is 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 6-7000 households.

Table 1. Commercial landings (kg) of eels (yellow and silver together) in freshwaters and sea from 2008 to 2019. (EMU = Fl Finl, NC = Not collected)

Year	Commercial Fresh	Commercial Sea	Fl Finl alltogether
2008	0	1000	1000
2009	NC	1800	1800
2010	0	2300	2300
2011	NC	1549	1549
2012	0	1539	1539
2013	NC	1307	1307
2014	0	1021	1021
2015	NC	609	609
2016	49	1277	1326
2017	36	1045	1081
2018	31	1064	1095
2019	95	299	394
2020	statistics of commercial landings in freshwater 2020 shall be published 15.10.2021	202	

Table 2. Recreational landings (kg, rounded to the nearest thousand)) of eels (yellow and silver together) in freshwaters and sea from 2008 to 2019. (EMU = Fl Finl, NC = Not collected)

Year	Recreational Fresh	Recreational Sea	Fl Finl altogether
2008	4000	13000	17000
2009	NC	NC	
2010	9000	1000	10000
2011	NC	NC	
2012	3000	2000	5000
2013	NC	NC	
2014	11000	9000	20000
2015	NC	NC	
2016	1000	7000	8000
2017	NC	NC	
2018	2000	0	2000
2019	NC	NC	
2020			statistics of recreational landings in 2020 shall be published 28.10.2021

No available data on effort.

3.1.3 Silver eel fisheries

There is 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 31 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 almost 1,8 milj individuals (mean weight 1 g) have been stocked. Roughly a little bit more than half of the eels have been stocked directly into coastal waters where they can freely leave for spawning migration. About 20-30 % 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. Amount of restocked quarantined glasseels in 2005-2020 in Finland.

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	37 500	97 000	134 500
2020	45 500	84 000	129 500
2021	36 000	118 000	154 000

3.3 Aquaculture

At the moment there is no eel aquaculture in Finland. In 2013 40 000 glass eels (on grown ~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.

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 eelfarmer in the country. Farming was experimental and conducted in a recirculation system. There were still eels in that single farm in spring 2021 as they tried to sell 1000 kg for restocking, but didn't find a buyer. Average size of the fish was about 30 cm, weight varied between 200-700 g.

3.4 Entrainment

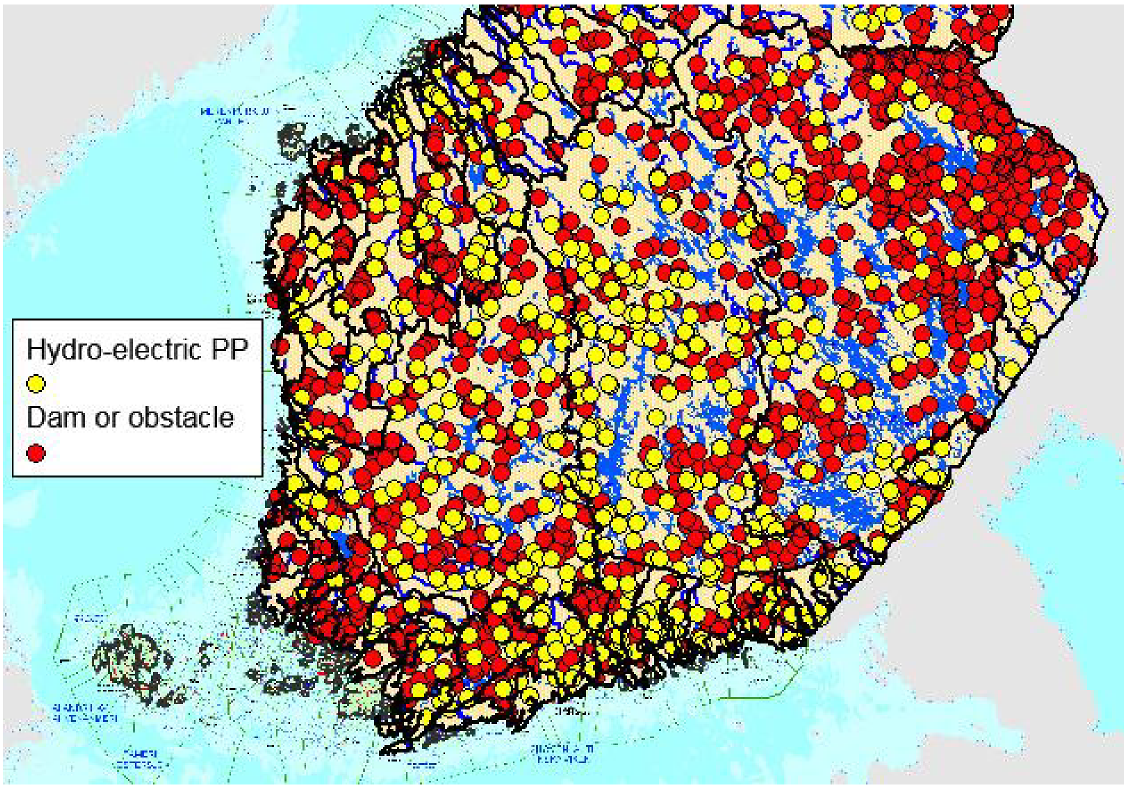


Figure 1. Hydro-electric power plants and other dams in Finland.

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

In the coastal area in 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 is electric powerplants 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 is still over 4 milj hectares of suitable growing areas for eel in the Baltic (from shoreline to the depth of 10 meters) where free migration is possible.

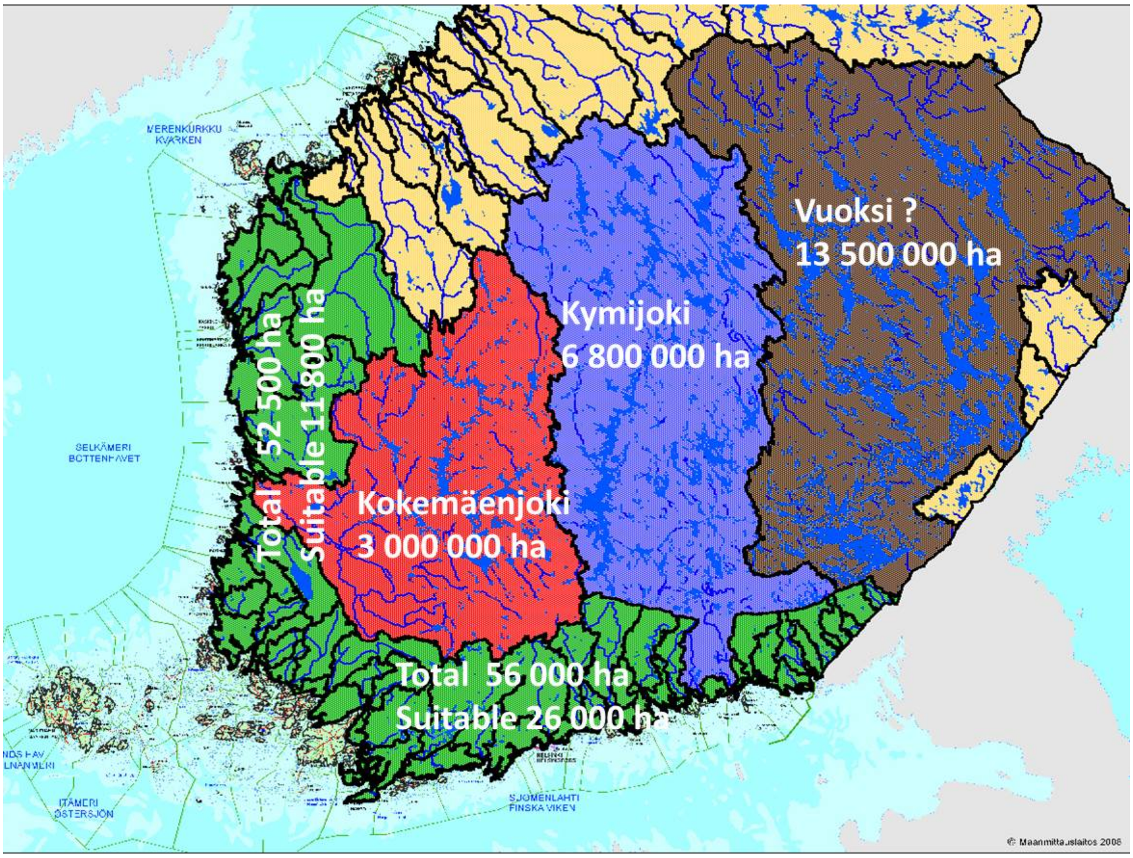


Figure 2. The three main watercourses and the small coastal watercourses in southern Finland and their water areas in hectares. Only in the coastal watercourses (green) there is some 30 000 hectares of suitable habitats left for natural immigration on eels. In all other areas eel populations originates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

3.6 Other impacts

4 National stock assessment

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

5.1 Yellow eel abundance surveys

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 (Table 4). Samples are collected in two locations in inland waters as well: lake Kulovesi (Kokemäenjoki watershed, Table 5) and lake Vesijärvi (Kymijoki watershed, Table 6), 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 a 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 otolihs have been removed and swim bladder 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.

Year	fish	mean length	mean weight	mean age (min-max)	Effort
	n	mm	g	years	
2017	22	877	1350		1,6
2018	83	849	1166	15,6 (8-26)	1,6
2019	46	845	1184	15,4 (8-24)	1,6
2020	94	832	1170	14,3 (7-26)	1,6

Table 4. In the sea (mainly Kotka area) eels were caught as a bycatch in a professional fisherman's fyke nets.

Year	fish	mean length	mean weight	mean age (min-max)	Effort
	n	mm	g	years	fish/hook/nigth
2017	35	743	911		
2018	59	777	1048	20,2 (11-25)	0,06
2019	51	755	883	21,4 (12-26)	0,05

Table 5. In the lake Kulovesi eels were sampled with longlines by a recreational fisherman.

Year	fish	mean length	mean weight	mean age (min-max)	Effort
	n	mm	g	years	fish/trap/nigth
2017	36	905	1431		1,05
2018	80	882	1301	19,5 (10-41)	1,65
2019	16	867	1226	19,4 (12-21)	1,14
2020	74	914	1473	20,8 (12-42)	1,85

Table 6. In the lake Vesijärvi eels were sampled with small fykenets by a recreational fisherman.

5.2 Silver eel escapement surveys

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 hydro-power dam.

Trap in the River Vääksynjoki

Vääksynjoki is running from Lake Vesijärvi in the upper reaches of the Kymijoki watercourse, 150 km from the sea. The trap catches all eels migrating downstream in the beginning of their spawning migration. 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 2014-2020 1994 eels have been caught and transported to the sea. This year until the end of August additional 314 eels have been caught. In total almost 3,5 tn of eels have been transported over the hydroelectric power plants into the Baltic.

Table 7. Eels trapped in the river Vääksynjoki and transported to the sea during 2014-2020.

	n	mean length, cm	(min-max)	mean weight, g	(min-max)
2014	189	93	78-115	1520	744-2637
2015	337	93	71-119	1492	743-3060
2016	298	93	65-113	1506	450-2610
2017	196	94	60-113	1581	401-3394
2018	371	94	67-116	1464	559-2752
2019	428	94	69-116	1477	511-2651
2020	175	92	65-116	1383	545-2588

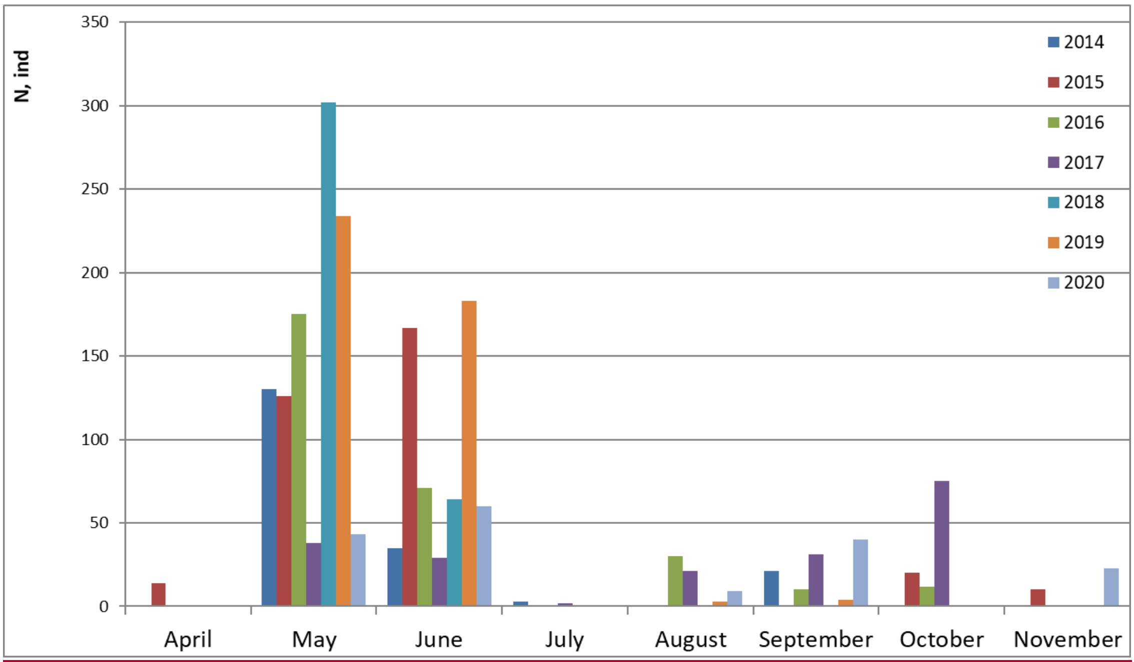


Figure 3. Seasonal variation in the silver eel catches in the trap in the river Vääksynjoki.

Tagging experiments since 2014 with the “trap and transport” eels from the River Vääksynjoki

All fish caught in Vääksynjoki since 2014 have been marked with T-anchor or Carlin tags and transported to the sea to the mouth of the River Kymijoki in Ahvenkoski. Recovery data on fish tagged during 2014-2018 have been obtained so far in total 47, more than half of them from Finnish territorial waters. From the rest of the Baltic Sea, there have been four returns from Estonia, two from Poland, five from Germany, three from Denmark and four from Sweden.

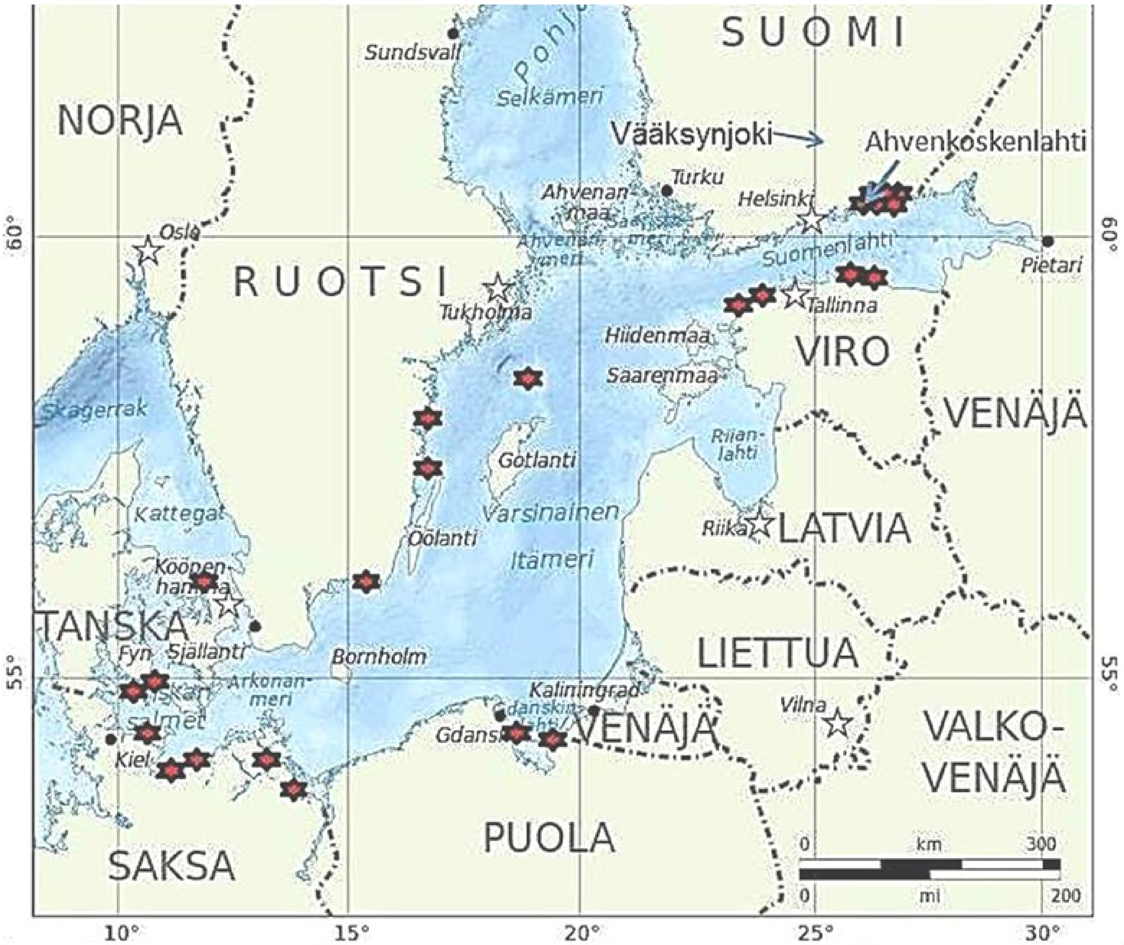


Figure 4. Recovery sites of eels caught in Vääksynjoki tagged and released in the Ahvenkoski during 2014-2018.

Returns from Finland are all less than 20 km east of the release site. Not a single fish has been caught from the western Gulf of Finland or the Archipelago Sea. In total, the return data has been obtained by 3.5% of the tagged fish. On average, the fish had swum for 134 days before being caught. The fish that migrated to Germany and Denmark had reached that distance of 1000-1200 km in an average of 270 days. The fastest fish (14 km/day) had reached the Danish Straits in 84 days . The eel that made the longest journey was the slowest of the set (1.7 km/day) and was caught in the Danish straits after 2 years and 37 days of the mark.

Eel catching has decreased by 2010 in the whole Baltic Sea region. During the winter of 2018-2019, the eel was for the first time tranquilized from commercial catching in marine areas of the European Union, including the Baltic Sea. This has potentially reduced tag returns, especially from the southern Baltic Sea of the coasts of Poland, Germany and Denmark.

Ultrasound taggings in 2020

In the autumn of 2019 the study on eel migration in the Baltic Sea received a new boost when the Danish University of Technology (DTU) placed acoustic ultrasonic receivers in the Danish Straits. Receivers record the specific sound signal whenever a transmitter marked fish overtakes a receiver and an extremely endangered fish does not need to be caught for information.

In the spring 2020 (May-June) Natural Resources Institute Finland marked 111 big silver eels with transmitters and released them in two locations in the Baltic Sea. Most of them where caught from the River Vääksynjoki (77 individuals) and from the lake above (15 individuals). These eels were released in Ahvenkoskenlahti in the mouth of the River Kymijoki. In the west coast in the Kokemäenjoki watercource additional 19 eels were caught in the Lake Vanajanselkä, tagged with transmitters and released below the lowest power plant in Harjavalta in the River Kokemäenjoki.

The first eel marked in spring in Finland was "heard" as early as the end of August in the Danish Straits. The fish in question had taken a direct route of about 1300 miles in 84 days. Until now almost 40 eels have been observed, most of them during winter months (October 2020- February 2021). The monitoring is still going on and most probably more eels will be detected in this coming winter.

Echosounder in the River Kokemäenjoki

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.

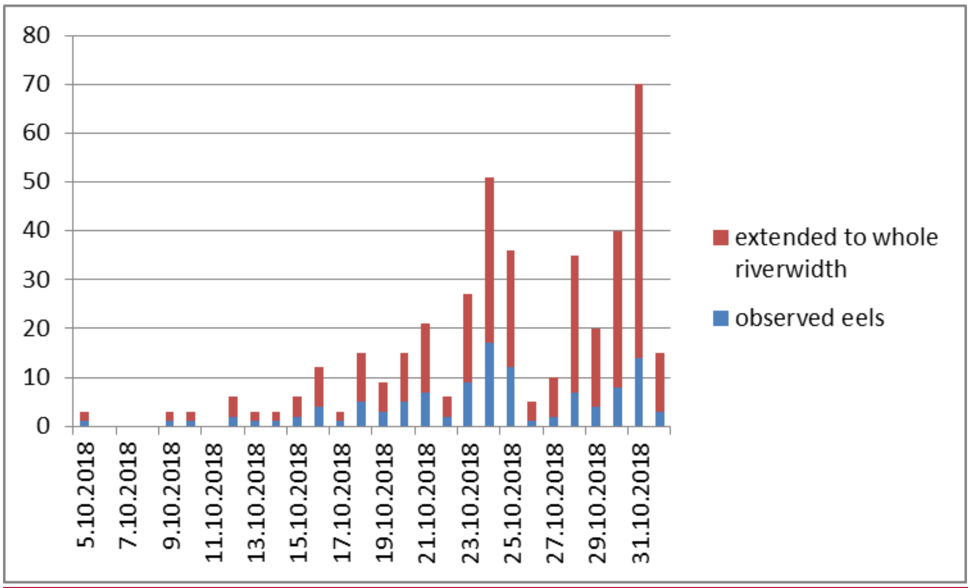


Figure 5. Eel activity in the lower reaches of the River Kokemäenjoki in autumn 2018. Both upstream and downstream migrating eels included

Year 2019 was the first time monitoring was possible through the whole ice free period. Monitoring began in May and lasted until November. DIDSON was installed in Pämpinkoski where the eels previously were mostly migrating downstream and were it was possible to cover almost 50 % of the river width (80 % of the deepest section of the main). In the year 2019 875 eels were observed to swim downstream. Next year (2020) in the same place with the same settings only 236 eels were observed.

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 swim bladders 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 1960's and 1970's and to estimate the yield to fishery and the proportions of eels escaping the lakes. The results were published mainly in 1980's (Pursiainen & Toivonen 1984, Pursiainen & Tulonen 1986, Tulonen 1988, Tulonen 1990, Tulonen & Pursiainen 1992).

There were no routine biological sampling programmes or eel research projects during 1994-2005. Some occasional samples were taken in few lakes on the author's 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 ind.) 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 & Pathogens or Contaminants

One sample of "natural" elvers has been collected in 2002 in South-West 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 & Saxen 1996, Tulonen & Vuorinen 1996).

6 New Information

The first observation of a spontaneously matured female European eel was made in an aquarium house (Maretarium) in the city of Kotka. The 43-year-old eel, together with eleven other females, resided at the aquarium house since their capture in 2002 and stocking as glass eels in 1978. In June 2019, the girth of the belly of the female increased as a sign of oocyte maturation. The specimen had an estimated gonadosomatic index (GSI) of 47, only half of the oocytes were hydrated and matured, indicating that European eels are polycyclic batch spawners. The live eels of the cohort were still in the previtellogenic phase but their eye sizes were close to that of the matured eel. It was hypothesized that substances released by other maturing and spawning fishes may have triggered puberty of the eel. This first observation, and the possibility of more eels maturing in the near future, provides a natural reference for the sexual maturation of the European eel.

7 References

Pursiainen M. and Toivonen J. 1984 The enhancement of eel stocks in Finland; a review of introduction and stockings. EIFAC Technical Paper No. 42, Suppl., 1:59-67.

Pursiainen M. and Tulonen J. 1986 Eel escapement from small forest lakes. Vie Milieu 36 (4): 287-290.

Tulonen J. 1988 Ankeriaan ikä, sukupuolijakaumat ja kasvu eräissä eteläsuomalaisissa järvissä. (Age, sex ratio and growth of eels in some lakes in southern Finland). Rktl, Monistettuja julkaisuja 81: 1-106.

Tulonen J. 1990 Growth and sex ratio of eels (Anguilla anguilla) of known age in four small lakes in southern Finland. Abstract in: Int. Revue ges. Hydrobiol. 75: 792.

Tulonen J. and Pursiainen M. 1992 Ankeriasistutukset Evon kalastuskoeaseman ja kalanviljelylaitoksen vesissä. (Eel stockings in the waters of the Evo State Fisheries and Aquaculture Research Station) Suomen Kalatalous 60:246-261.

Tulonen J. and Saxen R. 1996 Radionuclides 134Cs and 137Cs in eel (Anguilla anguilla L.) in Finnish freshwaters after the accident at Chernobyl nuclear power station in 1986 Arch. Ryb. Pol. 4:267-275.

Tulonen J. and Vuorinen P. 1996 Concentrations of PCBs and other organ chlorine compounds in eels (Anguilla anguilla, L.) of the Vanajavesi watercourse in southern Finland, 1990-1993 The Science of the Total Environment 187 (1996): 11-18.

Tulonen J. 2002 Anguillicola crassus tavattu ensikerran Suomessa (Anguillicola crassus found in Finland). Suomen Kalastuslehti 4(2002):36-37.

A. P. Palstra, P. Jéhannet, W. Swinkels, L. T. N. Heinsbroek, P. M. Lokman, S. Vesala, J. Tulonen, T. Lakka & S. Saukkonen 2020. First Observation of a Spontaneously Matured Female European Eel (Anguilla anguilla). Scientific Reports volume 10, Article number: 2339 (2020)

Rohtla, M., Silm, M., Tulonen, J., et al. 2020. Conservation restocking of the imperilled European eel does not necessarily equal conservation. *ICES Journal of Marine Science*, fsaa196, https://doi.org/10.1093/icesjms/fsaa196

Contents

i Report on the eel stock, fishery and other impacts in Germany, 2020–2021

Authors:

Lasse Marohn, Thünen Institute of Fisheries Ecology, Herwigstraße 31, 27572 Bremerhaven, Germany

Tel: +49 471 94460 132

lasse.marohn@thuenen.de

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Jan-Dag Pohlmann, Thünen Institute of Fisheries Ecology, Bremerhaven

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Karin Camara: North Rhine-Westphalia State Agency for Nature, Environment and Consumer Protection, Fishery Ecology, Kirchhundem-Albaum

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Till Czypionka: State Agency for Agriculture, Environment and Rural Areas of Schleswig-Holstein, Department Fisheries

1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

Table 1 presents the most recent data on assessed areas and stock indicators for the relevant German RBDs.

Table 1. Stock indicators of silver eel escapement, biomass and mortality rates, and assessed habitat area. EMUs averaged from 2017-2019 (Fladung & Brämick 2021).

Year	EMU_code	Assessed Area (ha)	B_0 (t)	B_{curr} (t)	B_{best} (t)	B_{curr}/B_0 (%)	∑F	∑H	∑A
2017-2019	DE_Eide[4]	468,783	1,708	455	478	27	0.02	0.01	0.03
2017-2019	DE_Elbe[2]	201,019	1,623	194	31	12	0.49	0.15	0.64
2017-2019	DE_Ems[2]	44,088	925	101	63	11	0.11	0.01	0.12
2017-2019	DE_Maas[1]	892	9	0.1	<1	1	0.22	0.07	0.29
2017-2019	DE_Oder[2]	80,366	445	92	88	21	0.21	0.00	0.21
2017-2019	DE_Rhei[1]	61,065	540	190	7	35	0.24	0.50	0.74
2017-2019	DE_Schl[3]	333,790	4,205	1,998	1,801	48	0.03	<0.01	0.04
2017-2019	DE_Warn[3]	368,309	903	710	761	79	0.17	<0.01	0.17
2017-2019	DE_Wese[2]	55,472	828	137	58	17	0.30	0.13	0.43

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 bio-mass 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, inland and coastal 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

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.

At present, four German recruitment time series are included in the international assessment (Frische Grube ('WiFG'), Wallensteingraben ('WisW'), Dove Elde eel ladder ('DoEl'), Verlath Pumping Station ("Verl")).

Baltic Sea: Since the early 2000s, immigration and upstream migration of young eels have been monitored at 3 locations in Eel Management Unit (EMU) DE_Warn (WisWGY, FarpGY, WiFG). Since these time series did not assess elvers and glass eels separately, a new time series was set up in 2016 directly in the Warnow River, where elvers and glass eels are reported separately (WaSG and WaSEY).

North Sea: In EMU DE_Eide ascending eels are monitored at three stations (VerlGY since 2010, BrokGY since 2012, LangGY since 2015). 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. In EMU DE_Ems recruitment is assessed at two stations (EmsBGY since 2013, EmsHG since 2014) and in EMU DE_Elbe elver monitoring takes place since 2003 at a station 230 km upstream (DoElY). Further monitoring activities have been started in EMU_Rhin, which are, however, so far not considered "time series".

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. The corresponding data are made available through WGEEL Data Calls and WGEEL reports. In Germany, inland fishery is under the legal competence and responsibility of the federal states ("Bundesländer"). For practical reasons, the relevant authorities and institutions in the states mainly focus on the requirements of the Progress Reports to the European 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. Currently, most data are therefore only available until 2019. If data for years later than 2019 had become available, they were included in the WGEEL Data Call 2021.

Figure 1: River Basin Districts (RBDs) in Germany (Source: Umweltbundesamt 2004).

In December 2008, Germany has submitted Eel Management Plans (EMPs) for all River Basin Districts (RBDs) (Fig. 1) that constitute a natural habitat for the European eel, as required by the Council Regulation (EC) No 1100/2007. EMPs have been prepared for nine EMUs (Baltic Sea: Eider, Oder, Schlei/Trave and Warnow/Peene; North Sea: Elbe, Ems, Meuse, Rhine and Weser). No plan was prepared for the river Danube, since according to an EC decision the Danube does not constitute a natural distribution area for eel in the sense of the Council Regulation (EC) No 1100/2007.

The German Eel Model (version GEM IIIc) has been used in all nine German EMUs to calculate the eel population parameters.

New rules from EMPs have become part of regional fisheries laws and/or fisheries regulations in the respective states.

2.2 Significant changes since last report

Due to subsequent corrections in some European time series, estimates for eel recruitment changed in some German EMUs for the time period 1985-2019. This affected former estimates of B_0 and $B_{current}$ in these EMUs and hampers their comparability with current stock parameter estimates.

3 Impacts on the national stock

3.1 Fisheries

3.1.1 Glass eel fisheries

There is no glass eel fishery in Germany

3.1.2 Yellow and silver eel fisheries

3.1.2.1 Commercial eel landings

Commercial fisheries in Germany are usually mixed fisheries, targeting different species and both eel stages, yellow and silver eel (though some gears primarily target one of these stages). Commercial eel landings are recorded by fishers and reported to regional authorities. Landings of yellow and silver eels have not been reported separately in the past, but separated reporting has been implemented in some EMUs during last years.

Table 2: Commercial yellow and silver eel landings (kg) in German EMUs since 2005.

	DE_Eide						DE_Elbe	DE_Ems	DE_Maas	DE_Oder
	F		T		C		F	F	F	F
Year	Y	S	Y	S	Y	S	Y/S	Y/S	Y/S	Y/S
2005	100		3,172		2,948		184,165	8,906	30	16,769
2006	0		2,807		2,804		199,174	9,257	30	16,979
2007	80		2,102		2,144		186,352	9,015	30	17,111
2008	0		No data		2,050		189,946	5,865	30	14,553
2009	176		1,534	440	1,041		204,729	6,286	30	13,722
2010	185		1,287	445	1,381		190,587	7,148	30	12,742
2011	145		1,149	651	1,215		130,043	5,902	0	8,606
2012	79		591	420	967		114,147	4,819	0	10,225
2013	95		553	493	796		125,800	5,099	0	10,278
2014	87		668	458	898		100,990	4,455	0	10,645
2015	70		1,014	339	581		104,774	3,856	0	11,403
2016	57		635	219	543		86,906	3,527	0	8,528
2017	7	6	990	168	457	164	96,288	3,577	0	15,814
2018	11	4	987	127	640	121	90,592	929	0	14,936
2019	0	0	1,218	272	528	133	75,436	1,098	0	13,213
	DE_Rhei	DE_Schl				DE_Warn				DE_Wese
	F	F		C		F			C	F
Year	Y/S	Y	S	Y	S	Y	S	Y/S	Y/S	Y/S
2005	51,990	22,048		20,194				22,175	88,256	34,008
2006	48,255	20,199		21,061				24,931	92,541	34,158
2007	47,596	21,858		11,269				22,399	71,604	32,075
2008	39,463	21,858		13,237				18,310	76,374	24,412
2009	22,312	9,643		8,423				18,705	63,789	23,755
2010	15,770	12,497		17,938				20,715	66,980	19,351
2011	14,686	11,392		15,076		14,721	7,349		41,596	26,353
2012	21,337	7,137		12,468		8,120	7,406		34,880	22,775
2013	20,139	9,339		15,084		11,159	5,571		37,955	22,482
2014	16,937	7,618		15,811		7,484	7,632	441	38,465	19,330
2015	18,105	5,225		17,375		8,310	6,067	25	34,236	14,747
2016	22,844	3,995		17,685		9,103	6,222		31,112	15,452
2017	20,855	5,032	4,269	14,253	1,980	7,094	6,776	737	38,315	23,916
2018	17,979	3,431	2,856	16,607	1,264	6,943	8,036	495	45,033	14,945
2019	20,004	3,325	3,702	17,876	1,250	6,252	5,461	206	38,218	19,862

3.1.2.2 Recreational landings

Recreational eel landings data from Germany are not collected and therefore estimated based on the total number of fishing licences per EMU. For the calculation, data from Fladung et al. (2012a) were used, who found that about 58% of all anglers in the river Havel system fished for eel, and of these about one third was successful. In relation to the total number of valid fishing licenses, the annual yield was 0.6 eels or 288 g eel per angler in this system. Similar results have been found for the State Mecklenburg-Pomerania in earlier studies (Dorow & Arlinghaus 2008, 2009).

Table 3: 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	20,240	2,705	113,328	25,315	408	11,314	87,007	18,546	19,167	22,386	11,489	66,192
2006	19,320	2,633	113,883	22,322	370	11,235	92,699	17,703	19,054	22,322	11,456	66,091
2007	18,400	2,004	112,505	15,896	404	10,656	91,557	16,860	10,874	22,904	11,755	61,575
2008	14,464	1,224	113,686	12,002	94	10,887	63,763	14,549	16,294	22,805	11,704	44,880
2009	12,983	1,196	116,449	13,116	82	11,178	60,096	12,524	9,263	23,408	12,014	37,514
2010	11,435	1,172	104,471	13,062	95	9,647	48,728	10,884	11,921	22,947	11,777	30,530
2011	9,200	969	105,571	10,563	84	10,088	45,416	9,106	11,986	24,602	12,627	31,584
2012	8,280	895	105,166	11,242	81	10,103	41,358	7,614	10,596	24,360	12,503	30,388
2013	6,989	724	105,111	11,898	80	10,102	42,929	5,552	10,521	23,357	11,988	35,971
2014	6,121	521	112,245	11,518	60	10,483	42,040	5,392	10,102	23,615	12,120	35,807
2015	5,527	579	112,427	9,438	60	10,541	41,243	5,490	9,442	24,190	12,415	39,128
2016	4,969	641	115,861	9,960	58	10,560	40,835	6,163	9,614	24,144	12,391	39,538
2017	4,499	467	113,711	10,199	79	10,503	45,363	6,757	9,935	23,553	12,088	38,361
2018	4,164	419	110,643	10,182	78	9,972	45,896	7,185	10,503	22,701	11,651	37,660
2019	3,950	378	112,149	10,099	79	10,086	46,931	8,364	11,087	23,406	12,013	37,439

3.1.2.3 Fishing effort

Fisheries in Germany are usually mixed fisheries, targeting different species and also both stages of eel, yellow and silver eel. Therefore, effort data in table 4 are not presented separately for eel life stages.

The main fishing gears for eel in Germany are fyke nets (different types), among which the "small fykes" are the most important group. A notable effort reduction in small fyke net (-25%) and stow net fisheries (-63%) was observed. All other gears also showed a reduction in effort. However, hook buoys and stationary traps only account for a small fraction of the total fishing effort on eel in Germany.

Table 4: Fishing effort with the most relevant eel fishing gears of commercial and semi-commercial fisheries in German waters in 2019 and change (%) in relation to the 2008-data. Data are presented as gear * days used (Source: German Progress Report (Fladung & Brämick 2021)).

EMU	Small fykes	Large fykes	Longlines/eel line (per 100 hooks)	Hook buoys	Stow nets	Stationary eel traps	Electro fishing
Eider	15,531	7,052	0		167	0	0
Elbe*	308,933	301,124	8	1,340	950	0	40
Ems	2,064	4,591	0		1,636	0	0
Maas	0	0	0		0	0	0
Oder	177,430	15,776	6,514	300	124	4	16
Rhein	150,654	4,317	45		340	0	78
Schlei/Trave	973,536	15,115	482		0	0	0
Warnow/Peene	2,877,108	41,358	165,354	300	0	241	2
Weser	171,524	5,698	0	0	583	0	0
Total	4,676,780	395,031	172,403	1,940	3,800	245	136
Change from 2008 to 2019 (%) *, **	**-25**	**-7**	**-7**	**-96**	**-63**	**-80**	**-83**

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

3.2 Restocking

Available data on eel stocking were taken from the WGEEL Data Call 2021. Generally, restocking intensity is influenced by glass eel price, funding and the contribution of commercial and recreational fishers. In tables 5 and 6 data on glass eel stocking is presented (weight and numbers), while tables 7 and 8 show combined information on ongrown and yellow eels.

Table 5: Total weight (kg) of glass eels restocked in German EMUs since 2005.

Year	DE_Eide	DE_Elbe	DE_Ems	DE_Maas	DE_Oder	DE_Rhein	DE_Schl	DE_Schl	DE_Warn	DE_Warn	DE_Wese
	F*	F*	F*	F**	F*	F**	F	C	F	C	F*
2005	0	254	131	0	0	1,454	0	0	0	0	67
2006	0	0	74	0	0	1,689	0	0	0	0	52
2007	0	0	53	0	0	1,943	0	0	2	0	16
2008	0	0	34	0	0	859	0	0	8	0	10
2009	0	34	25	0	0	1,062	0	0	8	0	48
2010	0	1,153	39	21	0	1,028	0	0	3	0	37
2011	0	548	36	30	0	3,070	30	50	3	0	47
2012	0	885	8	51	3	2,217	0	0	3	0	34
2013	0	1,416	NC	56	26	2,318	2	22	3	0	49
2014	0	2,025	NC	80	94	1,167	26	572	3	120	393
2015	0	1,036	NC	37	59	1,313	34	117	8	120	91
2016	0	581	14	0	81	844	116	254	20	114	246
2017	0	2,020	16	56	105	157	119	301	0	0	261
2018	0	2,600	14	19	100	384	137	177	189	0	320
2019	0	4,225	181	21	123	514	88	344	45	0	628

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

Table 6: Total number of glass eels restocked in German EMUs since 2005.

Year	DE_Eide	DE_Elbe	DE_Ems	DE_Maas	DE_Oder	DE_Rhein	DE_Schl	DE_Schl	DE_Warn	DE_Warn	DE_Wese
	F*	F*	F*	F**	F*	F**	F	C	F	C	F*
2005	0	636,667	436,667	0	0	572,014	0	0	0	0	223,333
2006	0	0	246,667	0	0	664,320	0	0	0	0	173,333
2007	0	0	176,667	0	0	764,320	0	0	6,719	0	53,333
2008	0	0	114,000	0	0	337,863	0	0	26,713	0	31,667
2009	0	102,819	84,667	0	0	417,736	0	0	25,116	0	158,333
2010	0	4,328,454	129,000	14,534	0	404,290	0	0	10,098	0	122,333
2011	0	1,638,050	112,917	16,000	0	1,207,661	100,000	166,667	9,168	0	152,517
2012	0	2,989,570	26,667	20,000	9,000	872,048	0	0	7,655	0	108,485
2013	0	3,824,120	NC	24,500	76,765	911,804	6,667	73,333	11,569	0	151,111
2014	0	6,024,572	NC	45,100	235,764	459,234	86,667	1,906,667	62,370	400,000	1,228,365
2015	0	3,564,919	NC	74,000	146,750	516,503	144,848	531,818	434,778	400,000	302,667
2016	0	1,707,042	46,667	0	203,000	331,966	473,173	1,019,400	66,830	378,000	800,889
2017	0	7,167,936	67,667	46,900	259,588	298,000	381,859	872,608	0	0	784,019
2018	0	9,091,454	46,667	62,100	286,143	1,277,240	423,467	590,000	701,500	0	1,066,600
2019	0	15,151,153	604,533	68,400	352,750	1,707,533	271,485	1,109,040	180,000	0	2,067,001

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

Table 7: Total weight (kg) of yellow and ongrown eels restocked in German EMUs since 2005.

Year	DE_Eide	DE_Elbe	DE_Ems	DE_Maas	DE_Oder	DE_Rhein	DE_Schl	DE_Schl	DE_Warn	DE_Wese
	F*	F*	F*	F**	F*	F**	F	C	F	F*
2005	0	34,433	8,726	0	4,120	23,524	20,724	0	3,139	17,421
2006	0	44,473	5,463	0	1,934	22,229	5,631	0	3,935	17,279
2007	0	38,581	6,241	0	1,547	20,460	5,235	0	4,876	15,787
2008	23	38,173	2,551	95	4,809	17,477	4,347	0	2,252	11,006
2009	0	39,265	1,896	99	3,866	17,659	4,545	0	2,143	10,505
2010	0	37,633	2,703	58	3,246	18,132	5,363	324	2,939	9,777
2011	0	37,529	2,912	15	4,512	17,777	2,809	434	3,116	7,028
2012	5	25,991	3,320	0	2,204	20,059	2,540	650	2,845	9,321
2013	0	24,176	2,963	15	1,207	19,973	2,800	3,180	2,351	10,621
2014	20	27,826	3,622	15	1,509	21,746	2,001	400	3,902	8,591
2015	0	14,585	4,432	83	1,330	20,808	3,162	1,632	3,050	10,392
2016	0	14,808	3,805	362	1,368	23,025	1,685	2,632	3,168	7,910
2017	34	25,030	2,838	125	1,382	13,101	2,688	3,289	4,004	8,601
2018	131	20,824	3,951	0	783	13,615	1,508	1,851	3,914	8,400
2019	51	21,566	3,071	0	777	12,336	1,222	2,115	3,804	8,745

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

Table 8: Total number of yellow and ongrown eels restocked in German EMUs since 2005.

Year	DE_Eide	DE_Elbe	DE_Ems	DE_Maas	DE_Oder	DE_Rhein	DE_Schl	DE_Schl	DE_Warn	DE_Wese
	F*	F*	F*	F**	F*	F**	F	C	F	F*
2005	0	1,974,829	839,854	0	131,277	1,493,826	849,478	0	151,300	1,413,887
2006	0	5,350,460	565,604	0	86,096	1,417,999	233,995	0	329,333	1,408,306
2007	0	5,344,928	648,434	0	70,597	1,310,382	228,455	0	441,221	1,313,390
2008	2,875	6,122,199	229,123	3,433	168,241	1,068,885	220,871	0	371,986	809,313
2009	0	6,187,205	207,452	1,140	148,608	1,093,815	253,206	0	314,294	695,184
2010	0	6,030,637	270,121	1,700	162,585	1,115,992	406,855	32,350	494,805	673,395
2011	0	4,501,324	370,932	150	150,844	1,124,118	168,497	43,400	311,832	752,246
2012	714	2,764,067	550,397	0	93,304	1,288,461	206,243	65,000	260,385	1,132,249
2013	0	2,861,634	452,874	150	141,897	1,269,989	245,464	318,000	393,527	1,299,491
2014	2,404	3,490,861	1,188,931	150	150,647	1,391,479	245,077	53,333	432,630	1,513,882
2015	0	2,777,928	1,184,006	8,680	220,320	1,327,016	364,171	224,214	264,222	2,327,270
2016	0	1,845,620	794,352	38,000	118,687	1,470,664	289,855	376,000	343,170	1,805,151
2017	4,910	3,657,062	833,975	13,042	151,615	1,633,286	428,260	479,630	420,149	1,924,268
2018	17,479	3,811,762	1,210,592	0	96,239	1,644,186	197,557	332,657	422,771	1,966,896
2019	5,009	4,330,140	732,885	0	95,785	1,488,274	178,930	353,557	506,644	2,043,771

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 for aquaculture are provided annually by the Federal Statistical Office. Information on the origin of glass eels is not available.

Table 9: 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
2019	Germany	ND	ND	G	2,265

3.3.2 Aquaculture production

Data on aquaculture production is provided annually by the Federal Statistical Office and data on the use of aquaculture production is provided in the yearly report on freshwater fisheries (Brämick 2019). Data on use/life stage of produced eels are separated as ongrown eels (used for stocking) and yellow/silver eels at marketable size (mostly for human consumption). Data for 2020 are still provisional.

Data on use/life stage is not reported for the years before 2015, because there was a drastic decline (magnitude of ~10) in the quantity of ongrown eels from 2014 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. 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 10: 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 (*provisional data)

<table>
<tr><th>Year</th><th>Donor country</th><th>YS (kg)</th><th>OG (kg)</th></tr>
<tr><td>2007</td><td>Germany</td><td colspan="2">774,000</td></tr>
<tr><td>2008</td><td>Germany</td><td colspan="2">749,400</td></tr>
<tr><td>2009</td><td>Germany</td><td colspan="2">667,000</td></tr>
<tr><td>2010</td><td>Germany</td><td colspan="2">681,000</td></tr>
<tr><td>2011</td><td>Germany</td><td colspan="2">692,000</td></tr>
<tr><td>2012</td><td>Germany</td><td colspan="2">744,000</td></tr>
<tr><td>2013</td><td>Germany</td><td colspan="2">758,000</td></tr>
<tr><td>2014</td><td>Germany</td><td colspan="2">926,000</td></tr>
<tr><td>2015</td><td>Germany</td><td>1,147,000</td><td>29,000</td></tr>
<tr><td>2016</td><td>Germany</td><td>1,061,000</td><td>38,000</td></tr>
<tr><td>2017</td><td>Germany</td><td>1,073,000</td><td>38,000</td></tr>
<tr><td>2018</td><td>Germany</td><td>1,094,500</td><td>37,500</td></tr>
<tr><td>2019</td><td>Germany</td><td>1,256,000</td><td>30,000</td></tr>
<tr><td>2020</td><td>Germany</td><td>1,095,000*</td><td>30,400*</td></tr>
</table>

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 EMUs 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 per cent, the whole system can be divided into ten sub-areas 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 sub-area.

Based on this stratified structure, the overall impact of technical obstructions on the eel stocks is calculated on 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 is 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 not considered.

3.6 Other impacts

Predation by cormorants has been included in the GEM under "natural mortality". Estimates are based on numbers of cormorants in the relevant regions and proportion of eels in the diet of cormorants.

4 National stock assessment

4.1 Description of Method

Stock indicators were calculated with the German Eel Model IIIc (GEM IIIc). The model calculates the cohort development separately for males (no habitat specific growth rates in all EMUs) and females and is also used to estimate mortality rates. A description of the previous version (GEM II) has been published by Oeberst & Fladung (2012).

The model incorporates weight and sex of eels as well as the mean water temperature to estimate the natural mortality. Natural mortality was estimated based on Bevaqua et al. (2011) with three density levels. The areas given in the EMPs and in the reports include all potential eel habitats. 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 Council Regulation (EC) No 1100/2007, coastal waters have been included in some EMUs. In case, coastal waters are not included, fisheries should be reduced 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 the available data do not allow for a more differentiated approach. 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. The model predictions have been compared to empiric data by tagging experiments and empirical monitoring of silver eel escapement. These experiments largely supported model estimates, at least in the order of magnitude in the Elbe and Schwentine river systems, but also showed that the accuracy of model input parameters is crucial to receive realistic model outputs (Fladung et al. 2012b, Prigge et al. 2013). Some of the input data are still not available for each EMU. In these cases, values from the EMU Elbe were used. However, efforts continue to collect system specific data in the frame of the DCF.

Restocking is not included in the calculation of B_0 and B_{best}. $B_{current}$ includes the effect of restocking in all EMUs, where restocking applies. The values of $\sum A$ represent real mortalities and are not lowered by restocking.

4.1.1 Data collection

The main input parameters of the GEM IIIc 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, growth functions and length-weight relationships. For details see Oeberst & Fladung (2012).

The biological sampling, e.g. to determine growth etc., is mainly done in the frame of the DCF. Additionally, various DCF independent data collection programs exist in several states aiming to provide input data for the model.

4.1.2 Analysis

A description of the basic model has been given by Oeberst & Fladung (2012). An 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 Council Regulation (EC) No 1100/2007 and in the annual WGEEL Country Reports. The Progress reports are publicly available (in German):

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

4.1.4 Data quality issues and how they are being addressed

The model used to calculate the different population parameters of eel in German waters (Oeberst & Fladung 2012), has been further developed and improved (GEM IIIc) 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.

4.2 Trends in Assessment results

Modelled fishing and other anthropogenic mortality rates have decreased in all EMUs since the 2005-2007 time period except in River (Tab. 11). In absolute terms, mortalities due to fisheries (i.e. landings) and hydropower (i.e. eels lost to turbines and cooling water intakes) were also reduced in all German EMUs (Tab. 12 & 13).

Apart from the considerable influence of stocking on recruitment and differences in the fishing intensity, the 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).

It should be noted, that although other anthropogenic mortalities are presumed to be almost exclusively caused by hydropower, ΣH is not considered a good indicator for the development of mortality at hydropower plants and pumping stations. A detailed explanation is given by Fladung & Brämick (2021). 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 in 6 out of 9 EMUs over the observed time period (Fladung & Brämick 2021).

Table 11: Development of anthropogenic mortality rates after the implementation of eel management plans.

EMU	∑F			∑H			∑A		
	2005-2007	2017-2019	Change (%)	2005-2007	2017-2019	Change (%)	2005-2007	2017-2019	Change (%)
Eider	0.04	0.03	-23	0.01	0.01	-25	0.04	0.03	-23
Elbe	1.15	0.64	-44	0.25	0.15	-40	1.15	0.64	-44
Ems	0.13	0.12	-4	0.01	0.01	-7	0.13	0.12	-4
Maas	1.05	0.29	-73	0.08	0.07	-12	1.05	0.29	-73
Oder	0.24	0.21	-10	0.02	0	-90	0.24	0.21	-10
Rhine	0.81	0.74	-9	0.5	0.5	1	0.81	0.74	-9
Schlei/Trave	0.07	0.04	-51	<0.01	<0.01	-48	0.07	0.04	-51
Warnow/Peene	0.15	0.17	19	<0.01	<0.01	-51	0.15	0.17	19
Weser	0.47	0.43	-8	0.16	0.13	-22	0.47	0.43	-8
Total	**0.24**	**0.20**	**-17**	**0.06**	**0.05**	**-27**	**0.24**	**0.2**	**-17**

Table 12: Eel landings from commercial and recreational fishing (in tons) in Germany by EMU. Change is calculated as the average from 2005-2007 to the average of 2017-2019 (Source: German Progress Report (Fladung & Brämick 2021)).

EMU	2005	2006	2007	2017	2018	2019	Change (%)
Eider	29	28	25	7	6	6	-76
Elbe	297	313	299	210	201	188	-34
Ems	34	32	25	14	11	11	-60
Maas	0.4	0.4	0.4	0.1	0.1	0.1	-81
Oder	28	28	28	26	25	23	-11
Rhein	139	141	139	66	64	67	-53
Schlei/Trave	80	78	61	42	42	46	-41
Warnow/Peene	144	151	129	90	96	87	-36
Weser	100	100	94	62	53	57	-41
Total	**853**	**871**	**799**	**517**	**498**	**485**	**-41**

Table 13: Estimated losses of silver eels due to hydropower and cooling water intakes (in tons) in Germany by EMU. Change is calculated as the average from 2005-2007 to the average of 2017-2019 (Source: German Progress Report (Fladung & Brämick 2021)).

EMU	2005	2006	2007	2017	2018	2019	Change (%)
Eider	25	22	18	5	4	4	-81
Elbe	173	124	90	47	58	73	-54
Ems	6	5	5	1	1	1	-77
Maas	<1	<1	<1	≈0	≈0	≈0	-88
Oder	3	3	2	0	0	0	-93
Rhein	388	398	395	187	178	166	-55
Schlei/Trave	4	4	4	2	2	2	-58
Warnow/Peene	<1	<1	<1	≈0	≈0	≈0	-76
Weser	84	79	73	23	27	31	-66
Total	**684**	**635**	**588**	**264**	**271**	**277**	**-57**

5 Other data collection for eel

5.1 Yellow eel abundance surveys

Since 2003, an elver monitoring takes place in river Elbe (DoFpY) at 224 km distance from the sea. A special fyke net operates 2-4 days per week from May to October. The estimate is a projection of total catch (nr) based on monthly mean CPUE. For information on other activities regarding yellow eels in Germany see Country Report 2020.

5.2 Silver eel escapement surveys

In river Warnow a stow net (10 mm mesh size) is operating from March/April to December/January at a distance of 17 km to the Baltic Sea. Silver eel catch rate was repeatedly evaluated (mean: 11,1 %) and the yearly estimate is a Petersen-Lincoln projection of total escapement (nr). The Warnow River eel stock is considered to consist of >90% eels from stocked origin (Frankowski et al. 2018). For information on other activities regarding silver eels in Germany see Country Report 2020.

5.3 Life-history parameters

For information on DCF data collection and other activities regarding eel life-history parameters in Germany see Country Report 2020.

5.4 Diseases, Parasites & Pathogens or Contaminants

The results of a German EMFF monitoring and restocking project, which investigated health status of different eel stages from three North Rhine-Westphalian rivers, showed no bacterial infections, but frequently infections with A. crassus (91%) and/ or viral infections (cell culture results ranging from 25 – 83%, depending on river and eel stage). Elvers, yellow and silver eels were examined for infections with pathogenic eel viruses via a combination of cell culture and PCR. Whereas the pathogens anguillid herpesvirus 1 (AngHV-1), Eel virus European X (EVEX) and the newly discovered Eel picornavirus 1 (EPV-1) were detected in yellow eels, silver eels carried EVEX infections. Further, EPV-1 was the only virus found in 18.8% of the investigated elvers migrating in the lower Rhine (Danne et al., 2021). Based on initial infection experiments with glass eels it was proposed that EPV-1 can severely impede eel health, because seven of 16 infected eels had died after infection with EPV-1 (Fichtner et al., 2013).

Further information on activities regarding eel diseases, parasites, pathogens and contaminants in Germany see Country Report 2020.

6 New Information

Capoccioni F, Leone C, Giustini F, Brilli M, Buttazzoni L, Hanel R, Ciccotti E (2021) δ13C and δ15N in yellow and silver eels (Anguilla anguilla, 1758) from different Mediterranean local stocks and their variation with body size and growth. Mar Freshwater Res 72(8):1208-1219, DOI:10.1071/MF20144

Diekmann M, Brauer C, Meyer A, Göckemeyer S (2020) Fang- und Transportmaßnahmen von Blankaalen im Wesergebiet –Ergebnisse des Projektes „Aaltaxi Weser“. Landesfischereiverband Niedersachsen e.V., im Auftrag des LAVES. Final project report (in German)

Dorow M, Lewin WC, Lill D, Ubl C, Frankowski J (2021) Using logbook-based catch-rate data to detect yellow eel population trends in the southern Baltic Sea. Fisheries Management and Ecology, 00, 1– 9. https://doi.org/10.1111/fme.12505

Dorow M, Jünger J, Frankowski J, Ubl C (2020) Application of a 3-pass removal experiment to assess the yellow eel specific capture efficiency of a 1-ha enclosure, Fisheries Research, Volume 221

Fladung E, Simon J, Jung-Schroers V, Hennicke M, Arlt E, Witkowski J (2020) Abschätzung der fischereibedingten Schädigung von Blankaalen beim Fang mittels Aalschokker. Institut für Binnenfischerei e.V. Potsdam-Sacrow, im Auftrag des LAVES, 59 S. Final project report (in German)

Freese M (2020) The role of chemical pollution in the continental life of the European Eel (Anguilla anguilla L.). Kiel: Univ Kiel, 218 p, Dissertation

Kullmann L, Habedank F, Kullmann B et al. Evaluation of the bioaccumulation potential of alizarin red S in fish muscle tissue using the European eel as a model. Anal Bioanal Chem 412, 1181–1192 (2020). https://doi.org/10.1007/s00216-019-02346-4

Miller MJ, Hanel R, Feunteun E, Tsukamoto K (2020) The food source of Sargasso Sea leptocephali. Mar Biol 167:57,

Righton, D, Piper, A, Aarestrup, K, et al. Important questions to progress science and sustainable management of anguillid eels. Fish and Fisheries. 2021; 22: 762– 788. https://doi.org/10.1111/faf.12549

Schneebauer G, Lindemann C, Drechsel V, Marohn L, Wysujack K, Santidrian E, Dirks R, Hanel R, Pelster B (2020) Swimming under elevated hydrostatic pressure increases glycolytic activity in gas gland cells of the European eel. PLoS One 15(9):e0239627, DOI:10.1371/journal.pone.0239627

Simon J, Wickström H (2020) Long-term retention of alizarin red S marks and coded wire tags in European eels. Fisheries Research 224, 105453. https://doi.org/10.1016/j.fishres.2019.105453

Stein FM, Frankowski J, Nijman V, Absil C, Kranendonk I, Dekker W (2021) Chinese eel products in EU markets imply the effectiveness of trade regulations but expose fraudulent labelling, Marine Policy, Volume 132

7 References

Bevacqua, D.; Melià, P.; De Leo, G.A.; Gatto, M. (2011): Intra-specific scaling of natural mortality in fish: the paradigmatic case of the European eel. Oecologia. 1-7. DOI 10.1007/s00442-010-1727-9.

Brämick, U. (2019) Jahresbericht zur Deutschen Binnenfischerei und Binnenaquakultur 2019. IBG Potsdam-Sacrow

Brämick, U., Fladung, E. & Simon, J. (2015): Stocking is essential to meet the silver eel escapement target in a river system with currently low natural recruitment. ICES Journal of Marine Science. Doi:10.1093/icesjms/fsv113.

Danne L., Horn L., Feldhaus A., Fey D., Emde S., Schütze H., Adamek M., Hellmann J. (2021). Virus infections of the European Eel in North Rhine Westphalian rivers. Journal of Fish Diseases. DOI: 10.1111/jfd.13536

Dorow, M. & Arlinghaus, R. (2008): Ermittlung der Aalentnahme durch die Angelfischerei in Binnen- und Küstengewässern Mecklenburg-Vorpommerns. Projektendbericht; Institut für Gewässerökologie und Binnenfischerei (IGB) Berlin, 150 pp.

Dorow, M. & Arlinghaus, R. (2009): Angelbegeisterung und anglerische Fischerträge in Binnen- und Küstengewässern Mecklenburg-Vorpommerns unter besonderer Berücksichti-gung des Aals (Anguilla anguilla). Fischerei & Fischmarkt in Mecklenburg-Vorpommern 9 (2), 36-46.

Fichtner D., Philipps A., Groth M., Schmidt-Posthaus H., Granzow H., Dauber M., Platzer M., Bergmann S. M., Schrudde D., Sauerbrei A., Zell R. (2013). Characterization of a novel picornavirus isolate from a diseased European eel (Anguilla anguilla). Journal of Virology. 87:10895-10899. DOI: https://doi.org/10.1128/JVI.01094-13

Fladung, E. & Brämick, U. (2018): Umsetzungsbericht 2018 zu den Aalbewirtschaftungsplänen der deutschen Länder 2008. Auftraggeber: Niedersächsisches Ministerium für Ernährung, Landwirtschaft, Verbraucherschutz und Landesentwicklung. https://www.portal-fischerei.de/fileadmin/redaktion/dokumente/fischerei/Bund/Bestandsmanagement/Umsetzungsbericht_dt._AMP_2018.pdf

Fladung, E. & Brämick, U. (2021): Umsetzungsbericht 2021 zu den Aalbewirtschaftungsplänen der deutschen Länder 2008. Auftraggeber: Ministerium für Umwelt, Landwirtschaft und Energie des Landes Sachsen-Anhalt für die obersten Fischereibehörden der deutschen Bundesländer.

Fladung, E., Simon, J., Brämick, U., Doering-Arjes, P., Stein, F., Wolf, P., Weichler, F. Kolew, J. & Hannemann, N. (2012a): Quantifizierung der Sterblichkeit von Aalen in deutschen Binnengewässern am Beispiel der Havel. Institut für Binnenfischerei e.V. Potsdam-Sacrow, Projektabschlussbericht, Potsdam, 135 pp.

Fladung, E., Simon, J., Hannemann, N. & Kolew, J. (2012b): Untersuchung der Blankaalabwanderung in der niedersächsischen Mittelelbe bei Gorleben. Institut für Binnenfischerei e.V. Potsdam-Sacrow, Projektbericht im Auftrag des Niedersächsischen Landesamtes für Verbraucherschutz und Lebensmittelsicherheit (LAVES), Potsdam, 21 S.

Frankowski, J, Dorow, M, Juenger, J, et al. (2018) Behaviour, escapement and mortality of female European silver eels within a regulated lowland river draining into the Baltic Sea. Fish Manag Ecol. 2019; 26: 86–96. https://doi.org/10.1111/fme.12307

Oeberst, R. & Fladung, E. (2012): German Eel Model (GEM II) for describing eel, *Anguilla anguilla* (L.), stock dynamics in the river Elbe system. Inf. Fischereiforsch. 59: 9-17.

Prigge, E., Marohn, L., Oeberst, R. & Hanel, R. (2013): Model Prediction versus Reality – Testing the predictions of a European eel (*Anguilla anguilla*) stock dynamics model against the in-situ observation of silver eel escapement in compliance with the European Eel Regulation. ICES-Journal of Marine Science 70(2): 309-318.

Contents

i Report on the eel stock, fishery and other impacts in Greece, 2020–2021

Authors

Dr. Sapounidis Argyrios[1], Dr. Koutrakis Manos[1], Papadopoulou Paraskevi

[1] Hellenic Agricultural Organization "DEMETER" - Fisheries Research Institute (F.R.I), Sector of Inland waters and Lagoons. Email: asapoun@inale.gr

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Research teams

1) Fisheries Research Institute – Hellenic Agricultural Organization "Demeter"
   - Sapounidis Argyrios
   - Koutrakis Manos
   - Arapoglou Fotis
   - Christidis Aris
   - Papadopoulou Paraskevi

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1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

Under the GFCM Project "Research Programme on European eel: Towards coordination of European eel stock management and recovery in the Mediterranean", the data on the "Escapement biomass and mortality rates" are under evaluation and validation. Thus, the data will be available to Joint ICES/EIFACC/GFCM WGEEL by the end of the project.

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	A								
2016	B								
2016	C								
2016	D								
2016	E								
2016	F								
2016	G								
2016	H								
2016	I								
2016	J								
2016	K								
2017	L								
2017	M								
2017	N								
2018									

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.

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) (Figure 2.1.1.). 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. More-over, there are no scientific data for eel recreational fishing until today.

GR_NorW or EMU-01 (7 Prefectures, 3 Regions) is located on the North Western 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.

GR_WePe or EMU-02 (5 Prefectures, 2 Regions) is located on 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-1980's, contrary to the general pattern and now represents about 40% of the Hellenic lagoon landings (about 40 t).

GR_EaMT or EMU-03 (4 Prefectures, 1 Region) is located on the North Eastern 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 1980's to less than 10 t.

GR_CeAe or EMU-04 covers the rest of the country, mainly central eastern continental Greece and the islands of the Aegean Sea (35 Prefectures and 8 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 repro-duction migration carried from September to January every year. The fyke nets are also used in certain lagoons, where no permanent installed traps exist or during the year except the period of migration. The fishermen 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 declare every month to the regional authorities. The fishermen 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, fishermen use special eel traps (fyke nets). 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 fyke nets 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 the 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 licenses are needed for eel exports, the concealing of real catch-es 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 fyke nets inside the lagoons. In addition, all the eels that are going to be exported in other EU countries or transported inside the country are al-lowed 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 at the whole country. However, it must be noted that due to the restrictions opposed for the Covid-19 pandemic, very few samplings took place during 2020. There is an effort to collect extra data in 2021.

Figure 2.1.1. Map of EMUs in Greece (modified by Hellenic Eel Management Plan, 2009).

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 the fyke nets in all the lagoons, yellow eels are not fished. There are no data for eel landings of any stage from the freshwater fisheries. It must be mentioned that due to the fact the eel fisheries are 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).

Table x. Commercial catches (kg) of glass eel from x reported to the y, from 2005 to 2020. NP = not pertinent, in this case because ……..

Year	EMU	EMU	EMU	EMU	EMU	EMU
2005						
2006						
2007						
2008						
2009						
2010						
2011						
2012						
2013						
2014						
2015						
2016						
2017						
2018						
2019						
2020						

Table x. Effort used to take Commercial catches of glass eel from x reported to the y, from 2005 to 2020. NP = not pertinent, in this case because ……..

Year	EMU	EMU	EMU	EMU	EMU	EMU
2005						
2006						
2007						
2008						
2009						
2010						
2011						
2012						
2013						
2014						
2015						
2016						
2017						
2018						
2019						
2020						

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 fyke nets 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 co-operatives of fishermen. 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 licenses are issued for eel fisheries in the river. These licenses are used for two years and concerns professional fisheries with boat.

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 de-crease 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 of **lagoons** in 2020 for the three EMUs (EMU-01, EMU-02 and EMU-03) were 25,314.50 kg. In EMU-1 (GR_NorW) the landings recorded were 21,363.50 kg, in EMU-2 (GR_WePe) the total landings were 3,500.00 kg and finally in EMU-3 (GR_EaMT) the landings were 451.00 kg.

Additionally, licenses for eel fisheries were provided to fishermen to perform eel fisheries in lakes, rivers and lagoons (independently from Fishing Cooperatives). The total landings of the licensed fisheries were 1,469.00 kg in EMU-1 (GR_NorW), 877.00 kg in EMU-3 (GR_EaMT) and 85 kg in EMU-4 (GR_CeAe)

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 2019, one permission was issued for the import of 155 kg of glass eel from France, 15.5kg 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 2019, the total biomass of silver eels that were released was 7,467kg, which corresponds to a 38.31%% of the total annual silver eels' catches, while the limit that was set by the HEMP was 30%.

3.3 Aquaculture

Regarding the Aquaculture production, eel rearing occurred in two units in the area of EMU-1 (GR_NorW). The first one, which is one of the major eel rearing farm, sold 6,000 kg in the internal market and 173,670 kg of live eels and smoked products abroad, mainly in Italy and Netherlands. The second rearing farm sold 4,770 kg of live eels in the internal market.

In total eels sold live or as smoked product is 184,440kg, all coming from EMU-1.

3.4 Entrainment

According to the Public Electricity Company (Argyrakis 2008), in Greece there are 16 large scale and 8 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 are 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 disrupts 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 age determination of eel, for 2020, carried out according to the modified Crack and Burn protocol, which was used the previous years.

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

As part of the Data Collection Framework a "Methodology and Data Quality Assurance Framework for anadromous and catadromous species" was prepared and it can be found online in the address (https://inale.gr/wp-content/uploads/2021/03/GREECE-Eel-Methodology-data-QAF_2020.pdf).

4.2 Trends in Assessment results

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 fyke nets in Lake Vistonida, after the Management Body of the National Park, issued a special research license for yellow eels' fisheries through-out the year. Due to unforeseen issues the presentation of the first results was postponed and are expected to be presented in the following years.

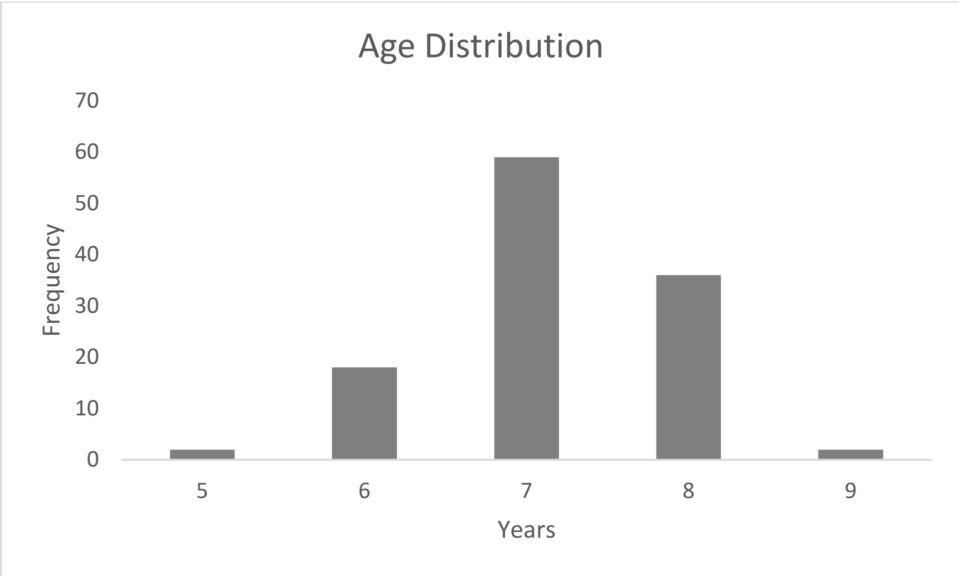
5.2 Silver eel escapement surveys

NO AVAILABLE DATA

5.3 Life-history parameters

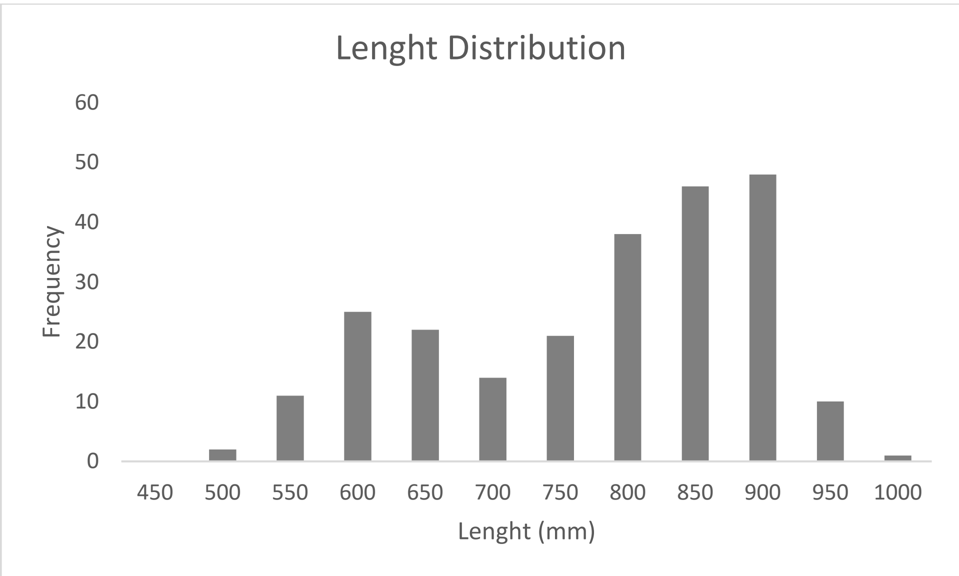
Age Distribution

The age was determined using otoliths from 119 samples collected from EMU 3. The youngest eels were 5 years old and the oldest one 9 years old. However, the most abundant class was the 7 years old, and the second most frequent the 8 years old.



Length Distribution

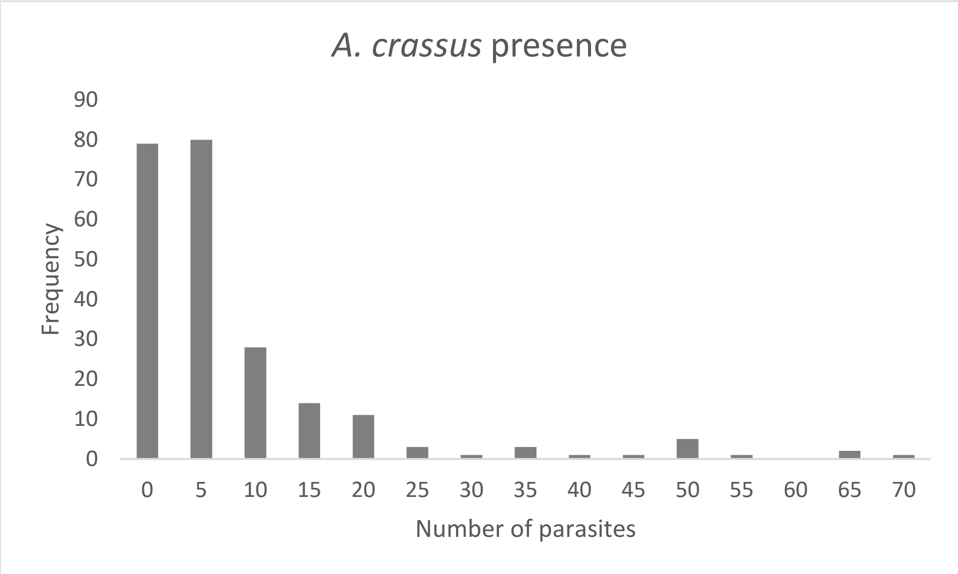
The length from 238 eel samples was used to create the Length Frequency Histogram. The smallest one grew in size of 450 mm, while the biggest one was 970 mm. the most frequent size class was the 850 mm and the 900mm.



5.4 Diseases, Parasites & Pathogens or Contaminants

Parasites & Pathogens

In 2020, 34,78%% of the eel samples that examines were not infected by the parasite *Anguillicola crassus*, and 30% were infected by the parasite (in 1 specimen 70 parasites were counted).



6 New Information

During 2020, one paper was published on the morphometric characteristics and pathogenicity in wild eels:

- Kantzoura V., Sapounidis A.S., Kouam M.K., Kolygas M.N., Krey G., Koutrakis E.T. 2020. Anguillicola crassus: morphometric characteristics and pathogenicity in wild eels (Anguilla anguilla) in Greece. *Veterinary Parasitology: Regional Studies and Reports*, 25: 100586. https://doi.org/10.1016/j.vprsr.2021.100586 .

Moreover, two projects are under implementation:

- Research Programme on European eel: Towards coordination of European eel stock management and recovery in the Mediterranean, funded by General Fisheries Commission for the Mediterranean (GFCM)
- Urgent measures in the Eastern Mediterranean for the long term conservation of endangered European eel – LIFEEL (LIFE19 NAT/IT/000851)", funded by LIFE.

7 References

Aschonitis V.G., Castaldelli G., Lanzoni M., Merighi M., Gelli F., Giari L., Rossi R., Fano E.A., 2015. A size-age model based on bootstrapping and Bayesian approaches to assess population dynamics of Anguilla anguilla L. in semi-closed lagoon. Ecology of Freshwater Fish 2017: 26: 217–232.

Cladas Y., Koutsikopoulos C., Zompola S. & Ioannou G., 1999. Glass eel (*Anguilla anguilla*, L.) of the western Greek coast: abundance and size composition fluctuations in relation to environmental factors. 8th Int. Congress on the Zoogeography and Ecology of Greece & adjacent regions, Kavala, Greece.

Daoulas C., Economou A.N., Psarras Th., Barbieri-Tseliki R., Papadakis V., Economou A.I., 2000. A study on glass eels (*Anguilla anguilla* L.) and the support of their ascent and dispersal in inland waters. Proceedings of the 9th Hellenic Congress of Ichthyologists, 165-168 (in Greek with English abstract).

Durif C., Guibert A., Elie P. 2009. Morphological discrimination of the silvering stages of the European eel. p. 103–111. In: Casselman, J. M., Cairns, D. K. (Eds) Eels at the Edge: Science, Status, and Conservation Concerns. American Fisheries Society Symposium. Bethesda, MD, U.S.A.

ICES, 2009. Workshop on Age Reading of European and American Eel (WKAREA), 20-24 April 2009, Bordeaux, France. ICES CM 2009\ACOM: 48. 66 pp.

Katselis G., Koutsikopoulos C., Dimitriou E. & Rogdakis Y., 2003. Spatial patterns and temporal trends in the fishery landings of the Messolonghi-Aitoliko lagoon system (western Greek coast).Scientia Marina, 67(4): 501-511.

Koutrakis E.T., Conides A., Parpoura A.C., van Ham E.H., Katselis G. & Koutsikopoulos C., 2007. Lagoon Fisheries' Resources in Hellas. Chapter 6, pp. 223-234. In. Papaconstantinou C., Zenetos A., Vassilopoulou V. & Tserpes G. (eds), State of Hellenic Fisheries. Hellenic Centre for Marine Research, Athens, Greece.

Koutsikopoulos C., Cladas Y., Katselis G., Zompola S., Dimitriou E., Mitropoulos D. & Chatzispyrou A., 2009. Hellenic Eel Management Plan. General Directorate of Fisheries of the Ministry of Rural Development and Food (MRDF, Des.No. 147800), 55pp.

MacNamara R., Koutrakis E.T., Sapounidis A., Lachouvaris D., Arapoglou F., Panora D. & McCarthy T.K., 2013. Reproductive potential of silver European eels (*Anguilla anguilla*) migrating from Vistonis Lake (Northern Aegean Sea, Greece). Mediterranean Marine Science. (In press).

MacNamara R., McCarthy T.K. 2012. Size-related variation in fecundity of European eel (*Anguilla anguilla*). ICES Journal of Marine Science, 69: 1333–1337.

Pankhurst N.W. 1982. Relation of visual changes to the onset of sexual maturation in the European eel Anguilla anguilla (L.). *Journal of Fish Biology*, 21: 127–140.

Scientific, Technical and Economic Committee for Fisheries (STECF) Evaluation of 2014 MS DCF Annual Reports & Data Transmission (STECF-15-13). 2015. Publications Office of the European Union, Luxembourg, EUR 27410 EN, JRC 96975, 287 pp.

Tesch F.W. 2003. The Eel. Fifth edition. Blackwell, Oxford, UK, 408 pp.

Volponi S. 1997. Cormorants wintering in the Po Delta: estimated and possible impact on aquaculture production. Suppl. Ric. Biol.323-332.

Zompola S., Cladas Y., Vavoulis D., Kentrou A., Pagoni S., Koutsikopoulos C., 2001. European eel (*Anguilla anguilla* L.) fisheries production in Greece. Proceedings of the 10th Hellenic Congress of Ichthyologists, 237-240 (in Greek with abstract in English).

Contents

i Report on the eel stock, fishery and other impacts in Italy, 2020–2021

Chiara Leone[1], Eleonora Ciccotti[1], Francesca De Luca[1], Fabrizio Capoccioni[2].

[1]Dipartimento di Biologia, Università di Roma – Tor Vergata

[2]Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria (CREA) - Centro di Zootecnia e Acquacoltura (ZA).

Reporting Period: This report was completed in September 2021 and contains data up to 2020.

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 rely on an eel management plan (9 EMUs). There is no fishery in the other 11 Regions, and no specific management measures have been foreseen for eel, but stock status parameters have been assessed for these regions as well.

In Italy, five habitat typologies have been identified relevant to eel. The relative wetted areas and eel stocks have been assessed in each region: 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 revised. 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 2019 and in the Progress report 2018 for art.9 Reg. 1100/2007 have been aggregated as required. In Table 1, data have been aggregated for each EMU.

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	IT_Abru	236	1927.81	406.48	472.53	21	0.01	0.12	0.13
2017	IT_Basi	218	2318.05	557.38	713.83	24	0.01	0.21	0.22
2017	IT_Cala	192	1579.90	388.61	486.50	25	0.03	0.15	0.18
2017	IT_Camp	570	4598.88	1493.50	1948.79	32	0.03	0.19	0.22
2017	IT_Emil	5663	30983.97	9094.20	7589.37	29	0.05	0.06	0.11
2017	IT_Frio	1356	5840.51	1330.19	1430.25	23	0.15	0.03	0.17
2017	IT_Lazi	1859	40194.23	5002.67	16868.37	12	0.84	0.42	1.26
2017	IT_Ligu	344	1683.58	627.58	714.35	37	0.02	0.07	0.09
2017	IT_Lomb	6163	65560.90	6673.20	11761.10	10	0.00	1.01	1.02
2017	IT_Marc	228	3515.90	622.99	861.77	18	0.02	0.27	0.29
2017	IT_Moli	73	902.62	206.37	277.35	23	0.01	0.25	0.26
2017	IT_Piem	780	15632.05	575.25	2801.16	4	0.01	1.37	1.37
2017	IT_Pugl	414	1883.14	541.42	579.70	29	0.01	0.04	0.05
2017	IT_Sard	600	17662.59	422.32	7488.11	2	2.01	0.15	2.16
2017	IT_Sici	238	2311.36	700.00	978.84	30	0.03	0.24	0.28
2017	IT_Tosc	1064	9254.46	3749.29	3911.69	41	0.01	0.25	0.26
2017	IT_Tren	370	7195.46	105.38	1288.16	1	0.01	1.77	1.77
2017	IT_Umbr	12800	3568.86	0.00	639.37	0	0.01	NP	NP
2017	IT_Vall	0	1082.24	0.00	193.66	0	0.01	NP	NP
2017	IT_Vene	10917	138796.53	32167.82	33979.45	23	0.11	0.09	0.20
2017	IT_Abru	NP	NP	NP	NP	NP	NP	Inf	NP
2017	IT_Basi	NP	NP	NP	NP	NP	NP	Inf	NP
2017	IT_Cala	NP	NP	NP	NP	NP	NP	Inf	NP
2017	IT_Camp	487	9740.00	4059.11	4072.15	42	0.00	0.00	0.00
2017	IT_Emil	21363	427251.90	74264.55	106467.43	17	0.49	0.00	0.11
2017	IT_Frio	14360	287192.00	70148.98	71552.10	24	0.09	0.00	0.09
2017	IT_Lazi	1543	30860.00	9126.29	14228.68	30	0.15	0.00	0.15
2017	IT_Ligu	NP	NP	NP	NP	NP	NP	Inf	NP
2017	IT_Lomb	NP	NP	NP	NP	NP	NP	Inf	NP
2017	IT_Marc	NP	NP	NP	NP	NP	NP	Inf	NP
2017	IT_Moli	NP	NP	NP	NP	NP	NP	Inf	NP
2017	IT_Piem	NP	NP	NP	NP	NP	NP	Inf	NP
2017	IT_Pugl	11533	397888.50	109595.85	123504.97	28	0.05	0.00	0.05
2017	IT_Sard	7961	192723.71	27655.04	81888.29	14	0.96	0.00	0.96
2017	IT_Sici	278	5560.00	2236.17	2362.53	40	0.02	0.00	0.02
2017	IT_Tosc	2700	66150.00	956.41	27651.34	1	3.36	0.00	3.36
2017	IT_Tren	NP	NP	NP	NP	NP	NP	Inf	NP
2017	IT_Umbr	NP	NP	NP	NP	NP	NP	Inf	NP
2017	IT_Vall	NP	NP	NP	NP	NP	NP	Inf	NP
2017	IT_Vene	81717	1634336.00	356543.06	407287.24	22	0.11	0.00	0.11

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 recruitment data series supplied in the past to the Working Group were relative to fishery-based monitoring (commercial catch) on the river Tiber estuary (Figure 1), 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 (Figure 2). 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 centralized monitoring programme of recruitment is currently in place anywhere in Italy.

Table 2 reports available time-series and monitoring of glass eel recruitment in Italy activated within the Regional Eel Management Plans or other Eel specific projects. Since 2013, some region recruitment monitoring has been progressively started 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 Eel Regional Plans implementation programmes supported by the European Fisheries Funds and funding at the local level (regional).

For the EMU Lazio, a regional monitoring has begun that considers some sites (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 crucial to have these monitoring sites in place in central Italy for comparison and eventually integration with the past time series. Other monitoring are carried out in other EMUs, such as Tuscany (TOS) and Emilia Romagna (EMR), but the regions have provided no details for the present report, nor in the report for the EMP, for what concerns sites, data and methodologies.

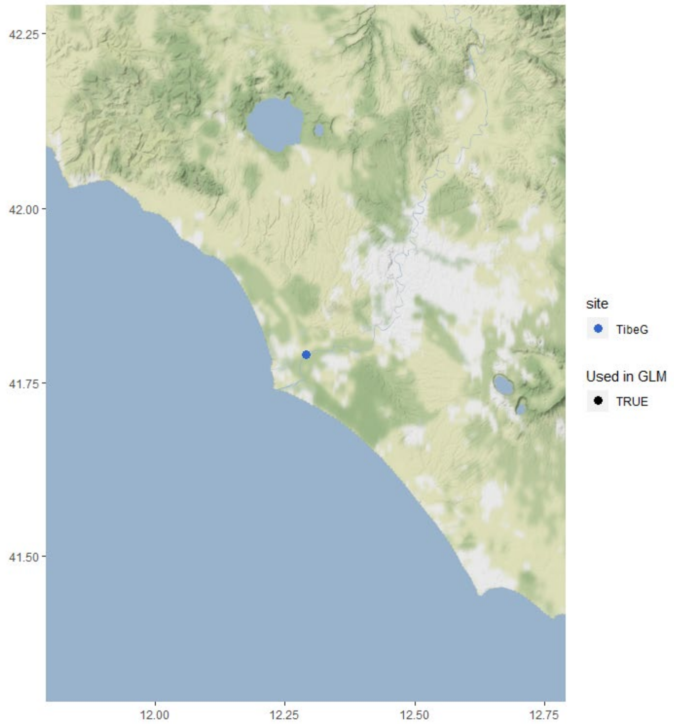


Figure 1 Map of the location of the recruitment time series at the river Tiber estuary, Italy.

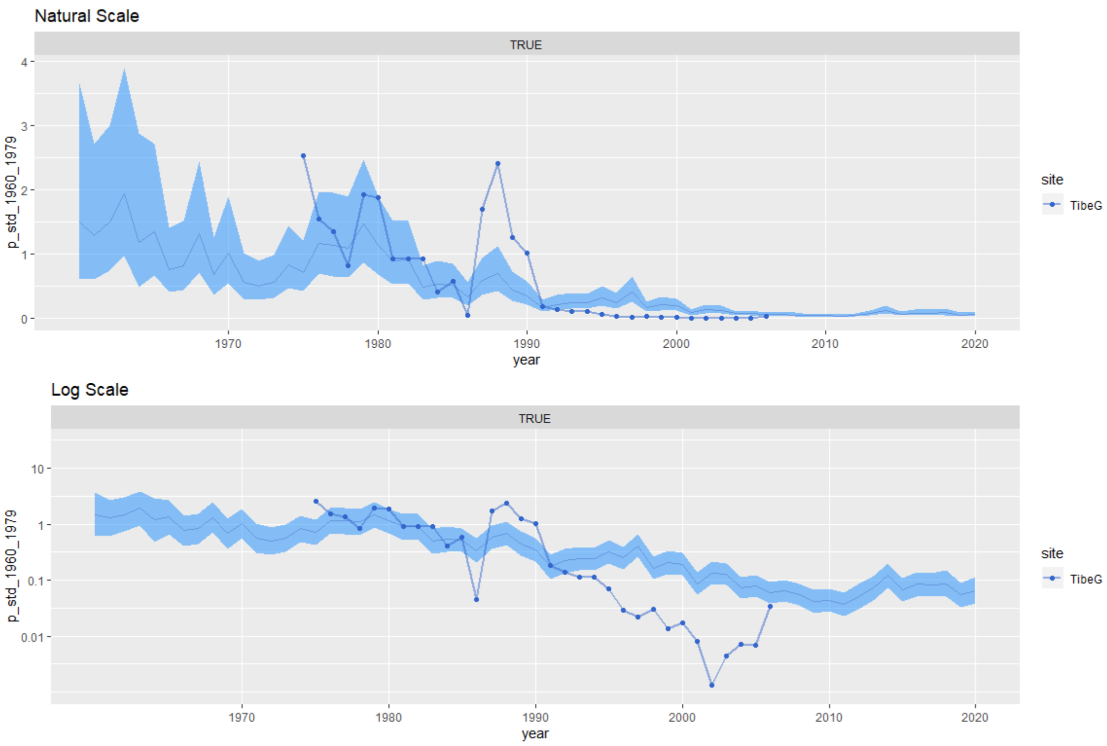


Figure 2. Recruitment time series supplied to the Working Group relative to the river Tiber, specifically carried out within a series of research projects for the resource assessment.

Table 2 Available time-series and/or monitoring of glass eel recruitment in Italy, and monitoring that has 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	2019
LAZ	F	Marta	com. catch+sci. monit.	kg	daily	1999	2008
LAZ	F	Marta	weekly monit.	Number	1 week/month	2013	2019
LAZ	T	Fogliano	weekly monit.	Number	1 week/month	2013	2019
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
LAZ	F	Garigliano	sci. monit.	Number, kg	1 week/month	2017	2019
TOS	T	Orbetello	sci. monit.	Number, kg	1 week/month	2019	2020
PUG	T	Lesina	sci. monit.	Number	1 week/month	2013	2019
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
EMR	T	Po di Goro	sci. monit.	Number, kg	1 week/month	2019	2020
EMR	T	Po di Volano	sci. monit.	Number, kg	1 week/month	2019	2020

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

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); this should ensure the setting up of a methodology for the long-term monitoring of recruitment data in key sites in Italy.

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. It 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 the 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). Regarding inland fisheries, which include lagoon and lake and river fisheries, each region has its Regulation. Since 2009, specific regulations for eel are being issued concerning the application of the Eel Management Plans. Up to now, no specific eel fishing licenses are foreseen. 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, in relation to local traditions, and are specified by each Administration and authorized times and places.

In the last two years (2019, 2020) after the Recommendation GFCM 42/2018/1 on a multiannual management plan for European eel in the Mediterranean Sea and the Council Regulation (EU) 2019/124 of 30 January 2019, art. 42, a Ministry decree n°403 25/07/2019 in 2019 set different fishing closure of three consecutive months in all the 9 EMUs, that has been harmonized at the National level from 2020 establishing a common fishery closure from 1st January to 31st March.

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 2020 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).

The management framework for DCF is the same 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 3). 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 3).

Figure 3 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 3 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 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.

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, great ecological heterogeneity exists in the different Italian EMUs, which also reflects in the 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 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 co-operative 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, based on 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 e Forestali (MIPAAF) (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, specifying that this quota relates to restocking into waters which flow into the sea, so that the measure will contribute to the 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 authorized to fish glass eel, allocation of quotas and the obligation to submit catch returns. This new legislation came into 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 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 and any other activity involving eels, such as commercial and recreational fishing for eels.

2.2 Significant changes since last report

In the last years (2019 and 2020), several coordination issues have arisen: the need for coordination with other activities at the 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; the need for coordination with activities required by other international frameworks for the management and restoration of the eel stock (Recommendation GFCM / 42/2018/1 on a multiannual management plan for the 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).

To implement the data collection system, the corrective measure to this situation 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 MIPAAF, to be set up within the European Maritime and Fisheries Fund (EMFF). It may envisage coordination for some common activities of Eel Management Plans, delegating to the Regions some data collection activities and monitoring, sharing and coordinating methodologies.
This will allow to set up a shared framework for the Eel Data Collection, which satisfies both the requirements of Data Collection in the following years and those imposed by the need to assess the eel stock according to Art. 9 of EC Regulation 1100/2007. Moreover, it will satisfy all additional frameworks defined at various national and international levels (CITES; GFCM, etc).
For 2020, the Fisheries Offices of the 9 EMUs were involved in surveying in a coordinated and shared way. The protocol for the surveys (questionnaires, interview methodology, data storage system) was shared during a first online meeting with the Regional Fisheries Offices coordinators and MIPAAF (Ministero delle Politiche Agricole Alimentari, Forestali) to conduct the interviews with their collaboration, as far as possible. Additionally, a questionnaire has been introduced to evaluate the COVID-19 impact. In detail, landings were asked to be reported on an annual and quarterly basis and questions about the periods of fishing downtime, the effects of the lockdown, the suspension of fishing activities and marketing activities were submitted.
In addition, within the Project of the GFCM "European eel research programme under Recommendation GFCM/42/2018/1 (on-going, September 2020-February 2022)", a revision of all available fishery-related data is currently underway. That will be finally acknowledged in 2022 for all data on the DCRF online platform and under the National frameworks.

In March 2021, a second online meeting was held with the Regional Fisheries Offices coordinators to revise results from 2018 to now of commercial and recreational landings for each region. Within the "Data collection framework" activities, a drop of ca. 40% in the landings is reported for the year 2020 with respect to catches reported in 2018, partly due to the COVID pandemic situation and partly to other reasons.

In 2020 in fact, the implementation of the fishery closure at the National level (within the Ministry decree n°403 25/07/2019 establishing a common fishery closure from 1st January to 31st March, concerning all eel life stages related to the commercial and recreational fishery in all habitat and aquaculture facilities) was completed, and other reasons at the local levels also resulted in a reduction in fishing effort in some EMUs.

Notwithstanding the coordination efforts among Regional Officers, Ministry and the Scientists involved, the coordination of the eel activities during 2020 and 2021 has been lacking due to reduced activities linked to the extended lockdown due to COVID-19 pandemics.
This has also reflected on the delayed response to international obligations and Data Calls of the last year (2020) and the missed implementation of a framework at the Central level for updating and gathering data for the National Report under art.9 of the Eel regulation as foreseen this year (2021).
For this reason, in the present report, no data have been reported or updated about: anthropogenic mortality, Biomass Indicators, Assessment and monitoring methods, Measures including conservation, management and others, Landings related to transport/relocation operations, Releases and Proportions of eel less than 12 cm.

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, which 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 challenging to assess. Theoretically, it would coincide with the number of fishers licensed for fishing in inland waters (river and lakes) and coastal lagoons, both commercial and recreational, even if in the practice fishers are 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 fishers exploit 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 EMU. Most eel catch is from fyke nets fisheries, used in all habitat typologies in all EMUs. 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 fisherman/cooperative 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 fishermen) is used to evaluate data for recreational anglers.

Annual mean cpue for 2020 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 2021.

3.1.1 Glass eel fisheries

The glass eel regulation foresees that glass eel fisheries can continue for restocking on a local scale 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, and that illegal fishing is definitively broken off. With regard to the destination of glass eel catches, based on 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 escape registration.

At present, 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.

For 2020 there are no declared glass eel catches to the Central Administration, as inferred by the fishermen declarations.

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

Table 3. Commercial catches (kg) of glass eel from 2005 were reported to 2020. NP = not pertinent, in this case, due to M.D. 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."

Year	IT_Lomb	IT_Vene	IT_Frio	IT_Emil	IT_Tosc	IT_Umbr	IT_Lazi	IT_Pugl	IT_Sard
2005	NP	NP	NP	NP	NP	NP	NP	NP	NP
2006	NP	NP	NP	NP	NP	NP	NP	NP	NP
2007	NP	NP	NP	NP	NP	NP	NP	NP	NP
2008	NP	NP	NP	NP	NP	NP	NP	NP	NP
2009	NP	NP	NP	NP	NP	NP	NP	NP	NP
2010	NP	NP	NP	NP	NP	NP	NP	NP	NP
2011	NP	NP	NP	NP	ND	NP	ND	NP	NP
2012	NP	NP	NP	NP	ND	NP	ND	NP	NP
2013	NP	NP	NP	NP	ND	NP	ND	NP	NP
2014	NP	ND	NP	NP	209	NP	217	NP	NP
2015	NP	ND	NP	NP	67	NP	92	NP	NP
2016	NP	15	NP	NP	10	NP	35	NP	NP
2017	NP	NP	NP	NP	ND	NP	146	NP	NP
2018	NP	NP	NP	NP	ND	NP	243	NP	NP
2019	NP	NP	NP	NP	ND	NP	243	NP	NP
2020	NP	NP	NP	NP	ND	NP	ND	NP	NP

3.1.2 Yellow eel fisheries

Figures 4 and 5 show *yellow eel landings reported by EMUs separately for commercial and recreational fisheries* in Italy since 2009, updated to 2020. Tables 4 and 5 show *yellow eel landings for commercial and recreational fisheries* in Italy since 2009. Annual landings of yellow eel for commercial and recreational fisheries in the year 2020 accounted for 48 tonnes, as evaluated under the DCF programme.

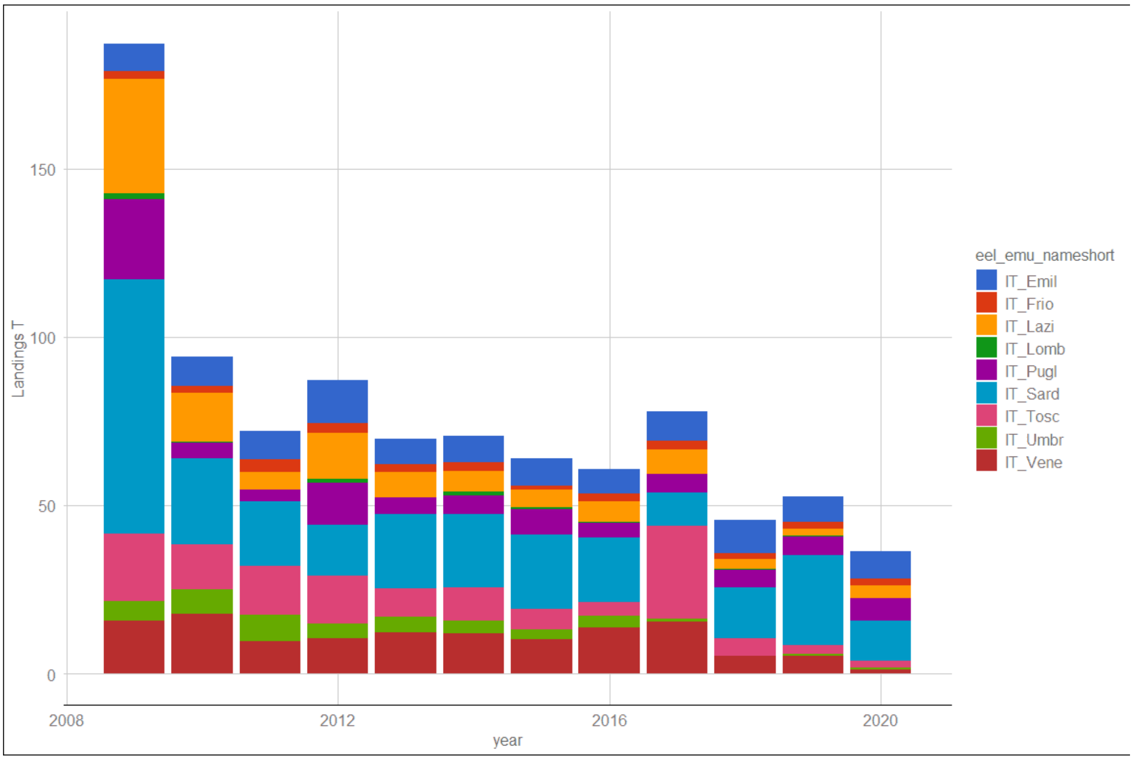


Figure 4 Commercial landings (t) of yellow eel reported per EMUs (9 Administrative Units) since 2009.

Table 4 Commercial landings (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	13,778	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	77	1,175		101	2,137		810
	T		3,879	1,876	8,681	5,153		743	5,378	14,388
2019	F	122	1,255	90	948		839	1,414		649
	T		3,879	1,917	6,648	2,499		743	5523	26,096
2020	F	71	211	90	728		610	2,557		1,786
	T		976	1,738	7,452	1,997		1,200	6,615	10,266

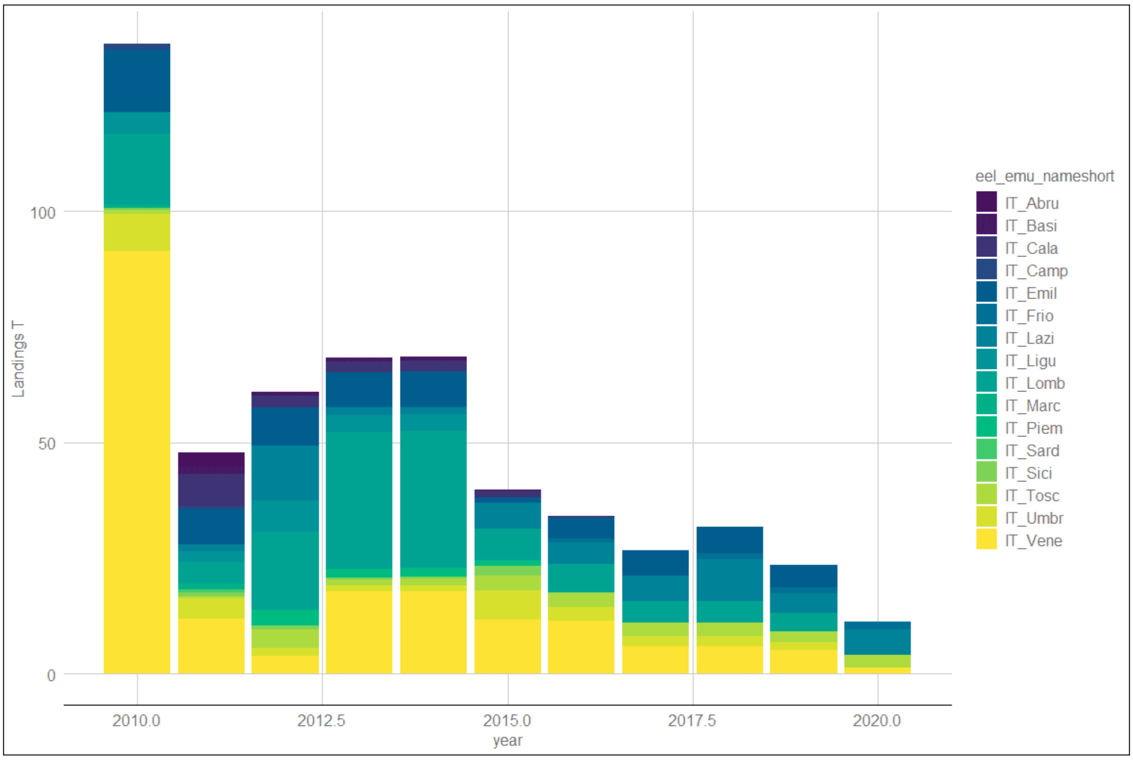


Figure 5 Recreational landings (t) of yellow eel reported per EMUs (9 Regions) and other Administrative regions since 2009.

Table 5 Recreational landings (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
	T										
2019	F	164	5,070	1,301	4,794	2,391	1,708	4,255			
	T										
2020	F		1,266	1,675		2,881		5,339			
	T										

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

3.1.3 Silver eel fisheries

Figures 6 and 7 show *silver eel landings reported by EMUs separately for commercial and recreational fisheries* in Italy since 2009, updated to 2020. Tables 6 and 7 show *silver eel landings for commercial and recreational fisheries* in Italy since 2009. Annual landings of silver eel for commercial and recreational fisheries in the year 2020 accounted for 66 tonnes, as evaluated under the DCF programme.

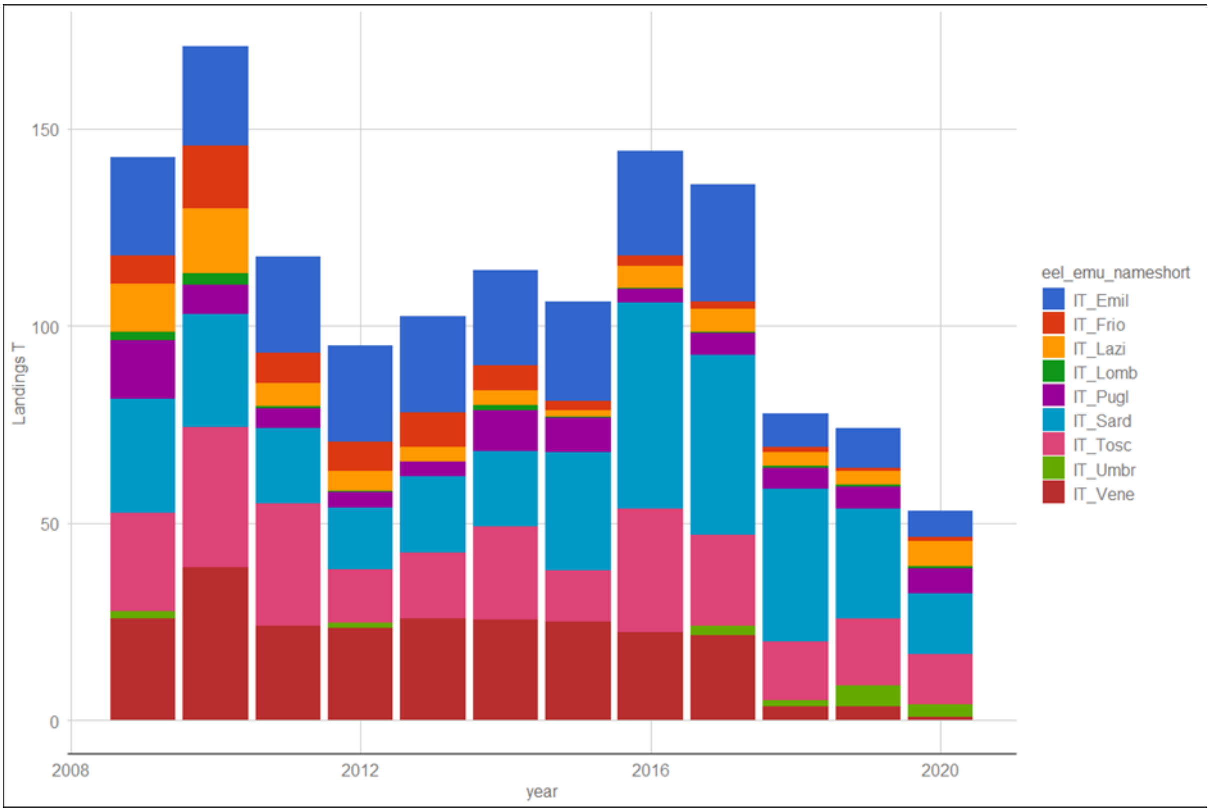


Figure 6 Commercial landings (t) of silver eel reported per EMUs (9 Administrative Units) since 2009.

Table 6 Commercial landings (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	95	40		1,621	2,028		2646
	T		2,150	1,423	8,331	14,855		1,403	5,428	36,096
2019	F	694	1,295	146	27		5,229	1,921		2,467
	T		2,150	821	9,873	17,233		1,403	5,574	25,174
2020	F	403	784	146	68		3,253	5,973		1,786
	T		53	1,054	6,514	12,683		400	6,510	13,542

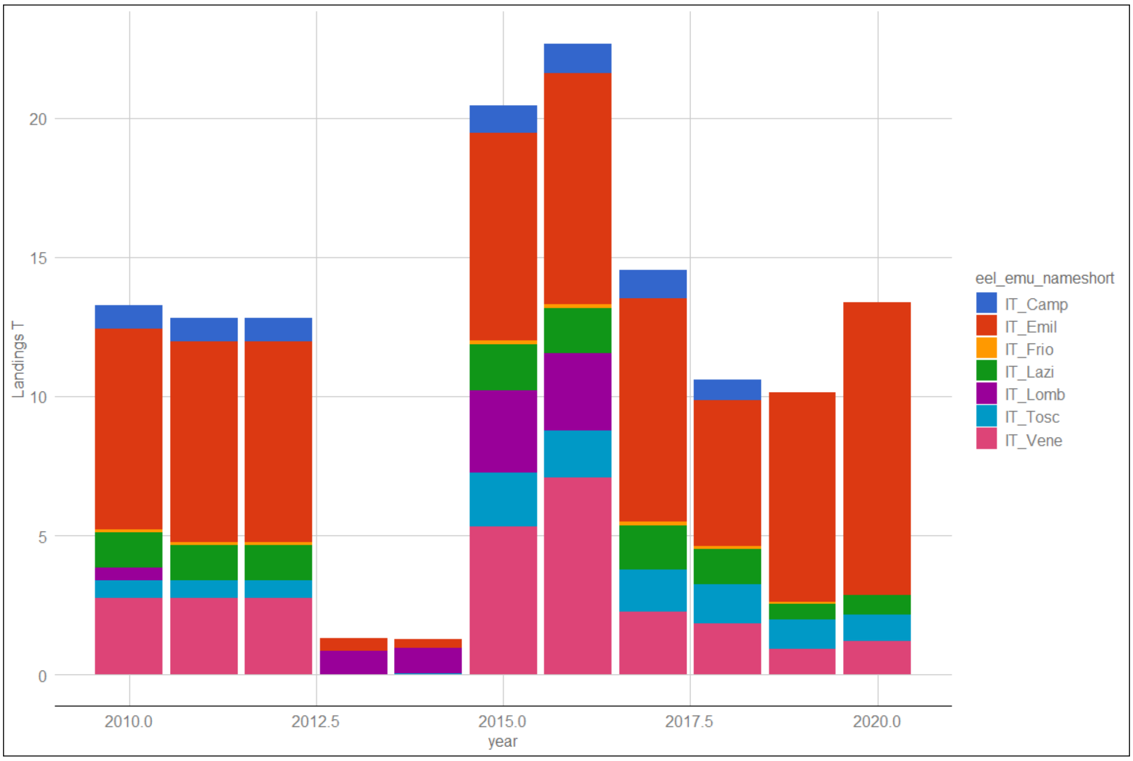


Figure 7 Recreational landings (t) of silver eel reported per EMUs (9 Administrative Units) since 2009.

Table 7 Recreational landings (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										
2019	F	3	907	60	7,545	1,066		559			
	T										
2020	F		1,202	30	10,500	961		677			
	T										

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

3.2 Restocking

No available data for 2020.

3.3 Aquaculture

Data are not available for 2020 national eel aquaculture production since the deadline for the EUROSTAT data call (under Reg. 762/2008) is December 2021. Figure 8 shows total aquaculture production in Italy since 2009, updated to 2019. Information requested in this section is collected under the DCF (Task "Aquaculture") and used for SIPAM databases and EuroStat (Regulations 788/96 and 762/2008 on the submission by the Member States of Statistics on Aquaculture production).

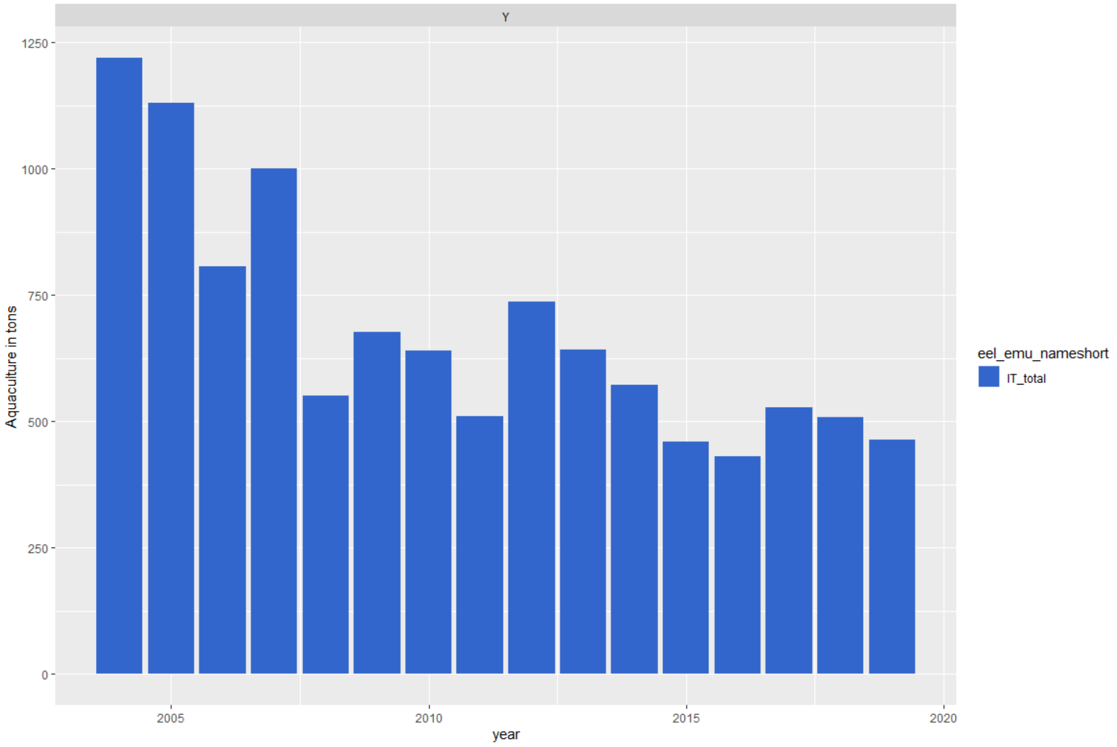


Figure 8. Aquaculture production in Italy from 2009 to 2019.

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 9 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 are 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 regularly under the DCF since 2009.

Since 2017, the new DCF established 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 2020, a total of 188 individuals (yellow and silver eel) were sampled 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 fisherman cumulated catch of the day or the week.

Further information is available in the Annual 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 2020 Regolamento CE 199/2008 Work Package 2 – Campionamento biologico - Task 2.3a Anguilla Work Package 3 – Pesca Ricreativa - Task 3.1 Anguilla).

4.1.2 Analysis

Procedures and methods usually used for the evaluation are described below.

Age determination

The procedure 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). Still, it has been modified in several steps in laboratories of the University of Rome "Tor Vergata" (Capoccioni *et al.*, 2015).

Life stages

The 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", 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 2020 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 under the requirements of Reg. CE 199/2008 and tables are uploaded to the National Database "FISHNET".

There is no objection to the disclosure of the central part of the CR and the Annexed Tables to any third party. In contrast, 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 evaluation 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, the DCF, with the eel modules concerning the commercial and recreational fisheries, and the biological samplings, proved to be necessary. Also, the specific monitoring carried out by Regions at the local level, but with a standardized methodology, are an irreplaceable tool. 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 Bcurrent, 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 (Bcurrent and Bbest) 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 no data from specific surveys are available. Since 2017 within the EU MAP 2017-2019 module 1E: "Anadromus and catadromus species data collection in fresh water", a pilot study started aimed at establishing a standardized methodology for the monitoring of *Anguilla anguilla* (glass eel + yellow and silver eel); this should ensure the setting up of a methodology for the long-term monitoring of recruitment data in key sites in Italy.

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 anguill*a (glass eel + yellow and silver eel); this should ensure the setting up of a methodology for the long-term monitoring of recruitment data in key sites in Italy.

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.

5.3 Life-history parameters

No available data.

5.4 Diseases, Parasites & Pathogens or Contaminants

No relevant data are available on diseases, parasites, pathogens and contaminants, because new data are not available, and no routine monitoring has been implemented on a centralized 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 particular results.

A research project between CREA and Tor Vergata University have been carried out. The project foresaw the study of eel quality through analysis of contaminants in two coastal lagoons of the central Tyrrhenian coast of Italy. Capoccioni et al., *2020* show low contamination profiles of silver eels in the two lagoons, assessed on many compounds, including OCs, pesticides and metals, without evident differences on a site basis. 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

Aalto, E., Capoccioni, F., Terradez Mas, J., Schiavina, M., Leone, C., De Leo, G. and Ciccotti E. 2016. Quantifying 60 years of declining European eel (*Anguilla anguilla* L., 1758) fishery yields in Mediter-ranean coastal lagoons. ICES J. Mar. Sci. first published online May 8, 2015 doi:10.1093/icesjms/fsv084.

Acou A., Boury P., Laffaille P., Crivelli A.J., Feunteun E. 2005. Towards a standardized characterization of the potentially migrating silver European eel (*Anguilla anguilla* L.). Arch. Hydrobiol., 164, 237–255.

Bevacqua, D., G. De Leo, M. Gatto, and P. Melià. 2009. Size selectivity of fykenets for European eel *Anguilla anguilla*. Journal of Fish Biology, 74:2178–2186.

Bevacqua, D., Melià, P., Crivelli, A.J., De Leo, G.A. and Gatto, M. 2006. Timing and rate of sexual maturation of European eel in brackish and freshwater environments. Journal of Fish Biology, 69 Supplement C:200–208.

Bevacqua, D., Melià, P., De Leo, G.A. and Gatto M. 2011. Intra-specific scaling of natural mortality in fish: the paradigmatic case of the European eel. Oecologia 165, 333–339.

Capoccioni, F., Leone, C., & Ciccotti E., 2015. In *Handbook for fish age determination theory and practice in Italian Data Collection Framework Context*. Report Del Progetto Di Ricerca: Costituzione Di Gruppi Di Lavoro Finalizzati All'ottimizzazione Delle Metodologie d'indagine Campionarie Per La Valutazione Dello Stato Delle Risorse (Ministero Delle Politiche Agricole, Alimentari E Fore-stali – Direzione Pesca E Acquacoltura) - gruppo di lavoro sulla lettura dell'età dei pesci. SOCIETÀ ITALIANA DI BIOLOGIA MARINA: 210 Pp.

Capoccioni, F., Leone, C., Belpaire, C., Malarvannan, G., Poma, G., De Matteis, G., ... & Ciccotti, E. (2020). Quality assessment of escaping silver eel (*Anguilla anguilla* L.) to support management and conservation strategies in Mediterranean coastal lagoons. Environmental Monitoring and Assessment, 192(9), 1-22.

Ciccotti E., 1997. Italy. In: Moriarty C. & W. Dekker (eds.), Management of European eel fisheries. Fisheries Bulletin (Dublin), 15: 91–100.

Ciccotti, E. 2005. Interactions between capture fisheries and aquaculture: the case of the eel (*Anguilla anguilla* L., 1758). In Interactions between Capture Fisheries and Aquaculture: a methodological perspective, pp. 190–203. Ed. by S. Cataudella, D. Crosetti, and F. Massa. GFCM Studies and Reviews, N. 78, Rome.

Ciccotti, E., Busilacchi, S., & Cataudella, S. 2000. Eel, *Anguilla anguilla* (L.). Italy: recruitment, fisheries and aquaculture. Dana, 12, 7-15.

Ciccotti E., 2015. Italy Country Report, 116-156. In: Cataudella S., Crosetti D., Massa F. (eds). Mediterranean coastal lagoons: sustainable management and interactions among aquaculture, capture fisheries and the environment. Studies and Reviews. General Fisheries Commission for the Mediterranean. No 95. Rome, FAO. 2015. 278 pp.

Colombo G. and Grandi G. 1996. Histological study of the development and sex differentiation of the gonad in the European eel. J. Fish Biol., 48, 493–512.

Council Regulation (EC) No 199/2008 of 25 February 2008 concerning the establishment of a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy.

Council Regulation (EC) No 762/2008 of the European Parliament and of the Council of 9 July 2008 on the submission by Member States of statistics on aquaculture and repealing Council Regulation (EC) No 788/96.

Durif C., Dufour S. and Elie P. 2005. The silvering process of *Anguilla anguilla*: a new classification from the yellow resident to the silver migration stage. J. Fish Biol., 66, 1025–1043.

European Commission. 2007. Council Regulation (EC) No 1100/2007 of 18 September 2007 establishing measures for the recovery of the stock of European eel. Official Journal of the European Union 22.9.2007 L 248: 17–23.

GFCM (The General Fisheries Commission for the Mediterranean). 2018. Recommendation GFCM/42/2018/1 on a multiannual management plan for European eel in the Mediterranean Sea.

ICES. 2009. Report of the 2009 session of the Joint EIFAC/ICES Working Group on Eels. ICES CM 2009/ACOM:15, 117 pp.

ICES. 2011. Report of the 2011 session of the Joint EIFAC/ICES Working Group on Eels. ICES CM 2011/ACOM:18, 223 pp.

Melià, P., Bevacqua, D., Crivelli, A.J., De Leo, G.A., Panfili, J. and Gatto, M. 2006. Age and growth of *Anguilla anguilla* in the Camargue lagoons. Journal of Fish Biology 68:876–890.

PNG Italia. 2011. Piano Nazionale di Gestione (PNG) per l'anguilla in Italia Reg. (CE) 1100/07. February 2011.

Schiavina, M., Bevacqua, D., Melià, P., Crivelli, A.J., Gatto, M. and De Leo, A.G. 2015. A user-friendly tool to assess management plans for European eel fishery and conservation. Modelling & Software, 64 (c): 9–17.

Contents

i Report on the eel stock, fishery and other impacts, in LATVIA 2020-2021

Authors

Ms. Janis Bajinskis, Institute of Food safety, animal health and Environment, BIOR, Riga, Latvia.

Tel: +37167612536

janis.bajinskis@bior.lv

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Acknowledgments:

1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

Current studies and data collection are not sufficient to provide good and reliable stock indicators for eel in Latvia. Eel landings in coastal waters of Latvia have stayed very low since 1999 - less than 0.3 t per year. Only the part of freshwaters is accessible for eel, this is why in the frame of eel recovery since 2011 glass eel restocking is carried out in waterbodies without man made obstacles for downstream migration.

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 mill dams. In Soviet times eel restocking have been done in some lakes where there is no information on eel presence before, thus expanding the overall range of this species in the country. According to 1950s survey data, the eels were found in 150 lakes, but frequently found – only in 12 of them (Kotov et al., 1958). According to rough estimates amount of waters in Latvia, where eel have been found historically could be 113 354 ha and historic silver eel biomass (B0) accordingly about 259600 kg (Tab. 1.1.).
The maximum eel productivity obtained in eel farming lakes in Latvia, after restocking them with glass eel, have ranged from 0.7 – 5.6 kg/ha. According to fishing statistics, the highest productivity of silver eel has been in some lakes in Daugava river basin district and it ranged from 4 to 5 kg/ha a year. This could be close to potential silver eel escapement from inland waters in pristine or nearly pristine conditions.

Historically coastal waters have yielded the highest eel landings in Latvia. In 1920s – 30s they reached 100 – 130t of eels per year. Today the proportion of eels in the total landings of coastal waters is less than 0.1%. Based on historical fisheries data, potential silver eel escapement from coastal waters could be estimated as 2 kg/ha.

Currently data is available only on fisheries related mortality. No studies have been done to assess other anthropogenic mortalities.

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	LV_Latv	113354	259600	3420	4542	1.3	0.79	NA	NA
2017	LV_Latv	113354	259600	5130	6813	2.0	0.54	NA	NA
2018	LV_Latv	113354	259600	2052	2725	0.8	0.34	NA	NA
2019	LV_Latv	113354	259600	3070	3501	1.2	0.48	NA	NA
2020	LV_Latv	113354	259600	5989	7296	0.8	0.83	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 distinguish restocked and naturally recruited European eels in Latvia. To evaluate the efficiency of the eel restocking program 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.

2 Overview of the national stock and its management

2.1 Describe the eel stock and its management

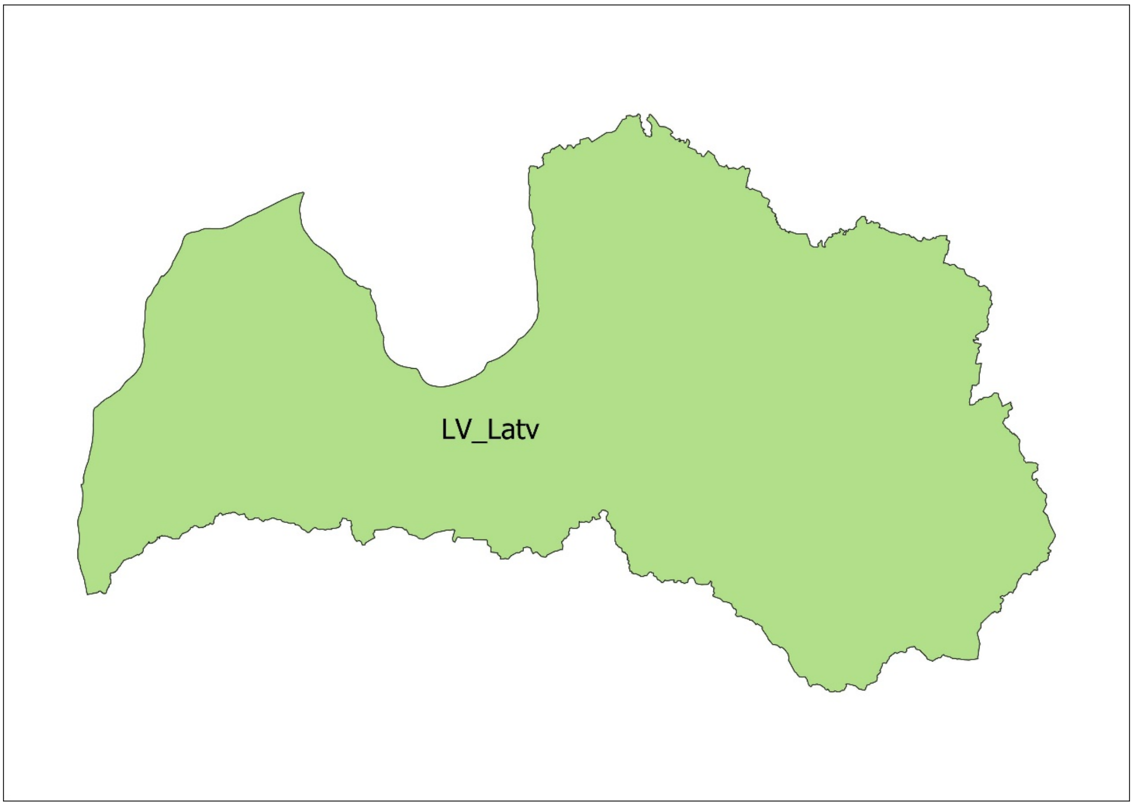

Figure 2.1.1. Latvian EMU

In comparison with 1990's several countrywide restrictions were introduced for inland fisheries since early 2000's (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 free eel migration due to HPS or old mill dams). These lakes were restocked by glass eel several times in 1960 – 1980.

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

- restocking of inland waters with glass eel (waters without downstream migration obstacles that can cause mortality);

All together more than 5.1 million glass eel were restocked from 2011 till 2019 in the rivers and lakes of Latvia.

- 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 2000's. However, looking forward, some technical regulation measures enforced – increased size limit from 40 to 50 cm, decreasing of bag limit for anglers from 5 to 3 individuals per angling occasion (bag limit). In 2019 eel fishing in Lake Liepajas was stopped. Three month closed season for eel landings was introduced in costal waters and open sea - November to end of January (this applies to both fishing and angling).

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;

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 – 2020.

- study of eel quality;

Study results are published in:

Bajinskis J., Aleksejevs Ē., Ozoliņa Z., Začs D. 2020. The composition and quality of European eel *Anguilla anguilla* stock in Lake Rāznas. Environ Exp Biol 18: 51–52.

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&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.

2.2 Significant changes since last report

No significant changes.

3 Impacts on the national stock

3.1 Fisheries

Specialised eel fisheries exist only in two lakes accessible for free eel downstream migration and in several eel growing lakes where eel migrations are limited by man-made obstacles. All eel caught in coastal waters are bycatch in fisheries for other fish species, proportion of eel is less than 1% from total catch by traps, fykes and longlines.

Table 3.1.1. Effort and eel landings in costal fisheries

			2013	2014	2015	2016	2017	2018	2019	2020
Commercial fisheries	FYK	Number of gear	308	356	445	418	385	436	455	41
		Days in operation	4318	4920	4745	5306	4773	4712	4312	189
		Landings, kg	40.5	30.8	6.5	33	31.7	123	210	126.2
		CPUE (kg/gearday)	0.00003	0.00002	0.000003	0.00001	0.00002	0.00006	0.00011	0.01629
	FFN	Number of gear	22	39	12	33	32	13	80	6
		Days in operation	978	1304	676	1401	1051	825	3399	220
		Landings, kg	104.2	37.8		17.1	13.8	22.8	38.2	42.1
		CPUE (kg/gearday)	0.005	0.001	0	0.0004	0.0004	0.0021	0.0014	0.0319
	HOK	Gear days	10900	14600	28598	2800	500	17009	17508	0
		Days in operation	48	34	41	28	5	22	32	0
		Landings, kg	22.9	48	38.8	19.6	14	22	20	0
		CPUE (kg/100 hooks*day)	0.210	0.329	0.136	0.7	2.8	0.129	0.114	0
Self-consumption fisheries	FYK	Number of gear	141	119	100	76	91	80	71	1.3
		Days in operation	7812	8620	6982	5721	5778	4482	3834	2
		Landings, kg	19.4	8	3.5	2.6	8.8	2	36.7	2
		CPUE (kg/gearday)	0.00002	0.00001	0.00001	0.00001	0.00002	0.00001	0.00013	0.76923
	HOK	Gear days	16075	13530	8998	3854	3755	4265	2670	480
		Days in operation	167	147	107	42	45	51	29	6
		Landings, kg	17.4	29.5	3.8	6	1	2.5	6	11
		CPUE (kg/100 hooks*day)	0.108	0.218	0.042	0.156	0.027	0.058	0.022	2.292

There are only 2 lakes accessible for eel migration in Latvian EMU waters where eel occur in commercial catches. Starting from 2019 eel fishing was 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 free migration, restocked with glass eel in 1980 – 1990. Restocking in some of these lakes is continued from private funds.

Table 3.1.2. Commercial eel landings in lakes of Latvia

	2012	2013	2014	2015	2016	2017	2018	2019	2020
Landings in Latvian EMU lakes accessible for eel migration (kg)	287	381	315	320	270	403	398	890	
Landings in eel growing lakes inaccessible for eel migration (kg)	5581	4037	3890	4766	3749	7646	5159	4930	

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 Latvian EMU waters are mixed type, there are no specialized fisheries targeting on of life stages of eel. Minimum eel size limit is 50 cm.

3.1.3 Silver eel fisheries

There are no specialized silver eel fisheries in the coastal waters, landings are mixed. In coastal waters eel landings are about 0.2 t per year in different types of fishery. In 2020 eel commercial landings in coastal fishery were 234.8 kg but in inland waters 6440.95 kg which is slightly higher than in previous two years – most of it landed in eel growing lakes inaccessible for free 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 share of that is caught in eel growing lakes where they have mainly been restocked in Soviet times and in small amounts in nowadays from private funds. In 2020 eel recreational landings in the inland waters where licensed angling is organised were 506.3 kg which is more than two times higher result than in 2019.

Historical data on self-consumption fishery (without rights to sell the fish) in coastal waters is available from year 2000. The landing of eels in this type of recreational fishery is very low - in 2020 landings were only 13 kg.

The biggest share of eels is caught as a bycatch in coastal fisheries from July till August – same month for highest 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.

Table 3.2.1. Number of restocked glass eel in waters with no downstream migration obstacles (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
2020	0	0	0
Total	3 414 600	1 743 600	5 158 200

No restocking from public funds is planned or done within the EMP in the inland waters where migration obstacles exist 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 2020 no glass eel has been restocked from public funds, but 9000 pre-grown eels (size unknown) were released in Lake Rāznas by local NGO from private funds – eel were bought from Lithuanian aquaculture company ŽUB "Žemele". Downstream migration from Lake Rāznas to the sea is not possible due to five HPP's and two sluice gates.

3.3 Aquaculture

There is no eel aquaculture in Latvia.

3.4 Entrainment

~14% of Latvian inland waters are freely 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 previously restocked eels from eel growing lakes to downstream sites in Latvia is constrained. Further construction of the HPPs in Latvia is restricted by the Cabinet of Ministers regulations which establishes the list of the rivers, where it is forbidden to build HPPs.

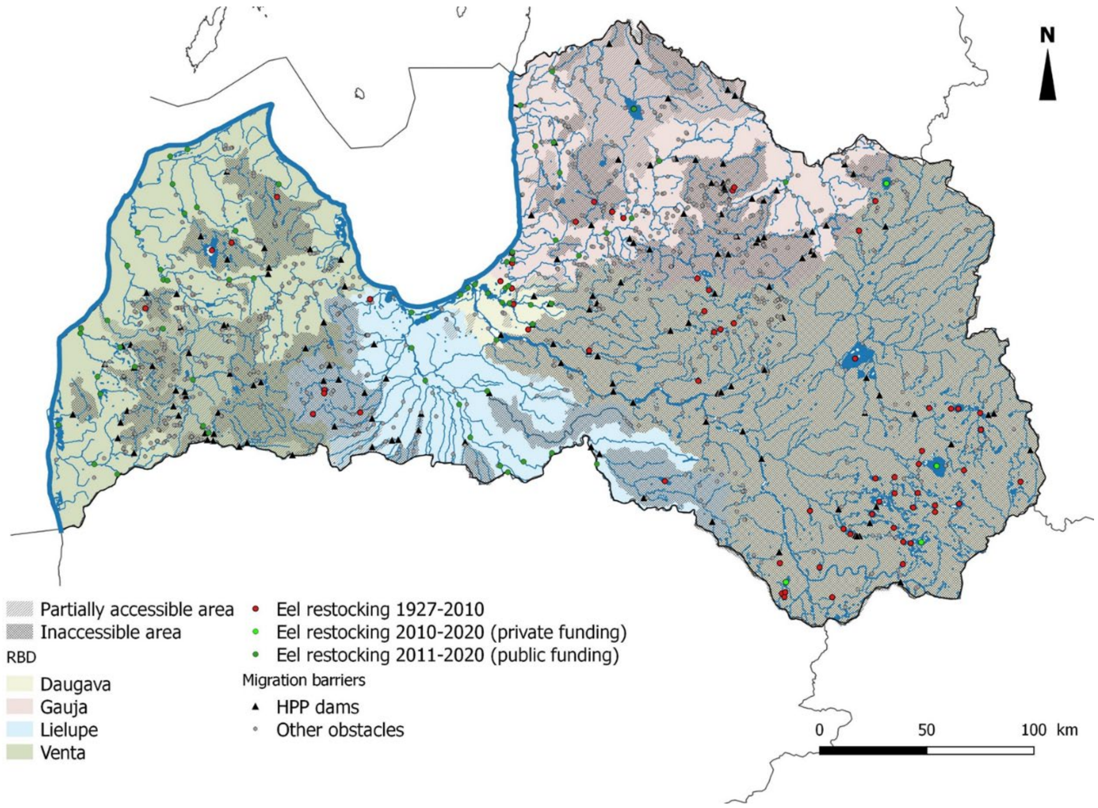

Figure 3.4.1. Accessibility of inland waters in Latvia.

In 2010 in 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%. 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

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

Table 3.5.1. Accessible inland[1] and costal water habitats for eel (Latvia's National Eel Management Plan 2009.- 2013.)

River basin district	River		Lakes	
	Number	Area (ha)	Number	Area (ha)
Daugava	5	3883	5	3071
Gauja	6	1401	9	1162
Lielupe	4	1255	2	2815
Venta	12	935	7	9054
TOTAL	27	7476	25	16102
TOTAL in inland waters				23 578
Coastal and transitional waters				89 776
TOTAL of habitats accessible for eel				113354

[1] – The table contains only major rivers and lakes.

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 volumes of landings are very small. In the fishery, eels are not sorted in 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 roughly assessed using the results of biological analyses performed to eel caught by contract fisherman. The collection of biological data on eel from commercial fishing in Latvia have 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 landings. 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).

Data collection in 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, stomach contents, *Anguillicola crassus* presence/absence in swimming bladder registered. Otoliths are collected for age reading which 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 Latvian 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 is 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 using electrofishing method (Tab. 5.1.1.).

Subsample of young yellow eels caught in rivers and lakes are sampled - length, weight, sex, eye diameter, pectoral fin length, stomach contents, and *Anguillicola crassus* presence/absence in swimming bladder registered. Otoliths are collected for age reading.

Electrofishing results indicate that yellow eel density and occurrence in the rivers of Latvia increases (Fig. 5.1.1.), which is explained by intensified restocking.

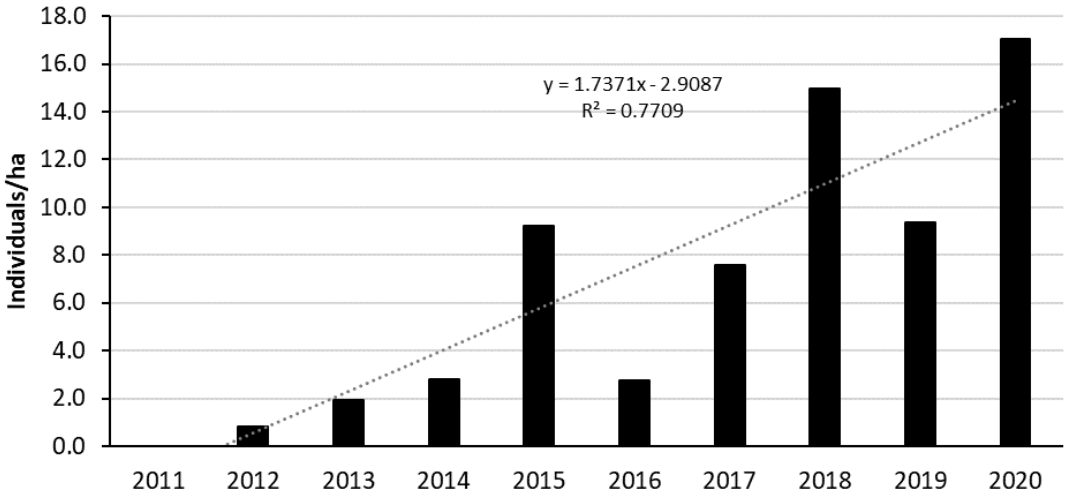

Figure 5.1.1. Density of yellow eel in the rivers of Latvia (electrofishing results)

Table 5.1.1. Yellow eel densities in electrofishing

Rivers	Num.of sampled sites	Num of rivers	Sampled area (Ha)	Eel density (ind./ha)
2012	36	6	1.24	0.5
2013	56	15	2.61	1.3
2014	66	14	2.52	6.8
2015	85	22	2.93	9.2
2016	78	20	3.61	2.8
2017	68	20	2.37	7.6
2018	99	22	4.08	15.0
2019	112	21	3.31	9.4
2020	66	20	1.7	17.1
Lakes	Num of transects	Num of Lakes	Sampled area (ha)	Eel density (ind./ha)
2014	7	7	2.10	11.4
2015	18	7	2.32	13.4
2016	16	7	2.99	10.0
2017	13	7	1.25	25.6
2018	23	7	0.89	30.3
2019	20	7	1.16	12.1
2020	17	7	1.23	10.6

5.2 Silver eel escapement surveys

The set of 4 small mesh size (8 - 10 mm from knot to knot) fyke-nets were used in the lower part of the river Daugava to catch yellow and silver eel. All caught eels 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 eels were tagged with *Carlin* tags or *T-bar* anchortags and released upstream. The aim of tagging is to estimate silver eel escapement given that it is only partial trapping and mortality rates in the fisheries.

Fyke-net 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 (Tab. 3.) were held alive in net – cage until sampling procedure. All caught eel from this gear were analysed at harbour, tagged with *Carlin* tags or *T-bar* anchortags and released.

Table 5.2.1. 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	0.04	0.04	0.08
2015	153	59	7	0.49	0.06	0.43
2016	70	26	4	0.34	0.07	0.43
2017	108	47	1	0.44	0.01	0.44
2018	77	14	0	0.18	0.00	0.18
2019	114	49	28	0.43	0.25	0.68
2020	96	75	4	0.78	0.04	0.82

Table 5.2.2. 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
2019	99	5	4	0.05	0.04	0.09
2020	107	35	38	0.33	0.36	0.68

5.3 Life history parameters

In 2020 67 eel caught in scientific fishery (fyke nets) of different life stages were analysed and aged using otolith thin sections. According to results, population is dominated by five to eight year old eels mostly corresponding to restocking years.

Table 5.3.2. Age structure of eels caught in scientific fishery in 2020 in inland waters of Latvia accessible for eel migration.

Age class	Average length Females (mm)	Average weight Females (g)	Number of Females	Average length Males (mm)	Average weight Males (g)	Number of Males
8	464.0	228.1	16	360.5	96.7	6
9	697.1	674.6	45	-	-	0

5.4 Diseases, Parasites & 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.

Table 5.3.2. 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
Accessible lakes	2019	Y	4	3	75
Accessible rivers	2019	Y	23	17	74
Accessible rivers	2019	S	20	10	50
Accessible rivers	2020	Y	18	7	38.9
Accessible rivers	2020	S	2	2	100
Accessible lakes	2020	Y	13	6	46.2

A complex study on eel parasites in freshwater habitats in Latvia was made in 2015 – se last years report. 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 PCB's, PBB's 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. determined limitation (Bajinskis et al., 2020; Rudovica, Bartkevis, 2015; Zacs et al, 2016).

6 New Information

No available data

7 References

1. Bajinskis J., Aleksejevs Ē., Ozoliņa Z., Začs D. 2020. The composition and quality of European eel Anguilla anguilla stock in Lake Rāznas. Environ Exp Biol 18: 51–52.

2. Durif C., Guibert A., Elie P. 2009. Morphological discrimination of the silvering stages of the European eel. American Fisheries Society Symposium 58, 103-111.

3. Kotov N.D., Nikanorova E.A., Nikanorov J.I. 1958. Ribohozjajstvennije issledovanija ozer Latvijskoj SSR. Ribnoje hozjajstvo vnutrennih vodoemov LSSR. vip. II tr. VII 259-292 (In Russian)

4. Lin Y. J., Shiao J. C., Plikshs M., Minde A., Iizuka Y., Rashal I., Tzeng W. N., 2011. Otolith Sr:Ca Ratios as Natural Mark to Discriminate the Restocked and Naturally Recruited European Eels in Latvia. 76th American Fisheries Society Symposium.

7. 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.

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&Contaminats: Part A. V.33., issue 3.

9. Zolovs M., Deksne G., Daukste J., Aizups J., Kirjusina M. 2015. Microhabitat preference and relationships between metazoan parasites on the gill apparatus of the European eel (Anguilla anguilla) from freshwaters of Latvia. Acta Biologica Universitatis Daugavpiliensis, vol. 15, no. 1: 241-249.

Contents

i Report on the eel stock, fishery and other impacts in Lithuania, 2020–2021

Authors

Dr. Linas Ložys, Nature Research Centre, Laboratory of Marine Ecology, Lithuania.

Tel: +370 610 06873, linas.lozys@gamtc.lt

Dr. Justas Dainys, Nature Research Centre, Laboratory of Marine Ecology, Lithuania.

justas.dainys@gamtc.lt

Dr. Tomas Didrikas, Fisheries service under the ministry of Agriculture of the Republic of Lithuania

tomas.didrikas@zuv.lt

Dr. Arvydas Švagždys, Klaipeda University Marine Research Institute, Lithuania

arvydasrusne@gmail.com

Reporting Period: This report was completed in September 2021, and contains data up to 2020.

Contribution to the report: L. Ložys and J. Dainys did the update of the assessment of eel stock in Lithuania, provided information on most other parts of the report and edited the text. T. Didrikas provided information on eel sampling and analyses performed by Fisheries Service under Ministry of Agriculture and contributed to the text of the report. A. Švagždys provided information and results on eel sampling implemented by Klaipeda University (chapters 5.3 and 5.4)

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We express our sincere gratitude to Dr. Willem Dekker for his help in 2018 and 2020 with assessments of Lithuanian eel stock.

1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

The most recent data (2020) on assessed areas and stock indicators for Lithuanian national EMU are presented in Table 1. Source: Ložys & Dainys (2020).

Table 1. EMP Progress Report (2020) summary table for stock indicators for 2011-2020 (Ložys & Dainys 2020).

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
2007	LT_Lith	116854	87000	30529	39650	35.1	18,5%	4,5%	23,0%
2008	LT_Lith	116854	87000	21309	29954	24.5	22,3%	6,6%	28,9%
2009	LT_Lith	116854	87000	22675	28491	26.1	13,0%	7,4%	20,4%
2010	LT_Lith	116854	87000	15141	31234	17.4	44,3%	7,2%	51,5%
2011	LT_Lith	116854	87000	23772	34029	27.3	23,3%	6,9%	30,1%
2012	LT_Lith	116854	87000	25608	34024	29.4	18,3%	6,4%	24,7%
2013	LT_Lith	116854	87000	16073	30496	18.5	41,2%	6,1%	47,3%
2014	LT_Lith	116854	87000	16324	24659	18.8	26,2%	7,6%	33,8%
2015	LT_Lith	116854	87000	12022	18571	13.8	27,7%	7,5%	35,3%
2016	LT_Lith	116854	87000	4405	13898	5.1	62,2%	6,1%	68,3%
2017	LT_Lith	116854	87000	1115	11226	1.3	85,7%	4,4%	90,1%
2018	LT_Lith	116854	87000	1158	10099	1.3	82,7%	5,8%	88,5%
2019	LT_Lith	116854	87000	6253	9569	7.2	28,9%	5,8%	34,7%
2020	LT_Lith	116854	87000	4938	8850	5.7	39,0%	5,2%	44,2%

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.

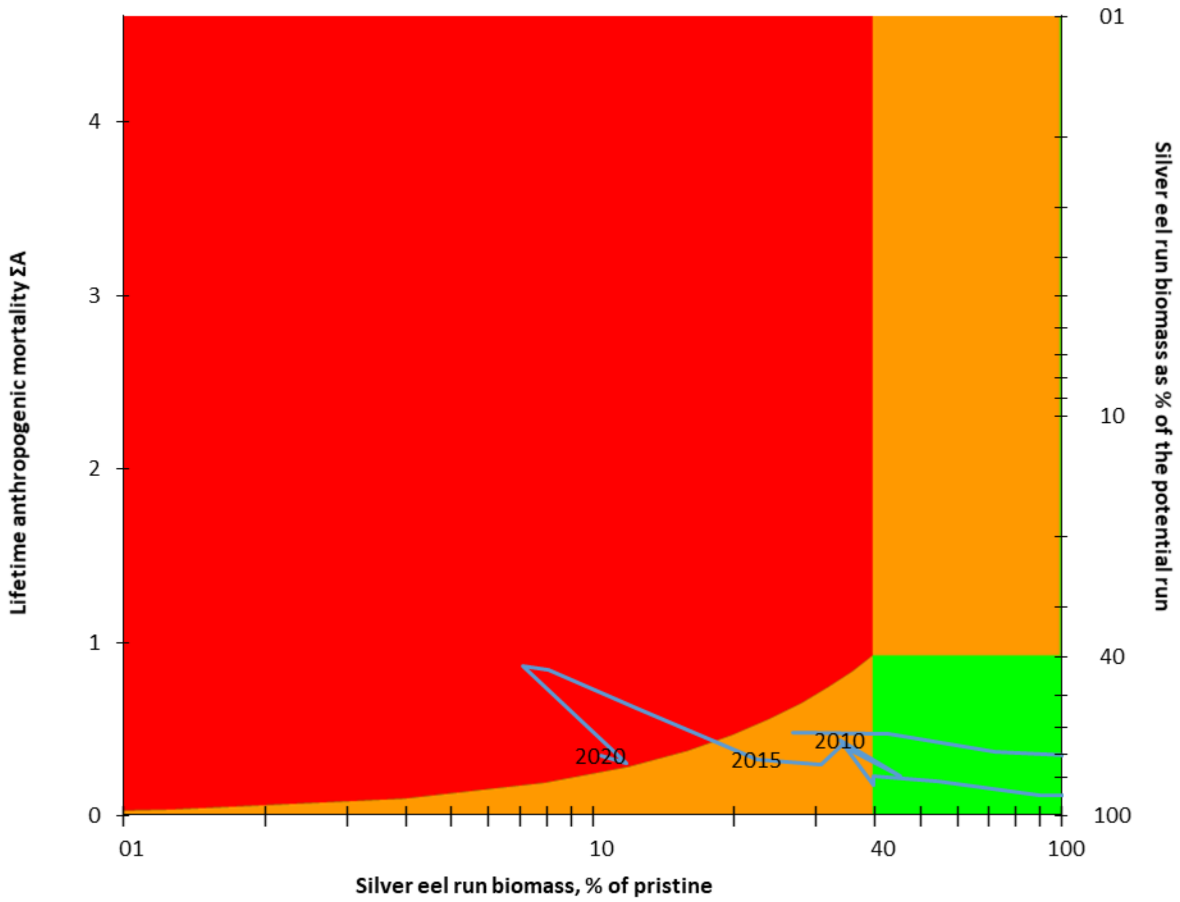

Fig. 1.1. Precautionary diagram for the Lithuanian eel stock in inland waters

1.2 Recruitment time series

Eels recruit to Lithuanian coastal waters at yellow eel stage and presumably in very low numbers nowadays. Recruitment is not monitored; therefore, there is no data on the 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 in rivers 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 waters 80% and 98% respectively are of natural origin and 20% and 2% are stocked (Shiao et. al. 2006 and Lin et. al. 2007).

Even in the past when eel stock was in good condition in all range of species distribution and stocking was not launched yet, large eel fishery was known in the Curonian lagoon, while there is 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 were 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 (Shiao et al. 2006) first stockings in Lithuanian inland waters were performed during 1928-1939 in Vilnius region (currently part of the 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 water bodies 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 and recruitment 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.

Even though eels in Lithuania are not abundant and the national fishery accounted for 0.1-0.2% of the total European eel catch only, 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 national 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 and 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 (Fig. 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, 2015 and 2018 accordingly.

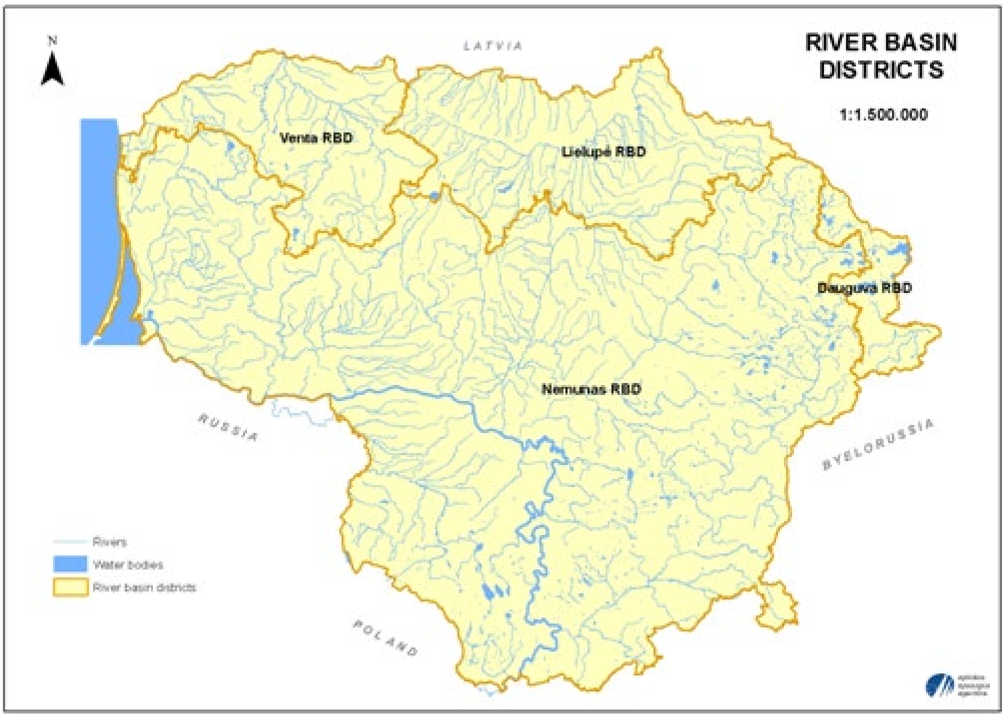

Fig. 2.1. Lithuanian River Basin Districts (map produced by Environmental Protection Agency).

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 the Klaipėda University has been appointed as responsible organisation for the collection of eel data under the programme in cooperation with Fisheries Service.

***The Ministry of Environment*:** is responsible for inland fish stock conservation and control policy, conducts management of the fisheries sector in country's inland water bodies. The Ministry regulates commercial and recreational fisheries in inland water bodies; manages and uses a data system of fisheries in inland water bodies (catches, fishery companies, etc.). The Ministry of Environment is responsible for the exploitation of fish stocks in inland water bodies, 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 water bodies (including eel stocking) are approved by 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 and half month per year (from mid-March till the end of May), commercial eel fishery in lakes is banned. In the Curonian lagoon number of fishing gears (fykenets) is reduced (eels are caught as minor by-catch). All companies operating in commercial fishery must have licenses and fill in log-books daily. Daily bag limit in recreational fishery is reduced to 3 eels per fishing trip. In the Baltic Sea commercial 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 3 months/year, to introduce restrictions related to long-line fishery, to reduce bag limit in recreational fishery (i. e. angling) and 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 5 eels to 3. 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 long-line 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 long-lines is actually banned and only fishery for migrating eels in rivers allowed from 15th of March until 1st of June.

Number of 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 extent of illegal fishery for migrating eels in rivers, however, despite very high fines (in 2020 increased from 290 to 480 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 5 to 3 eels in recreational fishery (under the definition „recreational fishery" falls not only angling using hook but also spearfishing). Spearfishing was allowed in 11 water bodies (12 in 2012) but now number has been reduced to 7 (6 lakes and coastal waters of the Baltic Sea). However, in case if 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 water bodies (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 1,65 million, in 2019 1,60 million, in 2020 1,37 million of on-grown (OG) eels where stocked. In 2021 due to unsuccessful public tender again stocking has not been done, however for the next year double amount is planned to stock aiming to compensate zero stocking in 2021. According to the national EMP, eels in Lithuania should not be stocked to basins upstream hydropower.

2.2 Significant changes since last report

There are no significant changes since last report.

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 (1997-2020), eel landings marginally increased in the inland waters (most eels fished are silver eels, c. 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 (fig. 3.1).

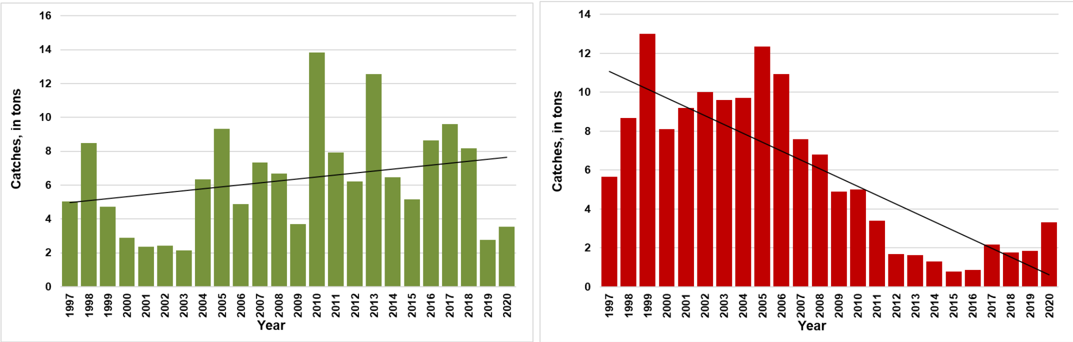

Fig. 3.1. Eel catches in commercial fishery in inland water bodies (green colour) and the Curonian Lagoon (red colour) during 1997-2020.

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 (fig. 3.3), while landings from inland waters fishery (stocked eels) seem to be more stable (fig. 3.2)

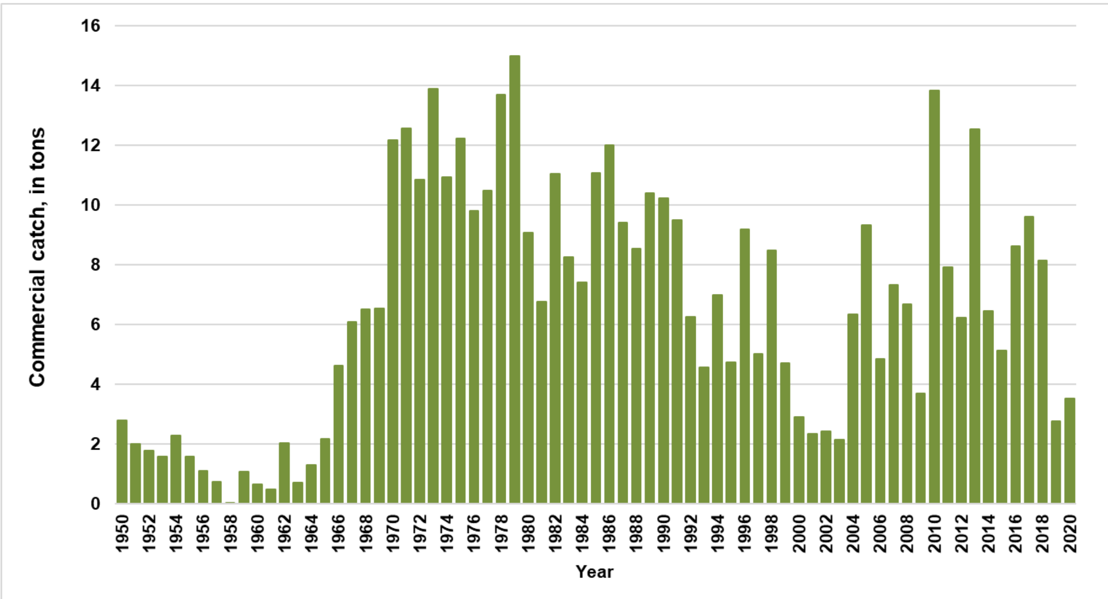

Fig. 3.2 Time trend in the reported catches from the inland fishery since 1950 to 2020 (without the Curonian lagoon).

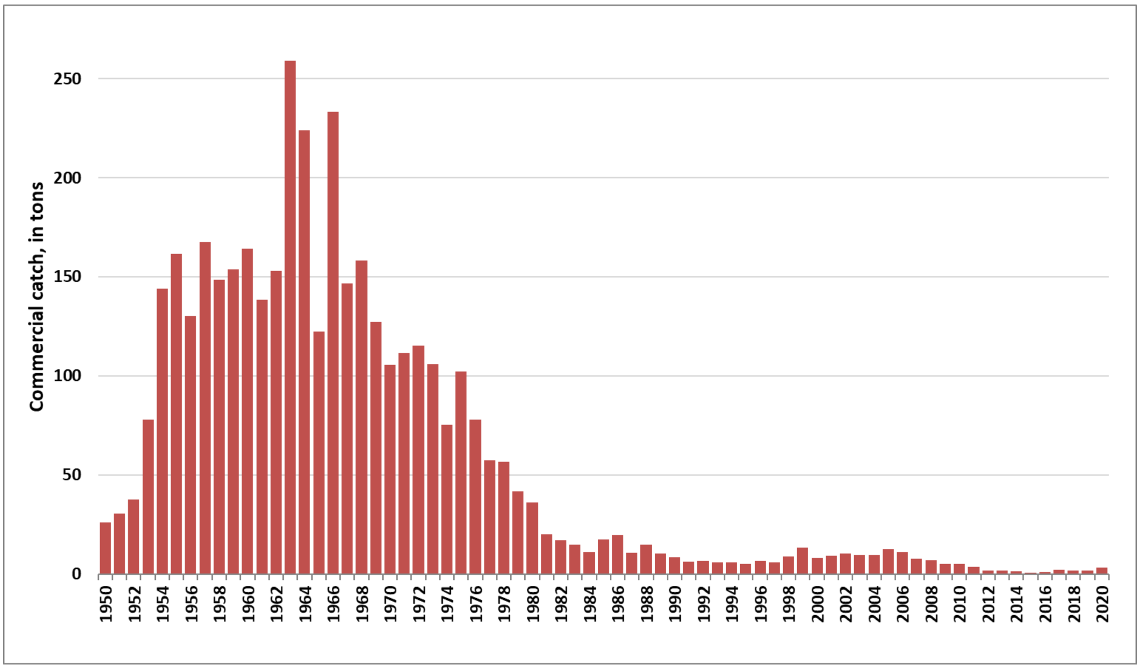

Fig. 3.3 Time trend of reported catches from the Curonian lagoon fishery since 1950 to 2020 (only Lithuanian part of the Lagoon, c. ¼ of total area, except Russian part of the lagoon).

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 on-grown 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 water bodies.

After EMP was approved by EC first stockings were performed in 2011, and until 2020 160 water bodies (mostly lakes) were stocked with >7 million of young eels, i. e. ~0,7 million annually on average during the period from 2011 to 2020. Due to unsuccessful public tender in 2017 and 2021 stocking was not made. In 2018, 2019 and 2020 accordingly 1,65, 1,61 and 1,37 million of glass eels were purchased and on-growing stocked.

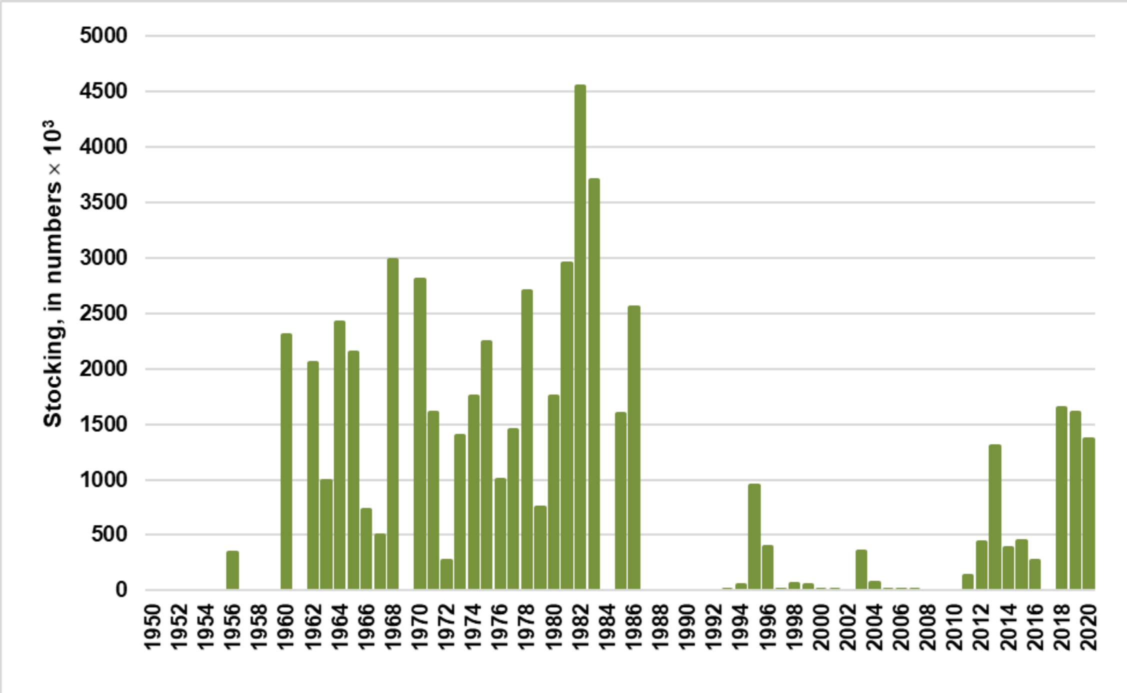

Fig. 3.4 Stocking of inland water bodies with OG eels in the period 1950 to 2020 (thousand individuals).

Table 3.1. Eel stocking activity in Lithuanian inland waters carried out by the Fisheries Service during 2011 – 2021*.

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
2019	500 kg	1 590 000	1	UK
2020		1 366 700	0.8	UK
2021	-	-	-	-

* *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, during 2017 - 2020 only one aquaculture company reported on production of farmed eels. Therefore, the information is confidential and can't be provided according to EU legislation.

Table 3.2. Eel production in aquaculture during 1998–2019.

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Production, in kg	2000	2000	1000	5000	17000	20000	9000	8000	12000	13000	10600	12000

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Production, in kg	8300	12600	3500	3466	7148	205	36400	*	*	*	*

** 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 (Fig. 3.5). Eel stockings carried during 2011-2020 were performed in accordance with approach of the Lithuanian EMP: eels were stocked to water bodies from which eel migration route to the sea is free or HPP‘s, if any, has fish pass.

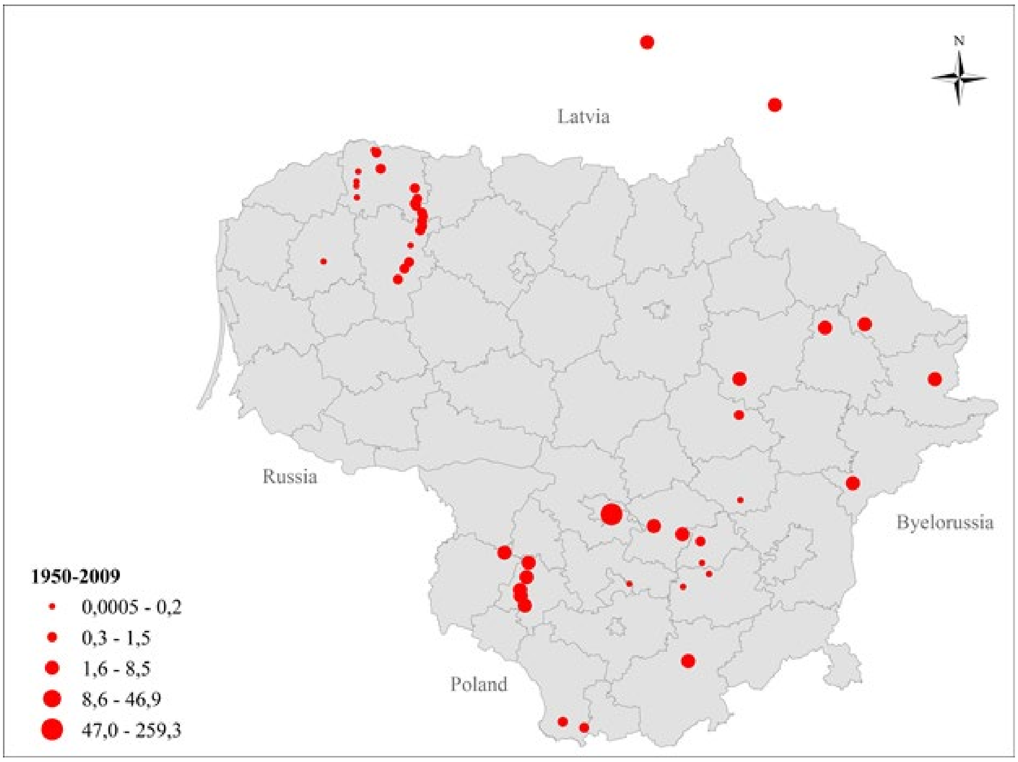

Fig. 3.5 Spatial distribution of the HPPs having an eel stock upstream (stockings were carried during 1950-2009, before the implementation of the Lithuanian EMP). The size of the symbols in this figure is proportional to the number of eels (in million) stocked upstream of each station.

Most of the eels were stocked to the water bodies 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 water body 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 6 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 water bodies 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 water bodies, 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 & Dainys 2020), in 2017, 2018, 2019 and 2020 accordingly 4,4%, 5,8%, 5,8% and 5,2% of silver eels produced in Lithuanian inland waters were estimated to be killed in HPP installations.

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

Stocked water body	Year of stocking	Year of HPP (re)construction	HPP name	Water body 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
Antalieptės Pond	2012 2013 2014	1961 (2001)	Antalieptės	HPP with fish pass

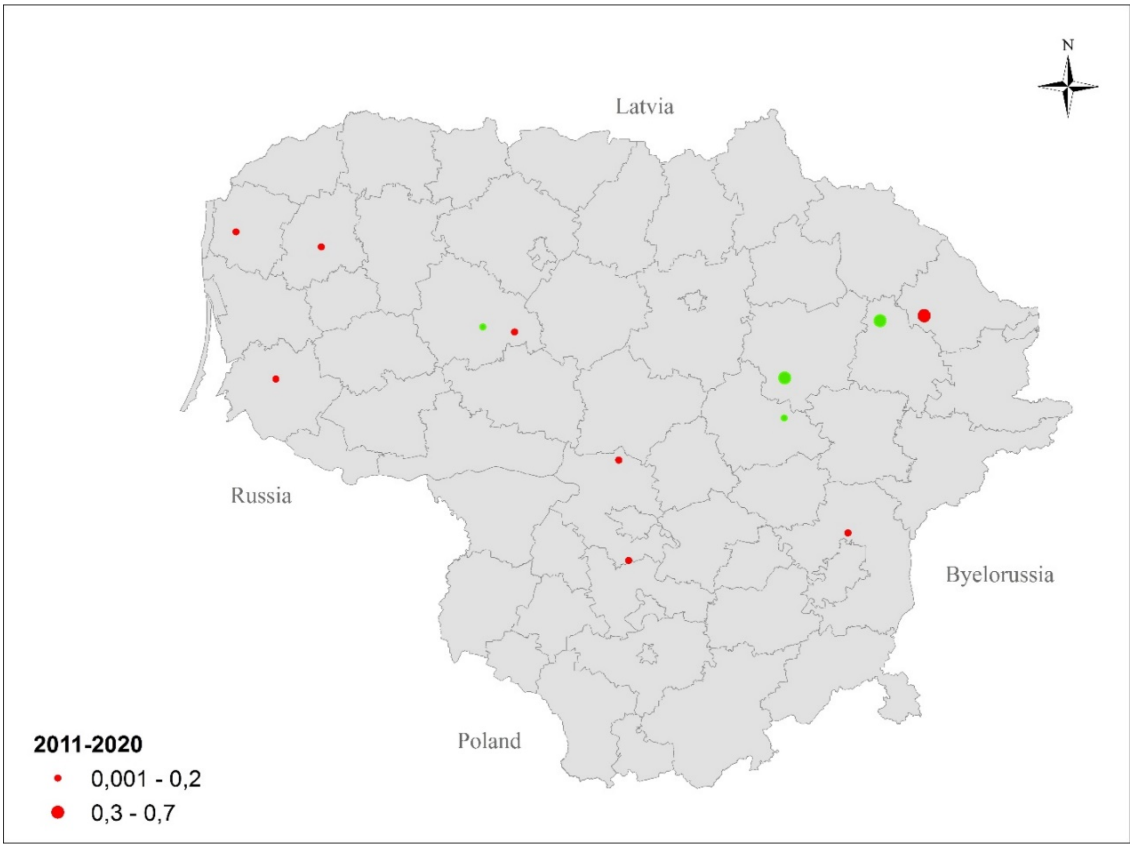

Fig. 3.6 Spatial distribution of the HPPs having an eel stock upstream (stockings were carried during 2011-2020 after start of the implementation of the Lithuanian EMP). The size of the symbols in this figure is proportional to the number of eels (in million) stocked upstream of each station (green colour 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 water bodies 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 down-sizing 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. Data series 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 water body, thus in the analysis this part of commercial catch or stocked eels was assigned to "unidentified water body". However, for some water bodies, continuous data series exist since the beginning of eel fishery or stocking in the particular water body, 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 HPP's that are affecting those water bodies. 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 HPP's 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 (water bodies of different trophic level; eels of different age groups and 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 is continuing on a regular basis in order to obtain silvering curves for eels stocked into Lithuanian water bodies.

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:

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

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 data sets (e.g. point-locations for release of recruits versus 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 2011-2020 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 on the implementation of national EMP. Interim report on the national eel stock assessment is submitted to Fisheries Service under Ministry of Agriculture in 2020; final report was submitted at the end of 2020.

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 mortality 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 during 1960-1970, on average ~2 t. Later silver eel production sharply increased and in 1998 reached its maximum of 366 t. However, since 2000 silver eel production started decreasing and in 2007-2017 it was on average ~27 t per year. If stocking intensity will remain same as it was since the beginning of EMP implementation, silver eel productions is expected to increase up to c. 113 tons in 2030-2040 (Fig. 4.1.).

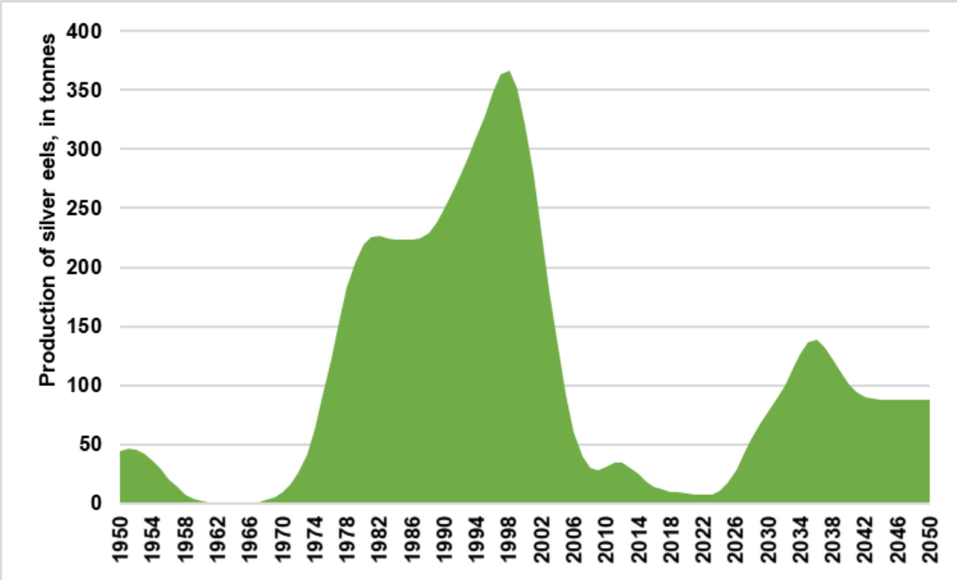

Fig. 4.1. Production of silver eel by year: the estimated total production in inland waters before the impact of fishery and hydropower (1950-2050). For these results, a natural mortality rate of M=0.10 was assumed. Future forecast is made on the assumption that stocking will be carried at the same intensity as during 2011-2020 (0.76 million of glass eels stocked 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 26% of the production, with rather high variation over the years from 1 to more than 100% (Fig. 4.2. – 4.3.). For the period from 1962 to 1970, 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.

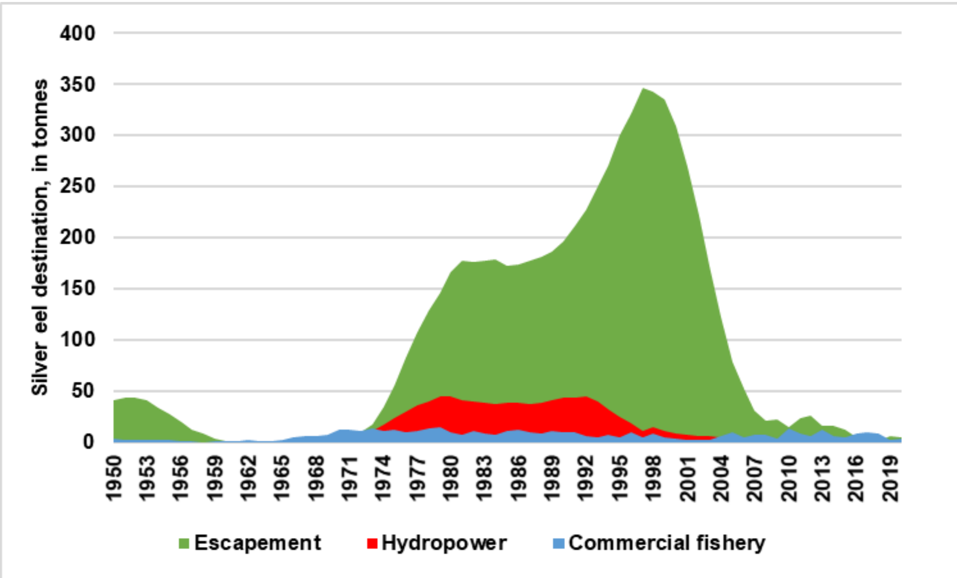

Fig. 4.2 Time trends in the destination of the silver eel produced in Lithuanian inland waters (1950-2020).

For the hydropower, the estimated impact varied between close to 0 t (in 1950-1970) and 34 t (in 1992), that is approximately 8,8% of the total production (range 0% - 27%). The estimated impact in 2020 was 0,5 t (5,2%).

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 over-estimation of eel mortalities, these “negative” data were omitted from further analysis.

Predicted escapement of silver eel ranged from 0 t (e.g. in 1962-1970) to 346 t (in 1997), on average 65% of the total production (range 0% - 99%). The 2020 escapement is estimated at 4,9 t., while 2011-2020 annual average is c. 11 tons (Fig. 4.3).

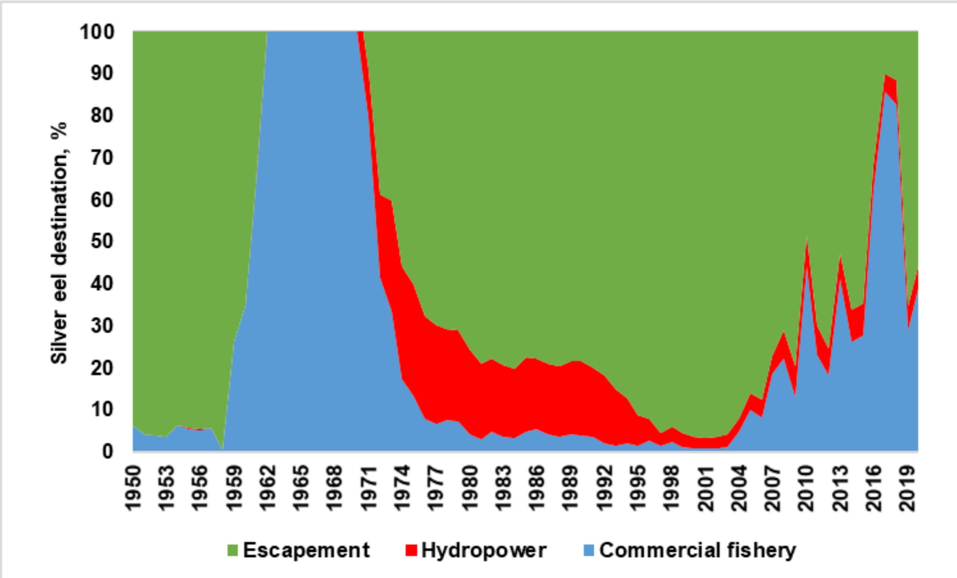

Fig. 4.3 Time trend in the estimated anthropogenic mortality and escapement, expressed in percentage impacts on the silver eel production in 1950-2010.

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	34029	23772	23,3%	6,9%	30,1%
2012	87 000	35 000	34024	25608	18,3%	6,4%	24,7%
2013	87 000	35 000	30496	16073	41,2%	6,1%	47,3%
2014	87 000	35 000	24659	16324	26,2%	7,6%	33,8%
2015	87 000	35 000	18571	12022	27,7%	7,5%	35,3%
2016	87 000	35 000	13898	4405	62,2%	6,1%	68,3%
2017	87 000	35 000	11226	1115	85,7%	4,4%	90,1%
2018	87 000	35 000	10099	1158	82,7%	5,8%	88,5%
2019	87 000	35 000	9569	6253	28,9%	5,8%	34,7%
2020	87 000	35 000	8850	4938	39,0%	5,2%	44,2%

	B_0	B_{TARGET}	B_{BEST}	$B_{CURRENT}$	ΣF	ΣH	ΣA
2011	87 000	35 000	34029	23772	0,265	0,052	0,32
2012	87 000	35 000	34024	25608	0,202	0,071	0,27
2013	87 000	35 000	30496	16073	0,531	0,026	0,56
2014	87 000	35 000	24659	16324	0,303	0,070	0,37
2015	87 000	35 000	18571	12022	0,325	0,093	0,42
2016	87 000	35 000	13898	4405	0,972	0,000	0,97
2017	87 000	35 000	11226	1115	1,944	0,000	1,94
2018	87 000	35 000	10099	1158	1,754	0,000	1,75
2019	87 000	35 000	9569	6253	0,341	0,056	0,40
2020	87 000	35 000	8850	4938	0,495	0,000	0,50

5 Other data collection for eel

Lithuanian waters are not recruited by eels at glass eel stage; yellow eel recruitment to coastal areas currently is very low and is not monitored.

Under DCF/EU MAP data collection and other survey programs 414 yellow eels were sampled in Lithuania for length, weight, age and other parameters in 2020 using longlines, small fyke-nets and electrofishing in lakes, trapnets in streams or were obtained from fishery in the Curonian Lagoon. 399 migrating silver eels were sampled for the analyses using trapnets in streams or were obtained from fishery in the Curonian Lagoon. Sampling was done by Fisheries Service, Klaipėda Universty and State research institute Nature Research Centre.

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 2020 yellow eel sampling was done in 6 inland lakes: Ūkojas, Kretuonas, Rubikiai, Kertuojai, Balsys and in Krokų Lanka lake-estuary (close and connected to the Curonian Lagoon). Eels were caught and analysed by age, length, weight, and other parameters (N=414).

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 water bodies 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 (Fig. 5.1.).

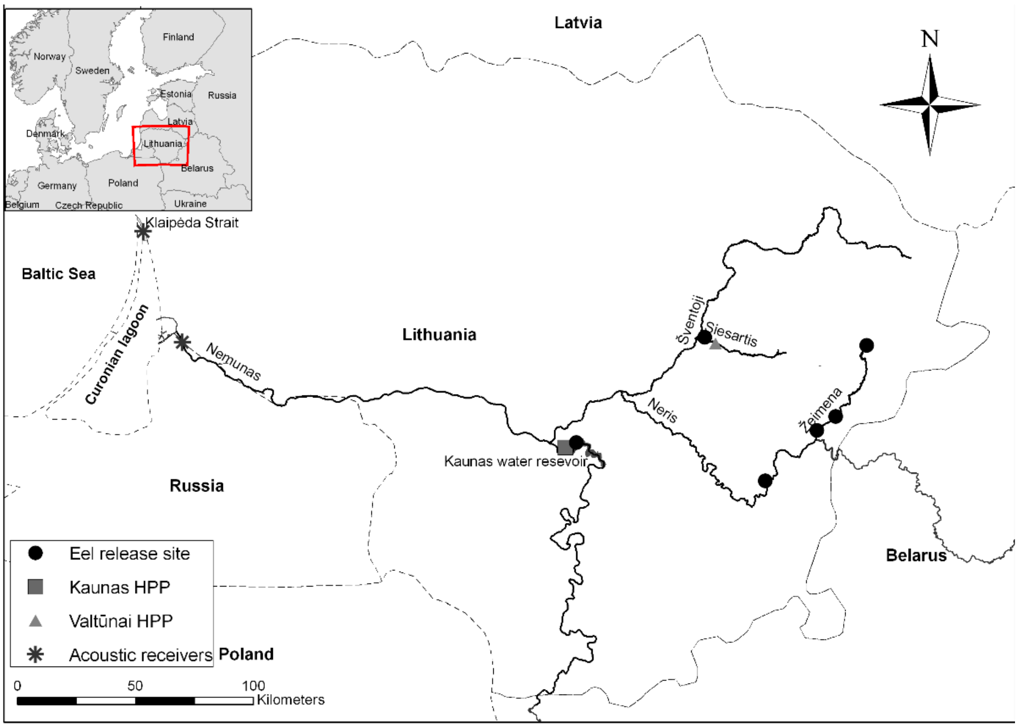

Fig. 5.1. Release sites of tagged eels.

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 became 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, 11 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 5 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%.

Second project on evaluation of silver eel migration patterns and success from Lithuanian inland water bodies started in 2019. In total 50 silver eels were tagged with acoustic transmitters and released into two rivers (Žeimena and Šventoji). Their migration is tracked by receivers installed in eel migration route towards the sea. At time of the reporting 22 eels out of 50 successfully escaped to the Baltic sea through the Klaipeda strait. The project will end and final results on eel migration patterns and migration success will be available at the end of 2021.

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 infection intensity of parasites. Fat is measured only occasionally.

As part of DCF/EU MAP data collection eels from a number of commercially fished streams/rivers and the Curonian lagoon were sampled since 2010.

As a part of EU MAP Data collection, eels from the Curonian lagoon and some inland lakes were sampled in 2017 - 2020 by Klaipeda University (Table 5.1, bellow).

Lake/year	Total N	Mean length (mm)	Mean weight (g)	Mean age (year)	Growth rate (mm year-1)	Aged (N)
Alausas						
2020(16 mm trap nets)	24	716	671	18	38	24
Kertuoja						
2020(16 mm trap nets)	35	743	739	17.5	40.1	33
Rubikiai						
2020(12 mm trap nets)	15	477	234	7.7	60.7	15
Curonian Lagoon						
2020 (12 mm trap nets)	41	544	291	7.7	70.1	41
2020 (20 mm fyke nets)	116	701	782	10.3	67.8	115
2019(20 mm fyke nets)	110	704	789	9.6	73.7	110
2018(20 mm fyke nets)	100	740	904	11.8	62	94
2017(20 mm fyke nets)	100	776	966	16.8	44.6	77
Siesartis						
2019(16 mm trap nets)	30	727	707	19.9	34.8	29
2020(16 mm trap nets)	82	681	524	21.6	29.7	82
Paežerys						
2017	58	524	299	10.6	47.2	54
Stirnė						
2018	100	737	721	18.5	38.1	98
Ukojas						
2017	100	560	340	14.8	35.5	97
Aisetas						
2017	100	537	315	12.6	40.3	97
Baluošas						
2017	100	655	487	15.2	41.2	97

Sampling for silver and yellow eel growth was performed by Klaipėda University in 2020 in the Curonian lagoon (N=127 yellow and N=30 silver eels) and Inland lakes in Eastern part of Lithuania (Siesartis, Alausas, Kertuoja, Rubikiai; N=93 yellow and N=63 silver eels). Length-at-age and weight-at-age for yellow eels (Fig. 5.2) suggests higher growth rate in the Curonian Lagoon compared to Inland lakes: average growth rate in the lagoon was 84 mm/year vs 30 mm/year in the Siesartis lake; 36,5 mm /year in the Alausas and 47,7 mm/year in the Kertuoja. Mean length at age was accordingly 678 mm/8,7 year for the lagoon and 658 mm/20,9 year for Siesartis lake, 736 mm/19,2 year for Alausas, 698 mm/14,1 year for Kertuoja.

Length-at-age and weight-at-age for silver eels (Fig. 5.3) suggests higher growth in the Curonian Lagoon compared to lakes: average growth rate in the lagoon was 50,9 mm/year vs 28,9 mm/year in the Siesartis lake; 33,2 mm/year in the Alausas and 38,5 mm/year in Kertuoja. Mean age at length was accordingly 767 mm/14,7 year for the lagoon and 699 mm/22,7 year for Siesartis lake, 738mm/21,1 year for Alausas and 773 mm/19,3 year for Kertuoja. However, it must be kept in mind that silver eels from lakes migrate through the lagoon; hence silver eels caught in the Curonian lagoon might be on the way of their migrations from inland lakes.

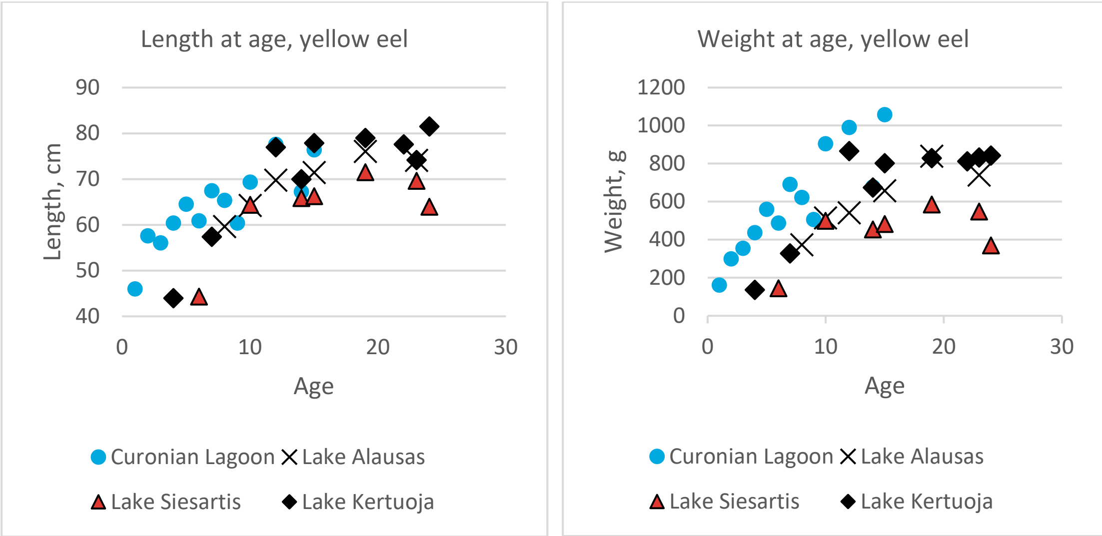

Fig 5.2. Length-at-age and weight-at-age of yellow eels caught in 2020 (n=220).

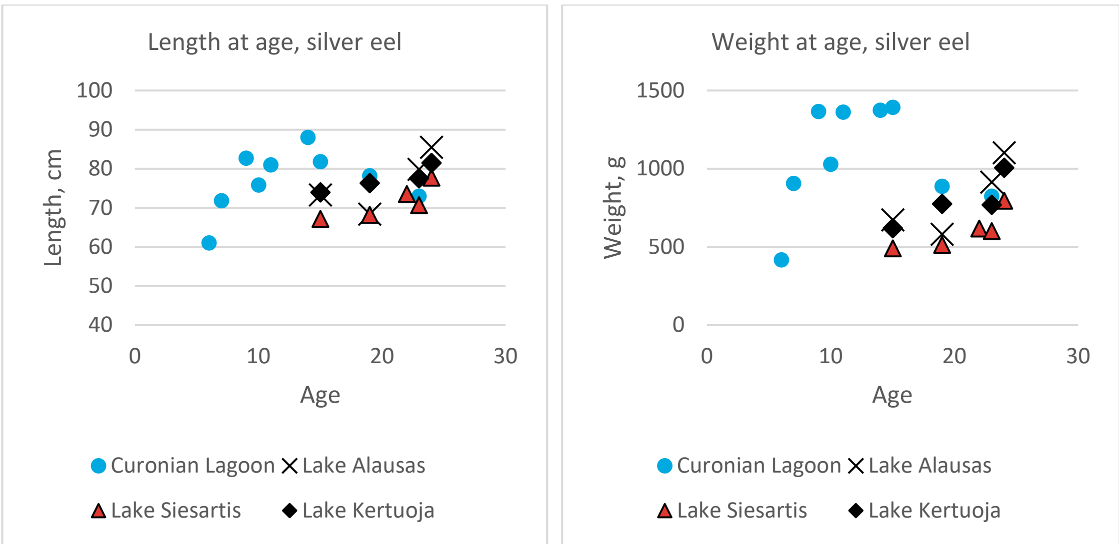

Fig 5.3. Length-at-age and weight-at-age of silver eels caught in 2020 (n=93).

5.4 Diseases, Parasites & 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 (water bodies of different trophic level; eels of different age groups and etc.) has started in 2017 only, thus since then eels were 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 in 2017 were infected with *A. crassus*. Infection intensity was relatively low: usually ranging between 1 and 4 nematodes (highest observed intensity was 23 parasites for one eel). Additionally, two other parasite species (*Diplostomum spathaceum* and *Pseudodactylogyrus* sp.) were found in analysed eels in 2017 (analysis was carried by the Fisheries Service).

In 2019 108 eels were screened for *Anguillicola crassus* at Klaipeda University. 80% (N=75) and 88% (N=33) of eels accordingly from the Curonian lagoon and lake in Eastern part of Lithuania (Siesartis) were infested. Infection intensity was found to be on average 3,4 and 4,4 nematodes respectively in the lagoon and lake. In 2020 312 eels were screened for *Anguillicola crassus* at Klaipeda University. 71% (N=111) and 86% (N=135) of eels accordingly from the Curonian lagoon and lakes in Eastern part of Lithuania (Siesartis, Alausas, Rubikiai, Kertuoja) were infested. Infection intensity was found to be on average 2,3 and 3,9 nematodes respectively in the lagoon and lakes.

6 New Information

Three shipments of about 66 tonnes in total of European eel as cooked fillets "kabayaki" (frozen) were arrested at customs in Klaipeda port in 2020. These shipments from China were supposed to go to Belarus. The cases of these arrests were still pending in courts in 2021, however, transit to eastern countries of eel "kabayaki" through Lithuania is stopped.

In 2017 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
- Dainys J., Gorfine H., Šidagytė E., Jakubavičiūtė E., Kirka M., Pūtys Ž., Ložys L. 2018. Are Lithuanian Eels Fat Enough To Reach The Spawning Grounds? Environmental Biology of Fishes, 101: 127:136. DOI: 10.1007/s10641-017-0686-y
- Dainys J., Stakėnas S., Gorfine H., Ložys L. 2017. Silver eel, *Anguilla anguilla* (Linnaeus, 1758), migration patterns in lowland rivers and lagoons in the North-Eastern region of their distribution range. Journal of Applied Ichthyology, 33: 918–924. DOI: 10.1111/jai.13426
- Dainys J, Gorfine H., Šidagytė E., Jakubavičiūtė E., Kirka M., Pūtys Ž., Ložys L. 2017. Do young on-grown eels, *Anguilla anguilla* (Linnaeus, 1758), outperform glass eels after transition to a natural prey diet? Journal of Applied Ichthyology, 33:361–365. DOI: 10.1111/jai.13347.

7 References

Anon. 2008. Europinių ungurių *Anguilla anguilla* L. išteklių valdymo planas (National Eel (*Anguilla anguilla* L.) management plan), Ministry of Agriculture of the Republic of Lithuania, 93 p.

Bilys S., Gužauskas R., Jakštas L., Kairys L., Kasiulis E., Punys P., Sabaliauskas A., Sabaliauskas L., Tornau V. 2017. Mažoji hidroenergetika. Vilnius: Trys žvaigždutės, 208 p.

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.

Dainys J. 2017. Migration of stocked European eels (*Anguilla anguilla* L.) in Lithuania and potential contribution to spawning stock restoration. *Phd thesis*. Vilnius, 98 p.

Dekker W. 2015. Assessment of the eel stock in Sweden, Spring 2015. Second postevaluation of the Swedish Eel Management Plan. Swedish University of Agricultural Sciences, Aqua reports 2015:11. Drottningholm, 93 p.

Lietuvos hidroenergetikų asociacija (Lithuanian hydropower association). 2011. Lietuvos hidroenergetika. 61 p. DOI: https://www.lsta.lt/files/Leidiniai/Lietuvos%20HIDROENERGETIKA/Knyga_Lietuvos%20HIDROENERGETIKA.pdf

Lin Y.J., Ložys L., Shiao J.C., Iizuka Y., Tzeng W.N. 2007. Growth differences between naturally recruited and stocked European eel Anguilla anguilla from different habitats in Lithuania. Journal of Fish Biology 71: 1773-1787.

Ložys L., Dainys J. 2020. Assessment of restoration and monitoring of the stock of European eel. (Europinių ungurių populiacijos išteklių atstatymo ir būklės monitoringo tyrimai). Nature Research Centre, Vilnius, 52 p.

Ložys L., Repečka R., Pūtys Ž., Gurjanovaitė K. 2008. Scientific justification of European eel (*Anguilla anguilla*) management plan: [in Lithuanian]. Vilnius

Mačionis A. 1969. Introduction of elvers into the lakes of the former region of Vilnius in 1928-1939. Vilnius: V. Kapsukas Stale University; pp. 241-254: [in Lithuanian].

Shiao J.C., Ložys L., Iizuka Y., Tzeng W.N. 2006. Migratory patterns and contribution of stocking to population of European eel in Lithuanian waters as indicated by otolith Sr:Ca ratios. J Fish Biol 69:749-769. DOI: 10.1111/j.1095-8649.2006.01147.x

Contents

i Report on the eel stock, fishery and other impacts, in The Netherlands, 2020-2021

J. C. van Rijssel, Wageningen Marine Research, Wageningen University Research, IJmuiden, The Netherlands.

jacco.vanrijssel@wur.nl

T. van der Hammen, Wageningen Marine Research, Wageningen University Research, IJmuiden, The Netherlands.

tessa.vanderhammen@wur.nl

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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 2018-2020 derived from van der Hammen et al. (in prep), assessed area from Tien & Dekker (2004).

Year	EMU	Assessed Area (ha)	B_0 (t)	B_{curr} (t)	B_{best} (t)	Bcurr/B_0 (%)	∑F	∑H	∑A
2018-2020	NL_Neth	378,700	10,400*	974	2,153	9.4	0.61	0.18	0.79

* Excluding coastal waters (2,600 t).

Key: EMU = Eel Management Unit; B_0 = prisine silver eel biomass; B_{curr} = silver eel biomass that currently escapes; B_{best} = silver eel biomass without anthropogenic influences on the current stock; ∑F = mortality due to fishing (rate); ∑H = anthropogenic mortality excluding the fishery (rate); ∑A = all anthropogenic mortality (rate); Assessed area (ha) = combined area total (ha) of inland waters.

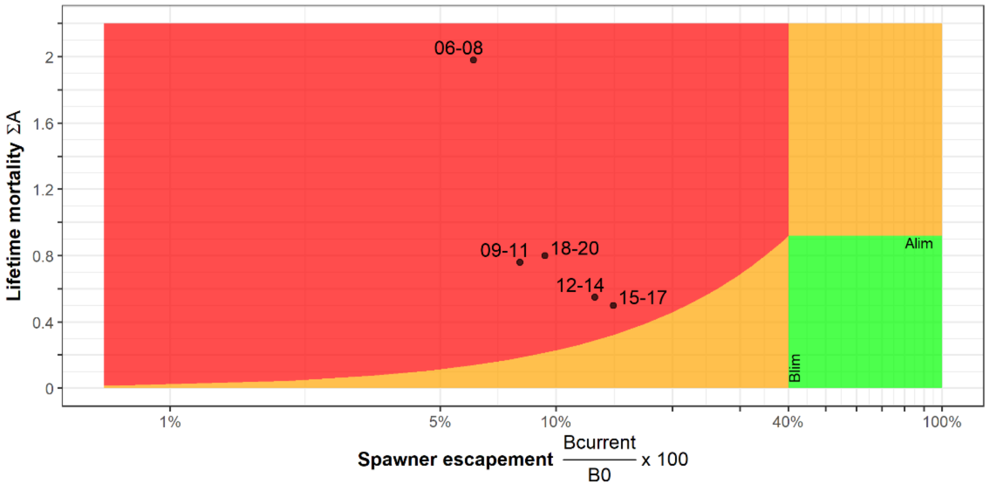

Figure 1 ICES modified precautionary diagram presenting the status of the eel stock in the Netherlands in 2006-2008, 2009-2011, 2012-2014, 2015-2017 and 2018-2020 with respect to management targets. The horizontal axis represents the status of the stock in relation to pristine conditions. The vertical axis represents the impact made by anthropogenic mortality. *ΣA* = Lifetime anthropogenic mortality, presented as a rate. Note that the x-axis is on a logarithmic scale. The target of the Eel Management Plan is 40% of the pristine 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 Advice reported to the EU Commission.

Recruitment of glass eel in Dutch waters is monitored at 11 sites along the coast. Eleven locations, however, rely on volunteers. In recent years, volunteers were not always available and not all locations are sampled every year. In 2021 sampling was done on only 6 locations due to COVID-19. 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).

The time series in Den Oever (Figure 2, Table 2) does not depend on volunteers, is the most extensively sampled and is the longest time-series (from 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 2017, in the past four years, the recruitment at Den Oever is at a similar low level as that of the 2000s. Since 2019, construction of the discharge sluices is conducted at the sampling location in Den Oever. This causes that in 2020 and 2021 sampling was done on the same location, but from a boat.

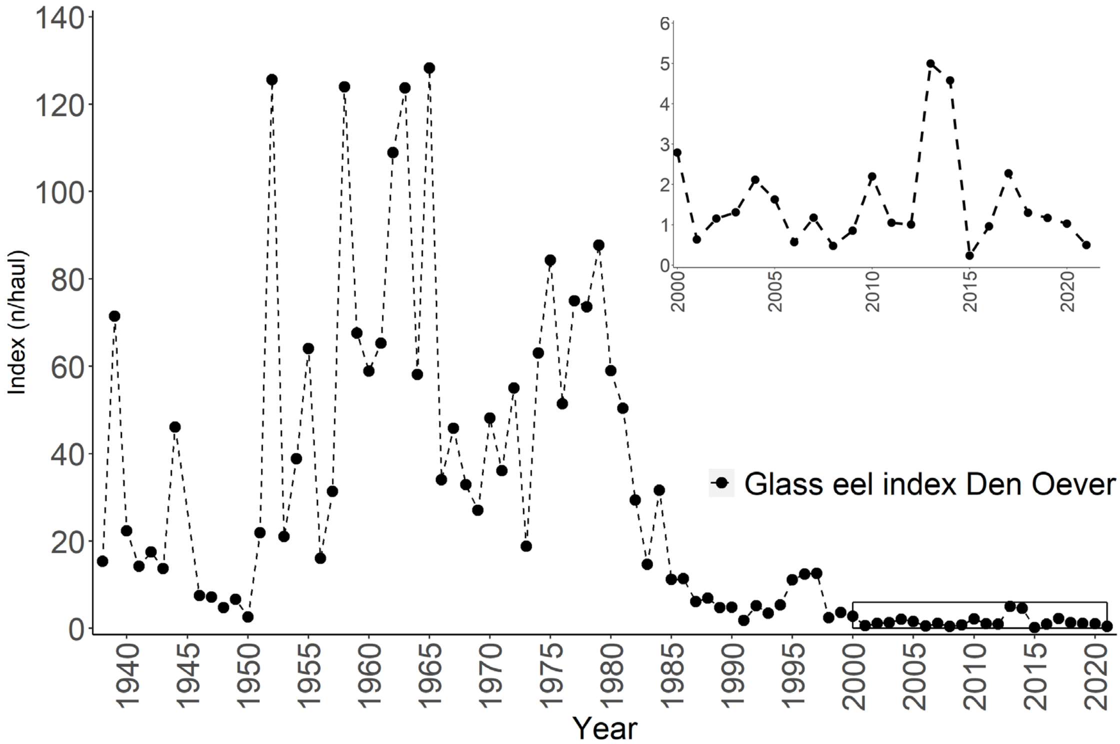

Figure 2 Glass eel trend index at the discharge sluices in Den Oever trend index (average number per lift net haul in April and May).

Table 2 Glass eel trend index at the discharge sluices in Den Oever trend index (average number per lift net haul in April and May).

Decade Year	1930	1940	1950	1960	1970	1980	1990	2000	2010	2020
0		22.4	2.7	58.9	48.1	59.0	4.9	2.8	2.2	1.0
1		14.3	21.9	65.2	36.1	50.4	1.8	0.6	1.1	0.5
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			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 11 sites in the Netherlands (1979-2020). If less than 6 hauls were carried out on a location in a year, data are not presented. Data are visualised in Figure 3. The locations in light grey are used in the ICES assessment.

Year	Schelde_Bath	Maas_BergscheDiep	Maas_Krammersluizen	Maas_Stellendam	Rijn_DenOever	Rijn_Harlingen	Rijn_IJmuiden	Rijn_Katwijk	Rijn_Lauwersmeer	Eems_NieuwStatenzijl	Eems_Termunterzijl
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
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	79.4	37.4		0.2	1.3		0.7	0.8	1.2		
2019	9.8*			0.3	1.2		0.0	2.3	0.8	11.9	1.1
2020	10.9			0.2	1.0		0.0	0.8	0.1	0.7	0.1
2021	44.8**			0.5	0.5		0.0	0.5	0.4		

*April only

**Two nights of sampling only

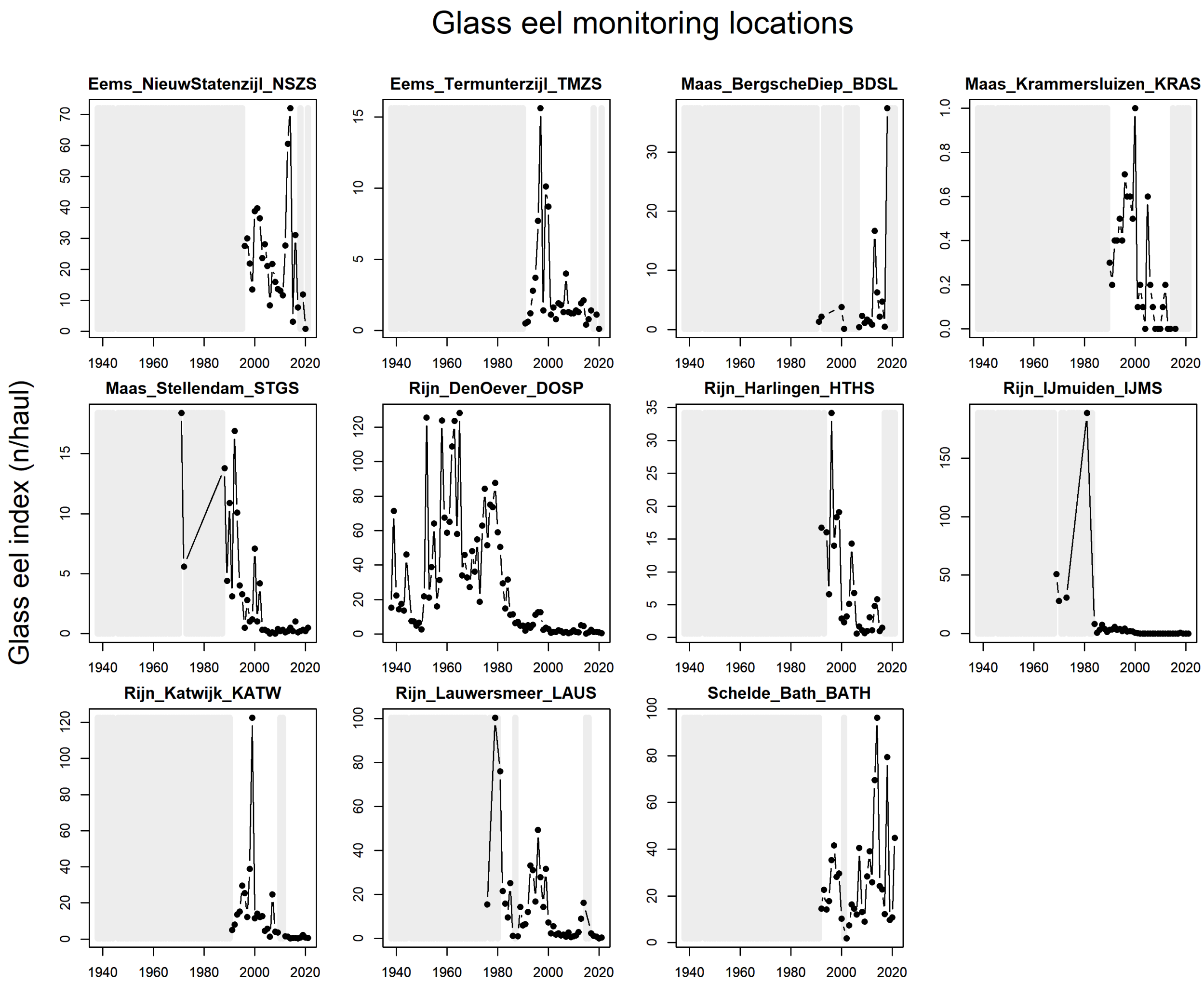

Figure 3 Time series of the glass eel indices (data of Table 3). Grey = not sampled/insufficient data (data Wageningen Marine Research).

2 Overview of the national stock and its management

2.1 Eel Management Units and Eel Management Plans

The Netherlands consists of one EMU and there is one Eel Management Plan (EMP)[1] that was implemented in July 2009 and revised in 2011 and 2018.

1 https://rijksoverheid.archiefweb.eu/#archive
Search for "aalbeheerplan"

2.2 Management authorities

The Dutch Ministry of Agriculture, Nature and Food Quality 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).

2.3 Fisheries

The following regulations apply: the minimum catch size is 28 cm, the fisheries are closed in the period 1 Sept-30 Nov (except for the province of Friesland), all eel caught between 1 September and 30 November have to be released. In 2011 the province of Friesland started a pilot on a quota system, which was adopted in the eel management plan in 2018. This allows those fishermen fishing in the province of Friesland to fish during the closed season based on a TAC (quota of 36.6 tonnes for all fishermen). Recreational catches have to be released throughout the year. In addition, since 2011 the main large rivers are closed for fisheries due to pollution (dioxins, Figure 4)[2].

Figure 4 Overview of the areas closed for eel fishery as of 1 April 2011 (Source: Ministry of Agriculture, Nature and Food Quality).

2.4 Management actions

An overview of all the measures described in the Dutch Eel Management Plan implemented to reach the 40% escapement objective are listed in Table 4.

2 https://wetten.overheid.nl/BWBR0024539/2019-08-14#Hoofdstuk3_Paragraaf3.2_Artikel28b

Table 4 Overview of the measures described in the Dutch Eel Management Plan implemented (source: Dutch Eel Management Plan[3]).

Measure	Planned implementation	Realized implementation
• Implementation of a program for the improvement of fish migration including eel, which is expected to resolve the issues at 1800 of the most important migration barriers.	2015-2027	2015-2027[a]
• Reduction of eel mortality at hydroelectric stations by at least 35%.	2009	November 2011[b]
• The establishment of zones where fishing is not allowed in areas that are important for eel migration.	2010	1 April 2011[c]
• Closed area to eel fisheries due to high levels of dioxins and	-	1 April 2011[c]
• Release of eel caught (a) at sea and (b) at inland waters by anglers.	2009	1 October 2009
• Ban on recreational fishing using professional gear in coastal areas.	2011	1 January 2011
• Annual closed season from 1 September to 1 December.	2009	1 October 2009[d]
• Decentralized eel management in the province of Friesland (a quota system).	-	2018[d]
• Stop the issue of licenses for eel snigglers (*Dutch: 'peur'*) by the minister of LNV in state-owned waters.	2009	1 May 2009
• Restocking of glass eel and pre-grown eel from aquaculture	2009	Early 2010
• Research into the artificial propagation of eel:		
PRO-EEL (EU-project)	2010	2010-2015
EEL- HATCH	2014	2014-2017
EELRIC (Dutch innovation centrum)	2015	2015 - ongoing
Glasaal Volendam (duurzame palingkweek/innovatief	2017	2017 - ongoing

[a] *In agreement with the EC, changes have been made to the original schedule of solving migration barriers.*

[b] *Due to technical difficulties, the maximum achievable reduction in mortality through adjusted turbine management is 24%.*

[c] *There was an (unforeseen) closure of eel fishery in contaminated (PCBs, dioxins) areas (all large rivers). The majority of the contaminated areas that were closed for commercial fisheries on 1/4/2011 include the main rivers. These rivers are the most important migration routes for diadromous species.*

[d] *In 2011 the province of Friesland started a pilot on a quota system. This system was adopted in the eel management plan in 2018. This allows those fishermen fishing in the province of Friesland to fish during the closed season based on a TAC (quota of 36.6 tonnes for all fishermen).*

3 Impacts on the national stock

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 (MLS = 28cm), closed season, quota (Friesland), and on the other hand site-specific licensing. Since 2010 there is a general registration of landings in fresh water.

Until April 2011 the total Dutch fresh water fishery on eel involved approx. 200 companies, with a total catch of nearly 442 tonnes of eel in 2010. However, on 1 April 2011 a large part of the fishery was closed due to high PCB-levels (Figure 4). This closure affected about 50 fishing companies catching 170 tonnes of eel in 2010.

3 https://rijksoverheid.archiefweb.eu/#archive
Search for "aalbeheerplan"

3.1.2 Spatial subdivision

The fishing areas in the Netherlands can be categorised into five groups:

1. **The Wadden Sea**; 53ºN 5ºE; 2,591 km². The Wadden Sea is an estuarine-like area, shielded from the North Sea by a series of islands. The inflow of sea water 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 license holders and assigns specific fishing sites to individual licensees. Fishing gears include fyke nets and pound nets; the traditional use of eel pots is in rapid decline. The fishery in the Wadden Sea is obliged to apply standard EU fishing logbooks.

2. **Lake IJsselmeer and Markermeer**; 52º40'N 5º25'E; now 1820 km². Lake IJsselmeer and Markermeer are shallow, eutrophic freshwater lakes, which were reclaimed from the Wadden Sea in 1932 by a dike (Dutch: Afsluitdijk), substituting the estuarine area known before as the Zuiderzee. The surface of the lakes was reduced stepwise by land reclamation, from an original 3,470 km² in 1932, to 1,820 km² since 1967. In preparation for further land reclamation, a dam was built in 1976, dividing the lake into two compartments of 1,200 km² (IJsselmeer) and 620 km² (Markermeer), 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 fyke nets, eel boxes and long lines; 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. Landings are 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)Estimated landings show differences between the three different sources, the official catch registration system of the Ministry is assumed to be the most reliable.

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, was slowly increasing before the closure from April 1, 2011. The traditional fishery used stow nets for silver eel, but fyke net 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 water bodies. Fishing is licensed to individual fishermen, mostly spatially restricted. Fishing gears are dominated by fyke nets. Management is partially based on marine, partly on fresh water legislation. This area has also been affected by the ban on eel fishery due to high pollution levels (April 2011).

5. **Remaining waters**; inland 1,340 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 km^2 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 fyke netting and hook and line. Individual licenses permit fisheries in spatially restricted areas, usually comprising a few lakes or canal sections, and the joining ditches. Only the spatial limitation is registered.

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 vessels is kept, but for the other waters there is no central registration of the vessels being used.

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 capacity of fyke nets 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 in several steps, the latest being a buy-out in 2006. Since the number of companies has reduced at the same time, the fishing effort per company has not reduced at the same rate, and underutilisation of the maximum capacity probably still exists. The effort in the longline fishery was not restricted, other than by the number of licenses.

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. 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. com. RVO, Ministry of Agriculture, Nature and Food quality, 2017). In 2021, the total number of gears allowed was 1,579 fixed fykes, 3,193 train fykes (1 fyke = 2 eel units), 7,415 eel boxes. These numbers have hardly changed in the past few years.

3.1.4 Glass eel fisheries

Fishing on glass eel in The Netherlands is forbidden as the minimum landing size is 28 cm.

3.1.5 Yellow and Silver eel fisheries

There is no reliable historical data on silver eel landings available. Silver eel and yellow eel landings have therefore been combined.

Since the closed season for fisheries 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 has 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 that Frisian inland fishers continue fishing during the closed period and will be catching more silver eels. 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. Together, the Frisian fishers are allowed to catch 36.6 ton annually regardless of the season.

3.1.5.1 Commercial Fresh water

Landings data from before 2010 is only available for the lakes IJsselmeer and Markermeer. Total landings of yellow and silver eel combined were reported. Collection of the IJsselmeer and Markermeer landings data has been done by LNV/PVIS and the PO IJsselmeer. Since 2010 all freshwater landings are registered by the ministry (LNV). Below the different sources are described.

LNV (1938-1993) / PVIS (1994-2012): Statistics from the auctions around lakes IJsselmeer and Markermeer were kept by the Ministry of LNV until 1994; and between 1994 and 2012 statistics were kept by the Fish Board (PVIS). The quality of this information from PVIS deteriorated considerably, 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.

PO IJsselmeer (2001-): From 2001 onwards the fishers organisation (PO IJsselmeer) has kept records of the catches of their associated fishers (>90% of the fishers active in the IJsselmeer area). These records cover the IJsselmeer only and only those fishers that are member of the PO. In recent years the members of the PO have decreased.

LNV registration system (2010 -): In January 2010 an obligatory catch registration system was introduced in the Netherlands by the Ministry of LNV. Weekly catches of eel are 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 up till 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 5, Figure 5). However, the data is self-reported and not checked by the authorities on being correct.

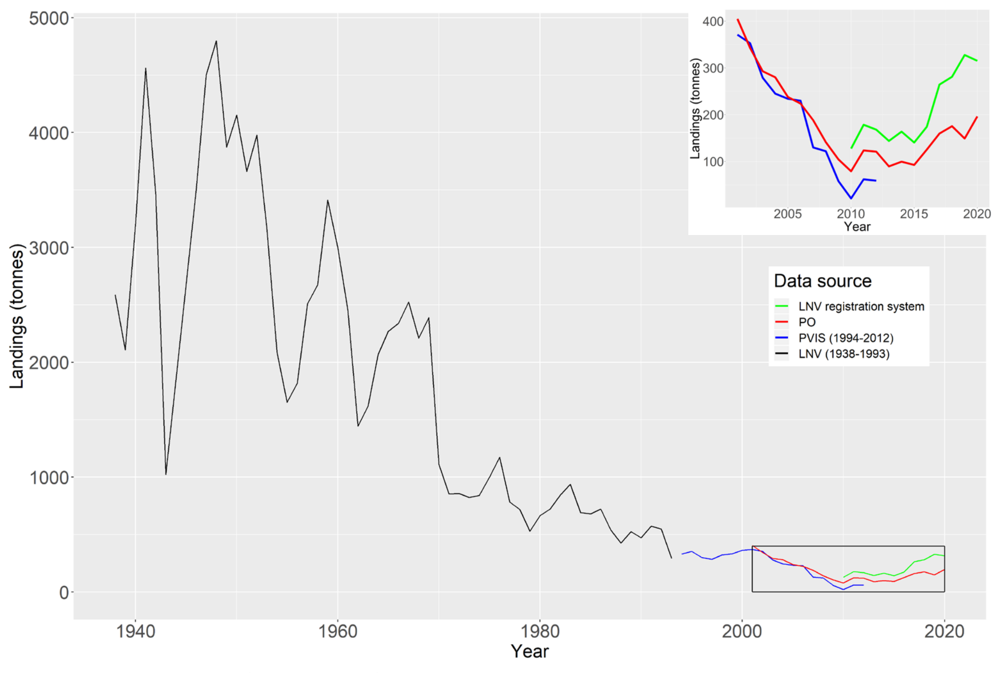

Figure 5. Time series of landings of yellow eel, silver eel and yellow plus silver eel combined from Lake IJsselmeer/Markermeer from 1938-2020 (before 1938 these two lakes were not separated and

directly connected to the sea and was called, "Zuiderzee"). Source data: LNV, Productschap Vis and PO IJsselmeer.

In addition to landings of Lake IJsselmeer, the Ministry of LNV collects also eel landing data from all other Dutch inland waters through the catch registration system since 2010 (Figure 6). 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. In 2020, landings in Lake IJsselmeer and Lake Markermeer, have ceased to increase. Landings in other inland water remained relatively stable over the past few years (Table 5).

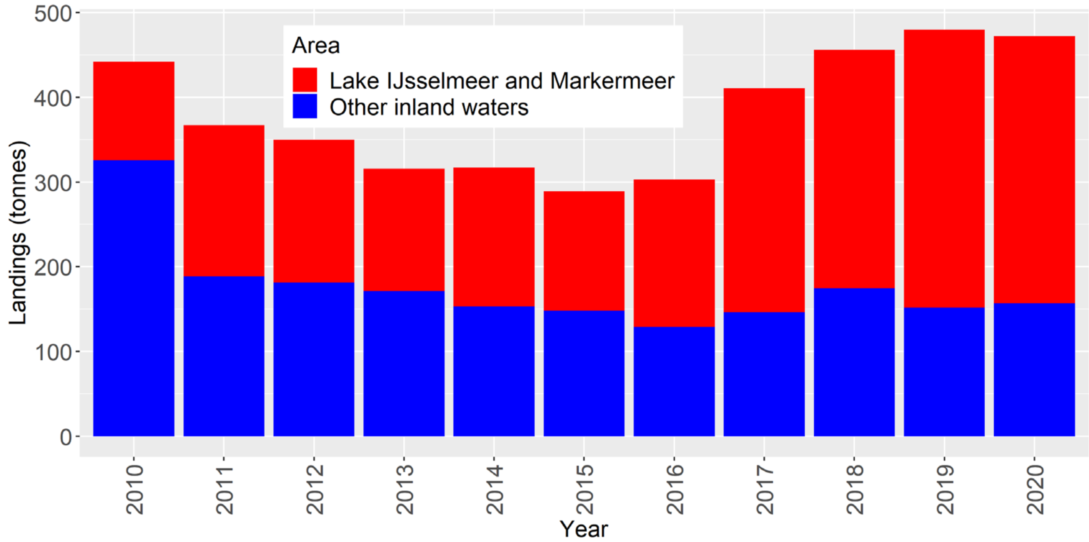

Figure 6 Time series of landings of yellow and silver eel combined from all inland waters based on the catch registration system. Source data: LNV.

Table 5 Time series of landings of yellow and silver eel combined from all inland waters based on the catch registration system. Source data: LNV.

Year	Lake IJsselmeer & Markermeer (kg)	Other inland waters (kg)	Total (kg)
2010	116,613	325,505	442,118
2011	178,535	188,566	367,101
2012	168,280	181,514	349,794
2013	144,124	171,465	315,589
2014	163,832	153,308	317,140
2015	140,544	148,425	288,969
2016	174,284	129,119	303,403
2017	264,489	146,268	410,757
2018	281,138	174,581	455,719
2019	327,674	151,987	479,661
2020	315,295	156,832	472,127

3.1.5.2 Commercial Silver eel landings at 5 locations.

Most of the landed silver eel is reported under 'Yellow and Silver eel fisheries' in section 3.1.5. This year, a fisheries time-series up to 2012 of silver eel catch data from three locations in the province of Friesland (Gruns, Inthiemasloot, Kortevliet), one in the province of Groningen

(Reitdiep) and one in the province of North Holland (Westeinderplassen, Figure 7) is included in the country report. Some of the data was already partly reported in the 2013 Dutch country report, ICES 2013).

At the Frisian locations Inthiemasloot and Korte Vliet, silver eel catches decreased prior to 1960, and the fishermen at these two sites ceased fishing in 1968 due to these reduced catches (Figure 8). At the third Frisian location (Gruns), a sharp decline of male silver eel catches in the 1980s and early 1990s is visible, as is an increase of female silver eels from the 1980s. The sex ratio changed from a male dominated population to a female dominated population. At the locations around Reitdiep there is a large increase of catches from the 1980s up to the early 2000s. This can partly be explained by an increase of effort where fykes with large wings that usually block a whole river (so-called ‘dichtzet’) were being replaced with large fykes. For the Westeinderplassen, catches of males increase up to 1980 after which they steeply decline up to 2012. Catches of females seem to have increased from the 1980s up to the 2000s. As with ‘Reitdiep’, the increase can be partly explained by the switch from the ‘dichtzet’ to large fykes during this period increasing the effort. Note that in the Westeinderplassen, the sex ratio changed in the same way (male to female dominance) at the same time as at the location Gruns (Figure 8).

Figure 7 Five catch locations where fishermen recorded their silver eel catches. Maps were created using ArcGIS® software by Esri. ArcGIS® and ArcMap™ are the intellectual property of Esri and are used herein under license. Copyright © Esri. All rights reserved. For more information about Esri® software, please visit www.esri.com.

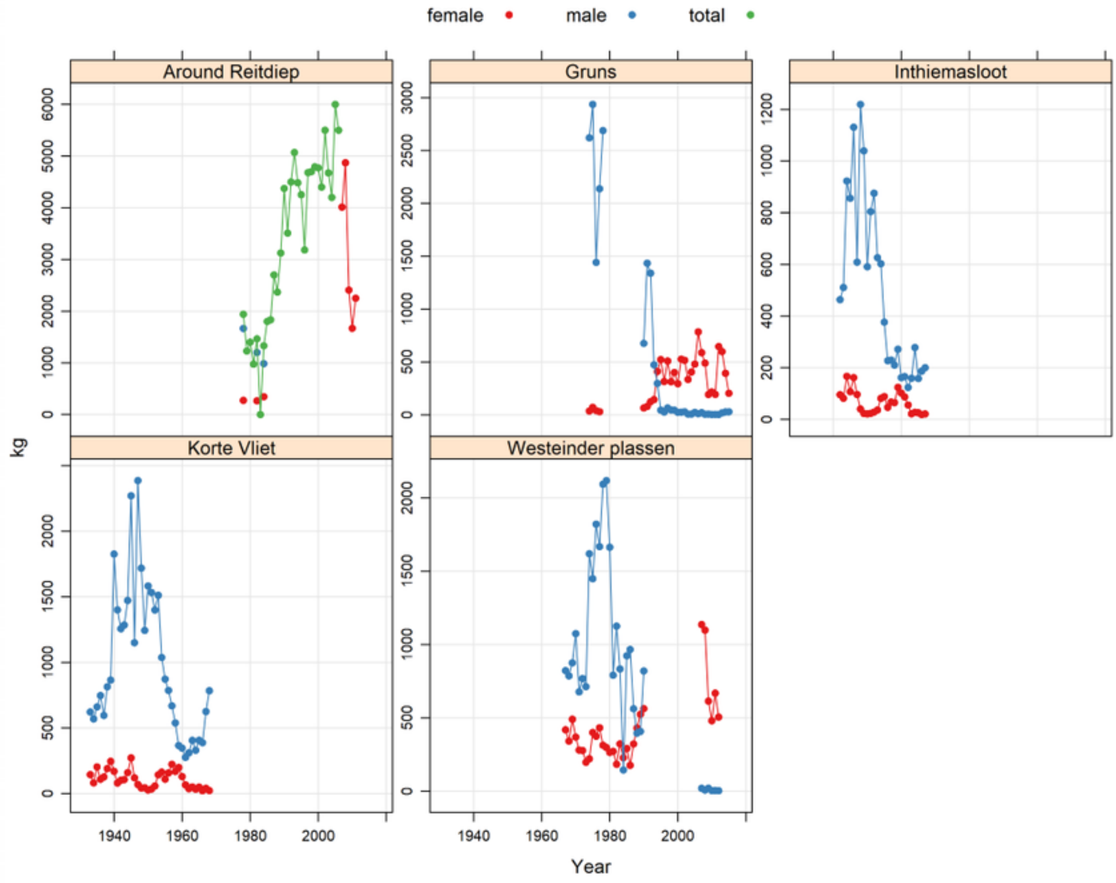

Figure 8 Silver eel (male and female) catches in kg at three closely related sites in Friesland, Groningen and Westeinderplassen between 1933 and 2012.

3.1.5.3 Commercial Marine water

Landings in marine water are mainly in the Wadden Sea. There is a sudden increase from ~4 tonnes in 2015 to 19 tonnes in 2018 (Table 6). In 2019 there is a decline again to similar quantities as before 2016 (4 tonnes). The reliability of the (registration) of the marine landings data is doubted and the data should be used only carefully.

Table 6 Dutch marine fisheries landings.

Year	Landings (tonnes)	Year	Landings (tonnes)
1999	25	2011	3
2000	22	2012	3
2001	34	2013	3
2002	27	2014	3
2003	17	2015	4
2004	30	2016	9
2005	17	2017	10
2006	17	2018	19
2007	9	2019	4
2008	6	2020	3
2009	3		
2010	6		

3.1.5.4 Recreational Fishery

In 2009 an extensive biennial Recreational Fisheries Program was started in the Netherlands. In December 2009, 2011, 2013, 2015,2017 and 2019, ~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, 2018 and 2020), 2000-2500 recreational fishermen were selected for a 12-month logbook programme. By combining the results from the screening survey, the logbook survey and the Dutch population size the total number and weight of eel caught by recreational anglers in The Netherlands was estimated (van der Hammen, 2019).

From 2010 to 2016 the estimated number of retained eel decreased from 111 tonnes to 24 tonnes (*Table 7*). In the 2016 estimate only few eels were reported during the logbook survey which makes the estimates only approximate (low precision, *Table 7*).

The Dutch eel management plan states that since October 2009 all eel caught by recreational anglers should be returned (*Table 4*).

Table 7 Recreational Fisheries: retained and released catches of eel by anglers in numbers and biomass in the Netherlands in inland and marine areas (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				

3.2 Restocking

3.2.1 Reconstructed Time Series on Stocking

The amount of restocked (glass) eels over time is shown in Figure 9. No (historical) data is available with regards to origin and whether or not stocked eels were quantined.

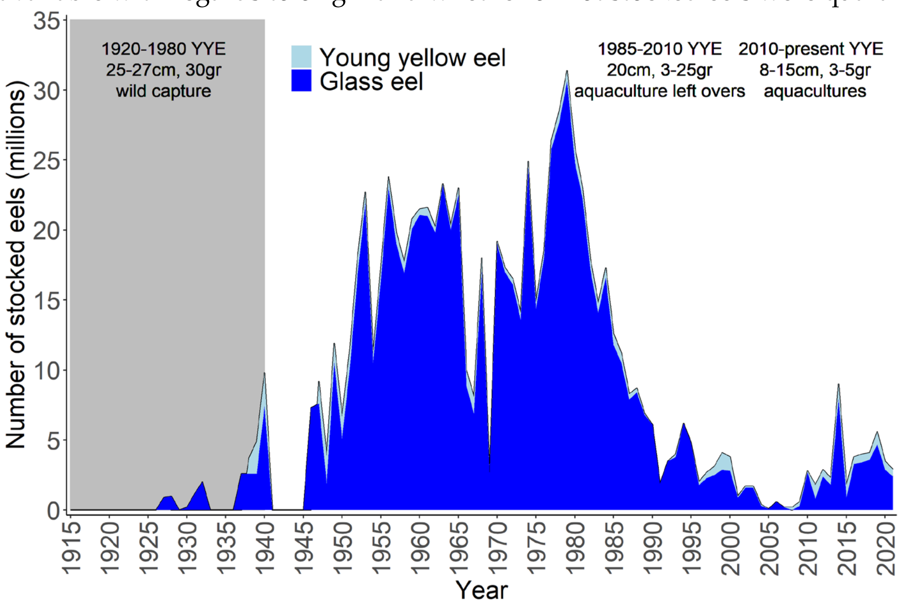

Figure 9 Overview of stocking of glass eel and young yellow eel in the Netherlands. Note that the average weight of stocked young yellow eel decreased from ~30g to ~3 g between 1920 and 2010. YYE = Young Yellow Eel

3.2.2 Amount stocked

The locations and numbers of eels stocked in 2020 in the Netherlands can be found in Table 9.

Table 8 Overview of glass eel and young yellow eel stocked in the Netherlands in 2020 (Source DUPAN).

	Date	Location	Origin	kg	Number	No./kg
Glass Eel	03-03-2021	Zuidelijke Randmeren	France	282	761,132	2,699
	03-03-2021	Veluwe Randmeren	France	467	1,262,366	2,703
	03-03-2021	Vechtboezem	France	27	74,257	2,750
	03-03-2021	Twentekanalen	France	31	83,539	2,695
	03-03-2021	Vollenhovemeer	France	21	55,639	2,649
	March 2021	Westeinderplassen	France	21	63,000	3,000*
	March 2021	Flevopolders	France	15	45,000	3,000*
	March 2021	NW Overijssel	France	15	45,000	3,000*
	Total			879	2,389,933	
Young Yellow Eel	26-05-2021	Frieze boezem	Glass eel from France (aquaculture in NL)	378	123,980	328
	26-05-2021	Amstelmeer	Glass eel from France (aquaculture in NL)	204	67,016	329
	26-05-2021	Kromme Mijdrecht	Glass eel from France (aquaculture in NL)	31	10,052	324
	26-05-2021	Zwartemeer	Glass eel from France (aquaculture in NL)	828	271,416	328
	Total			1,441	472,464	
Glass eel +	Total			2,320	2,862,397	

*Estimation

3.3 Aquaculture

3.3.1 Seed supply

Table 9 Origin and amount (kg) of glass eel used for aquaculture in the Netherlands since 2010. Amounts are rough estimates (Source DUPAN).

Year	France	Spain	England	Total (kg)
2010	4,725	1,890	135	6,750
2011	5,325	1,350	100	6,775
2012	5,500	650	550	6,700
2013	3,400	250	1,250	4,900
2014	4,400	500	300	5,200
2015	5,200	0	Few hundred kg*	5,500
2016	5,300	800	150	6,250
2017	4,690	900	300	5,890
2018	5,730	0	550	6,280
2019	4,340	0	1,000	5,340
2020	3,780	0	1,450	5,230
2021	5,,970	200	0	6,170

*assuming ‘a few hundred kg’ to be 300 kg

3.3.1.1 Production

The estimated production of yellow eels through aquaculture remains relatively stable over the past decade (Figure 10).

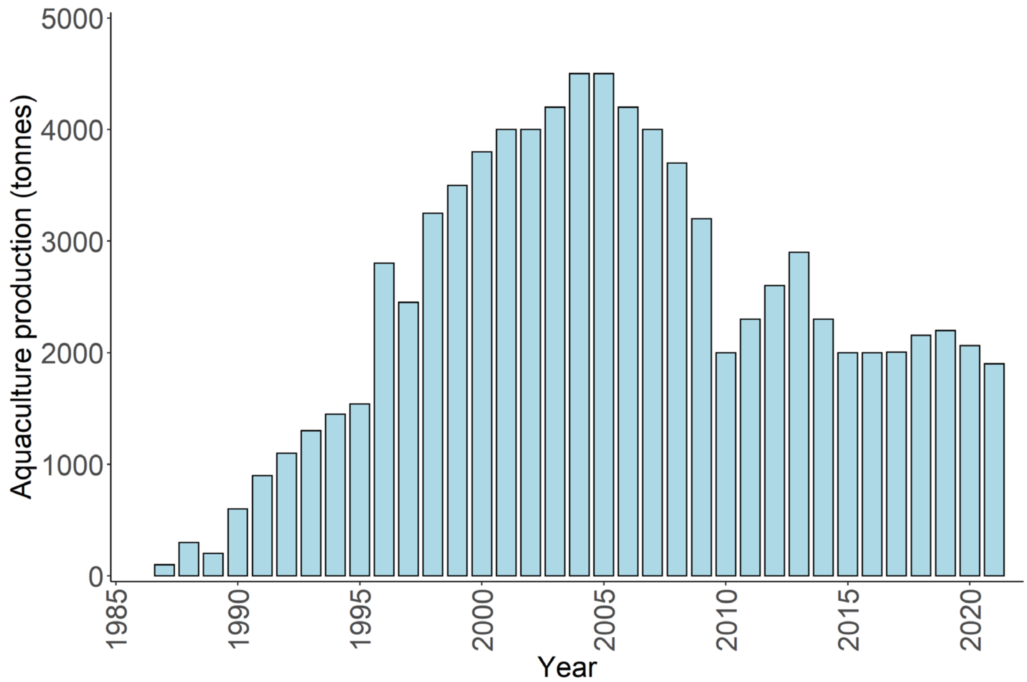

Figure 10 Trend in aquaculture production of yellow eel for consumption in the Netherlands. In 2021, a (rough) estimate of the production was 1900 tonnes (Source DUPAN).

3.4 Entrainment

A summary of the methods to estimate entrainment is given below, more information can be found in van der Hammen et al. (in prep).

A conceptual model for silver eel migration was built, based on a hierarchy of water bodies, 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 water body type. These three main water body types correspond to the three main hierarchy levels of water bodies in The Netherlands:

1) 1st hierarchy (termed **'polder' water bodies**): water bodies which are below sea level and serviced by a large number of small pumping stations with often high levels of mortality during passage.
2) 2nd hierarchy (termed **'boezem' water bodies**): water bodies such as canals, small in-land 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 water bodies (the 3rd hierarchy of water body in the model; see below) via larger pumping stations and/or sluices;
3) 3rd hierarchy (termed **'national' water bodies**): large nationally managed water bodies such as sections of the main rivers and large lakes.

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. 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.

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.

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)].

From polder waters to boezem waters or to the sea: a best guess estimate of 35% mortality was used, where pumps result in the highest mortality (Table 11). Transition rates between the three hierarchies of water bodies (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 10 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	0.54	56	29.3
Pump Mortality			34.7%

* Mortality is % dead + 0.5 % damaged.

3.4.2 Mortality rates from boezem water bodies to national water bodies, 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 & 2013b) and updates.

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 5% for passage to the sea and 15.2% for passage to national waters (van der Hammen et al. in prep).

3.4.3 Mortality rates from national water bodies to sea, and hydro-power stations

The approach for barrier mortality estimation for national waters is also based on the inventory of Winter et al. (2013a, 2013b) and updates.

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 2% (van der Hammen et al. in prep).

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).

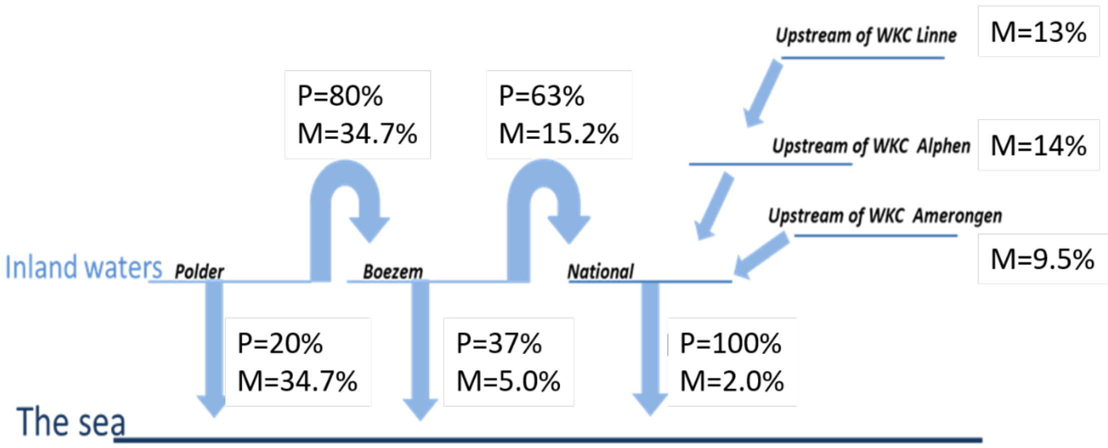

Figure 11. Migration mortality scheme used to estimate overall migration mortality of silver eel. 'WKC' = hydropower station (Dutch: 'waterkrachtcentrale').

3.5 Other impacts

3.5.1 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 2020, about 9,500 kg was caught and released, which is considerably less compared to the previous two years (Figure 12).

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 2020 was estimated to be 1,300 kg (Figure 12). This is quite a bit lower than the previous years, mainly because the majority of eels were caught and released at two large barriers (WKC Amerongen and WKC Alphen) which are estimated to have relatively low mortality rate (10% and 14% respectively).

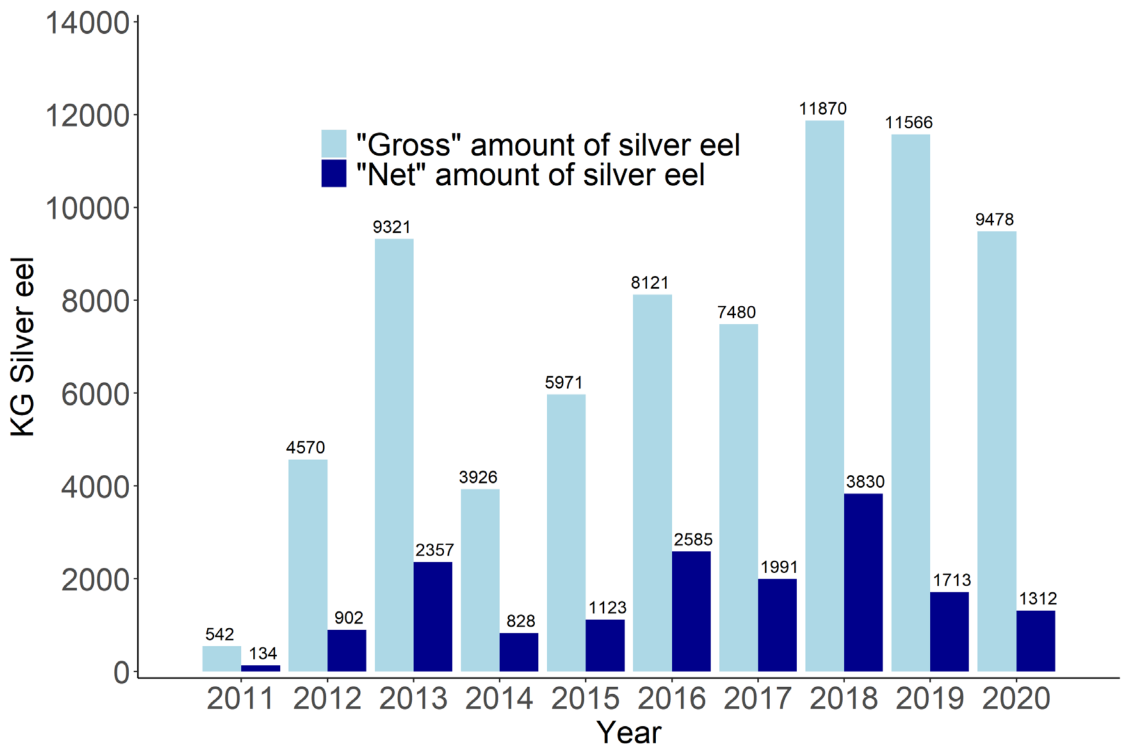

Figure 12 Overview of the "gross" and "net" amount of silver eel (kg) assisted over migration barriers in the Netherlands.

3.5.2 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). In 2015 in total 202 fishing gears associated with illegal eel fishing were seized (61 incidents), this number decreased to 51 (24 incidents) in 2017 (Figure 13). In 2018 this number increased again to 89. In 2019, both the number of incidents and the number of gears seized did not change much. In 2020 both the number of incidents and the number of gears seized decreased again. The most common cause of illegal fishing in 2020 was fishing without licence (Table 12, Figure 13).

Table 11 Overview of suspected causes of illegal fishing activities in the Netherlands (2020). Number of cases (incidents) per area (Source: NVWA).

	IJsselmeer	Markermeer	Zuid-Holland	Noord-Holland	Flevoland	Zeeland	Friesland	Total
Fishing out of the season			2	2		1		5
Fishing without licence	2	3	1	3		5		14
Fishing using illegal gears							2	2
Retention of eel below size limit								
Illegal selling of catches								
Fishing in closed areas				1	1			2
TOTAL	**2**	**3**	**3**	**6**	**1**	**6**	**2**	**23**

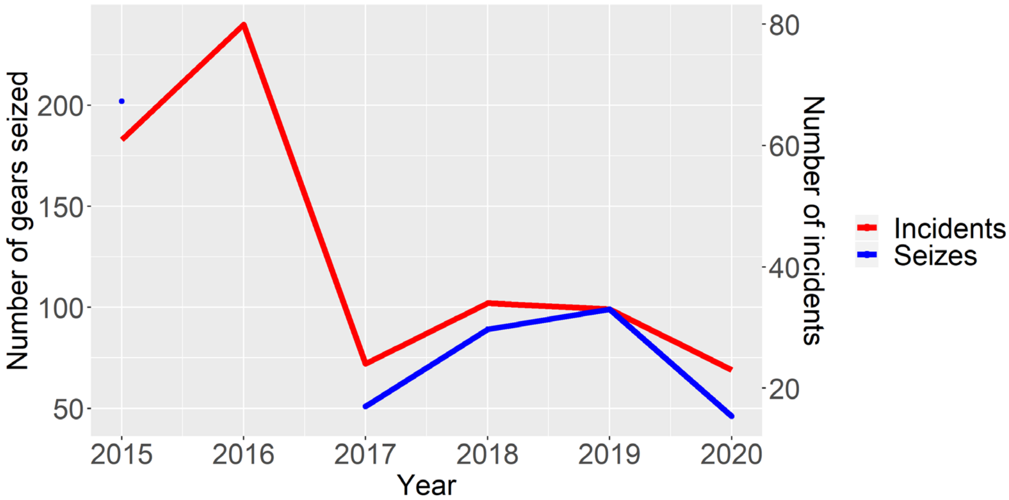

Figure 13 Number of gears seized (blue) and number of incidents (red) per year as reported by the NVWA.

4 National stock assessment

4.1 Description of Method

Methods are described in Van der Hammen et al. (in prep).

4.1.1 Data collection

1) **Retained catches.** Retained catches are defined as the landings from commercial fishers. Since 2010 all freshwater landings are provided by the Ministry of Agriculture Nature and Food Quality (LNV) and are stored in a database ('Visstat'). For lakes IJsselmeer and Markermeer, PO (product board) data is available for the periods before 2010.

2) **Market sampling**. Representative samples are taken from retained catches from commercial fisheries each year and the lengths of the individual eels are measured. Furthermore, several eels per length class were selected from each sample for dissection and measurements of maturity, weight and sex (see van Keeken et al. 2020 for methods). These measurements are used to calculate maturity-at-length, weight-at-length, and sex-ratio-at-length. Since 2010, otoliths have been obtained annually. From 2014 onwards, ~50-100 otoliths are sent 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.

3) **Surveys in regionally managed water bodies**. Eel sampling within the Water Framework Directive (WFD, 2000/60/EC) waters was executed following an EU certified protocol. In the assessments presented here only data from electrofishing with electric dipping nets were used. Sampled water bodies are representative for water types defined within the Netherlands based on WFD regulation. Data collection is managed and stored by regional water boards. Electric dipping net data

for recent years were obtained from ATKB (consultancy for water, soil, and ecology) and several water boards. A total of ~8800 samples by electric dipping nets were available between 2006 and 2019, covering most of the combination of water boards and water body types.

4) **Surveys in nationally managed water bodies**. Within the survey program "Fish Monitoring National Waters," fish species in the main Dutch rivers are monitored yearly (van Keeken et al., 2020). In the program, the main rivers and water bodies connected to the main rivers are sampled in autumn or in some cases early spring. Depending on the region, sampling started in 1997 or later.

5) **Non - Water Framework Directive waters.** Ditches are underrepresented in the set of WFD water bodies. Therefore, a survey with an electric dipping net is carried out by WMR every year and is added separately to the spatial model. A total of ~350 samples by electric dipping nets were available between 2013 and 2020.

6) **FYMA electric trawl survey in lakes IJsselmeer and Markermeer**. Since 1989, WMR has been conducting an annual (yellow) eel survey in lake IJsselmeer (25 sites) and lake Markermeer (15 sites) with an electrified trawl. The survey takes place in the autumn (October-November).
7) **Glass eel survey liftnet Den Oever** Since 1938, recruitment monitoring has been running at Den Oever. The monitoring is conducted with a liftnet (1x1 m) during March-May. Glass eel data are presented as the average number of glass eels per haul in the months of April and May.

8) **Recreational landings** Since 2010 a biennial survey has been conducted in the Netherlands to estimate the total eel catches in the recreational fisheries.

9) **Transponder research Meuse** The anthropogenic mortality of migratory silver eels in the Dutch rivers is determined by means of tracking silver eels equipped with a transponder. Within this transponder research, 150 silver eels are provided with a NEDAP transponder once every three years and released in the upper reaches of the Dutch part of the river Meuse. The data is used to estimate silver eel escapement in relation to anthropogenic mortality of silver eel by hydroelectric power stations. Unfortunately, data from the last field season (2019) could not be used due to database crashes at NEDAP and damaged detection stations.

10) **Diadromous fish monitoring programme** A survey programme started in 2012 to monitor the abundance of migrating silver eel 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. The programme is a collaboration between WMR, Rijkswaterstaat and commercial fishermen. The months September, October and November were selected for illustrating trends in silver eel abundance at each location.

4.2 Trends in Assessment results

Current biomass of escaping silver eel ($B_{current}$)

Between 2006-2008 and 2015-2017, the biomass of escaping silver eel increased every period ($B_{current}$, Table 13). 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 (B_{best}) has a steep decrease between 2006-2008 and 2009-2011, after which there was a modest increase in 2012-2014 from where the levels remained relatively stable (Table 13).

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 2006 and 2017 from 83% to 40%. In each 3 year period, a reduction was achieved (Table 13). 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 2006-2008 and 2015-2017. In the 2018-2020 period, however, mortality increased again to 55%. This is due to a lower estimate of the standing stock compared to previous years, as well as an increase in the landings (344 tonnes in 2015-2017 vs. 479 tonnes in 2018-2020 (van der Hammen et al., in prep).

Table 12. 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	2006-2008	2009-2011	2012-2014	2015-2017	2018-2020
B_0*	10,400 t	10,400 t	10,400 t	10,400 t	10,400 t
$B_{current}$	634 t	837 t	1,311 t	1,463 t	974 t
B_{best}	3,759 t	1,791 t	2,270 t	2,420 t	2,153 t
% escaping Silver Eel	6.1%	8.1%	12.6%	14.1%	9.4%
LAM	83.1%	53.2%	42.2%	39.5%	54.8%

* Excluding coastal waters (2600 t)

5 Other data collection for eel

5.1 Yellow eel abundance surveys

5.1.1 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 14). This data set shows a pattern of a 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). For all the previous years, only eels that were caught in spring and autumn were used for this figure. For 2020 however, the fyke was only set during 55 days in autumn because of Covid-19 measures during spring 2020. In 2020, 13 eels were caught within a period of 55 fyke days. This is the highest number since 1991. Although this number cannot be compared with previous years as the spring is not sampled in 2020, in the last three years (2017, 2018, and 2019) only 3, 4 and 10 eels were caught in spring and autumn combined, indicating higher catches for 2020 compared to previous years.

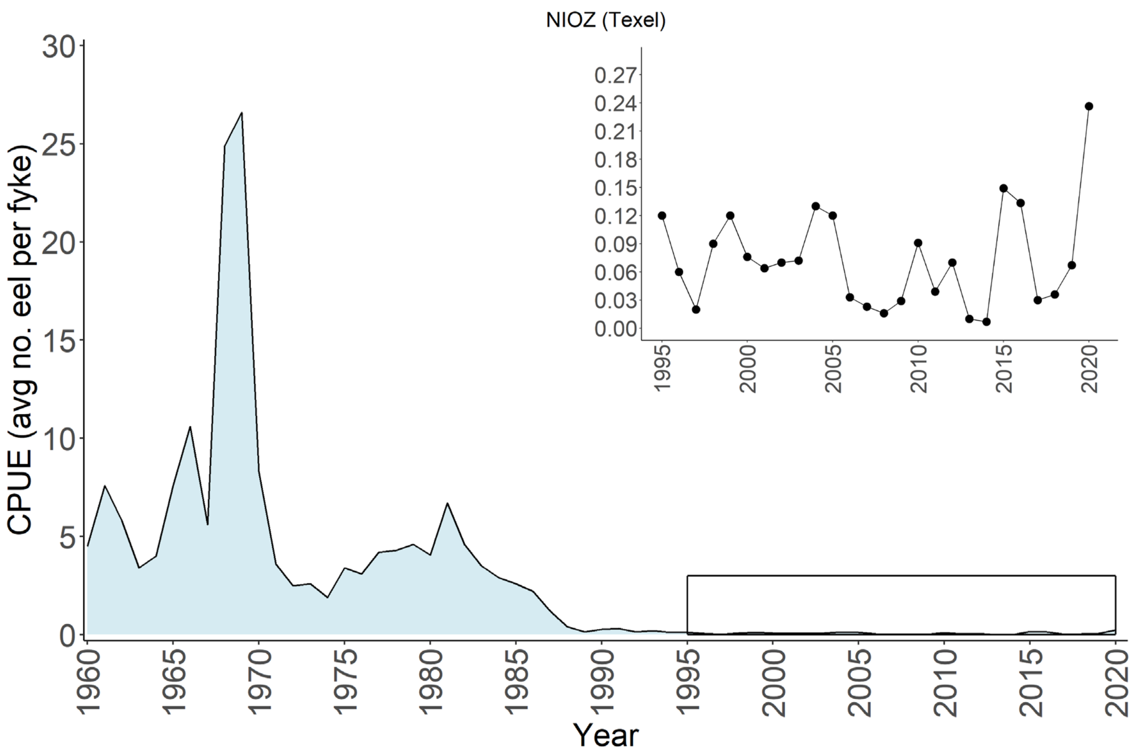

Figure 14 Time series of the mean catch per fyke (numbers) of eel caught in spring and autumn at NIOZ 1960-2020 (data Van der Meer et al., 2011 and NIOZ).

5.1.1.1 Lake IJsselmeer/Markermeer (active gear)

Figure 15 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 2017-2020 are relatively high compared to the previous decade. The number of eels remains low, indicating an increase of heavier (larger) eel in the lakes.

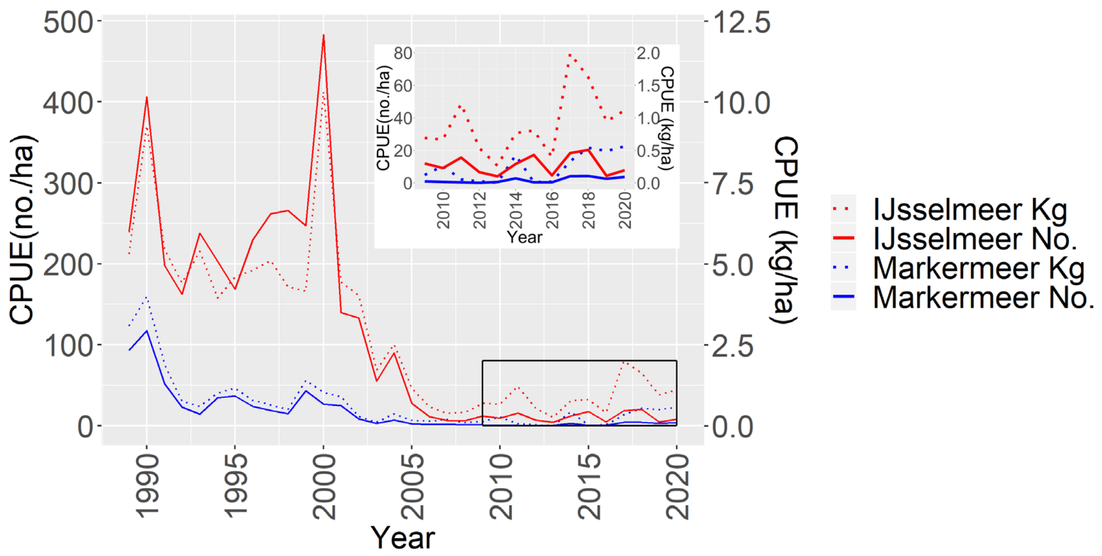

Figure 15 CPUE trends in Lake IJsselmeer stock surveys (no/ha and kg/ha), using the electrified trawl. Note: The northern and southern compartments (IJsselmeer and Markermeer resp.) have been separated by a dyke since 1976 (data: Wageningen Marine Research).

Figure 16 presents the trends in CPUE for the annual eel surveys along the shore of Lake IJsselmeer and Lake Markermeer, using an electric dipping net. Sites that were sampled with a beach seine or sites that included a so-called "preshore" (Dutch: vooroever) were excluded as only a few eels were caught at those sites. For Lake IJsselmeer both numbers and biomass of eel caught between stones fluctuate but seem to increase over time. For Lake Markermeer, there is a steep decline in 2013, followed by a clear upward trend since 2015 of eel caught between stones, both in numbers as in biomass with the highest numbers and biomass since the start of the monitoring in 2020. Eels are consistently more caught between stones then along shores with reed. Both the biomass and number of eels along shores with reed seem to be fairly stable through time for both lakes, although Lake Markermeer shows a decrease in 2014, and both the number as the biomass of eels do not seem to recover in this habitat. This pattern is also visible in Lake IJsselmeer only less pronounced.

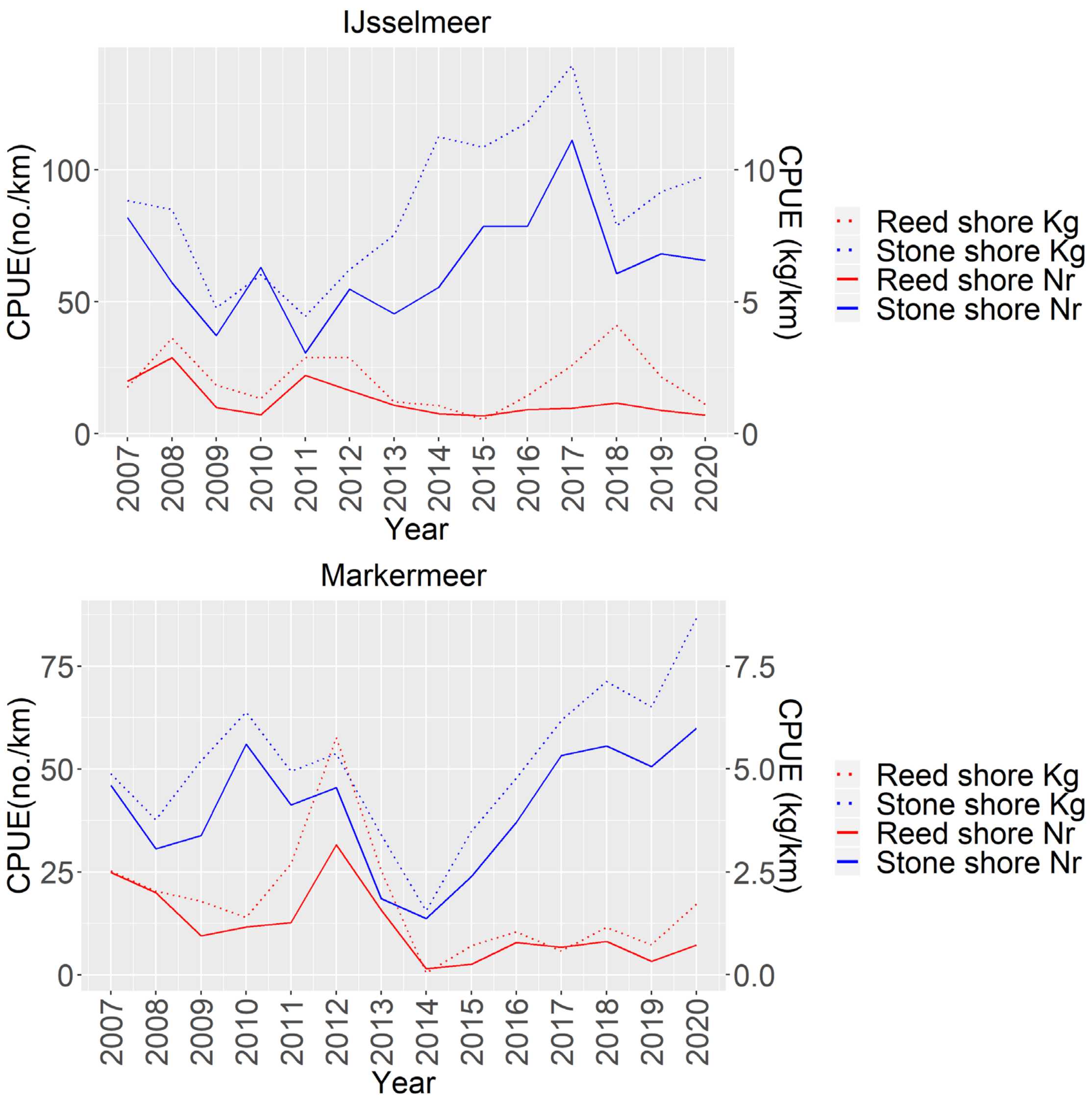

Figure 16 CPUE trends along the shores of Lake IJsselmeer (top) and Lake Markermeer (bottom) shore surveys (no/km and kg/km), using an electric dipping net, separated by shores that are covered by reed (green) and shores that mainly consist of rock (black), data: Wageningen Marine Research.

5.1.1.2 Main rivers (active gear)

A selection of data collected from 1999-2020 was made over five so-called "VBC-areas" (Figure 17). VBC areas were selected when annual monitoring data was collected for 12 years or more. Figure 18 shows the trends in CPUE for the annual (yellow) eel surveys in these five VBC areas collected by electrofishing along the shores of the main stream. 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 and slight signs of recovery in 2020 (except for VBC Waal plus).

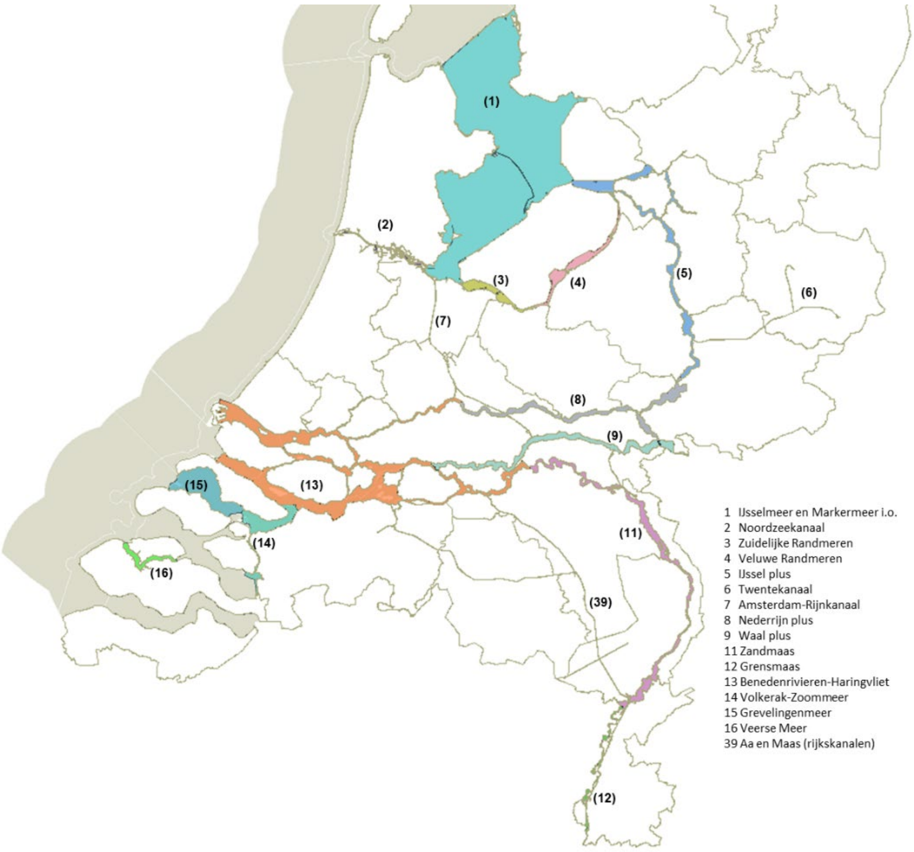

Figure 17 Map of VBC areas in the Netherlands.

Figure 18 CPUE trends in five VBC areas (kg/km), sampled by electrofishing (data: Wageningen Marine Research).

5.1.1.3 Main rivers (passive gear)

The Silver Eel Index in the Netherlands is calculated by using a survey programme that started in 2012. In co-operation 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 (Figure 19).

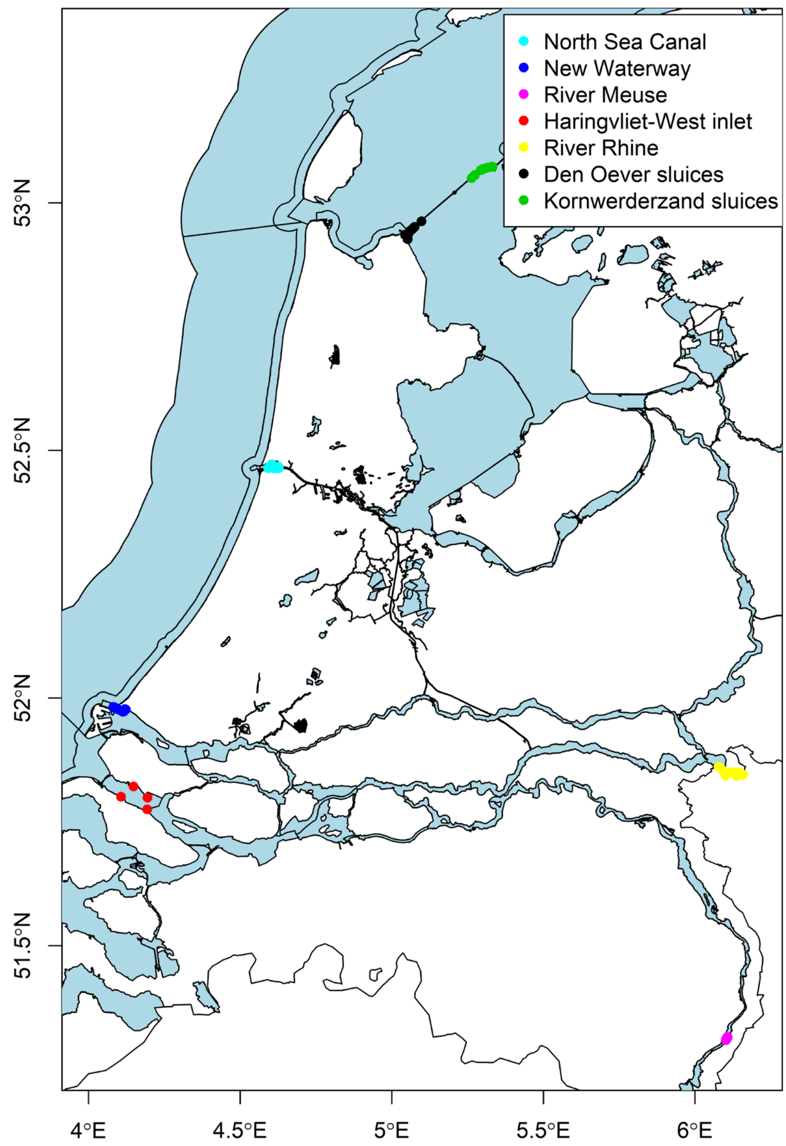

Figure 19 Locations of the diadromous fish monitoring programme.

The months September, October and November were selected for illustrating trends in silver eels at each location. Eel numbers fluctuate strongly on a yearly basis (Figure 20). Most eels are caught at the Kornwerderzand and Den Oever (both lake IJsselmeer) sluices.

Figure 20 CPUE of silver eel (number per fyke day) caught during the diadromous fish monitoring per catch location. Data is missing or not used because of inconsistency of sampling locations/period for the Haringvliet-West inlet in 2018, for the Den Oever sluices in 2012, 2014 and 2015, for the Korn-werderzand sluices in 2012, 2013 and 2015, the River Meuse in 2017 and 2018, the North Sea Channel in 2015 and for the River Rhine in 2012, 2016 and 2018.

5.1.1.4 Coastal waters (active gear)

The number of (silver) eels caught in a coastal survey DFS (Demersal Young Fish Survey) is presented below. The DFS has been designed to target young flatfish with a beam trawl in inshore areas like the Dutch, German and Danish coastal zone, the Dutch Wadden Sea, and the south-western Dutch Delta. The survey has been carried out each year in September-October, since 1970.

Until the mid-1980s, considerable catches of eel were observed, after which a gradual decrease was observed (Figure 21). Only a few eels are caught in the Wadden Sea and the Eastern Scheldt in the past few years.

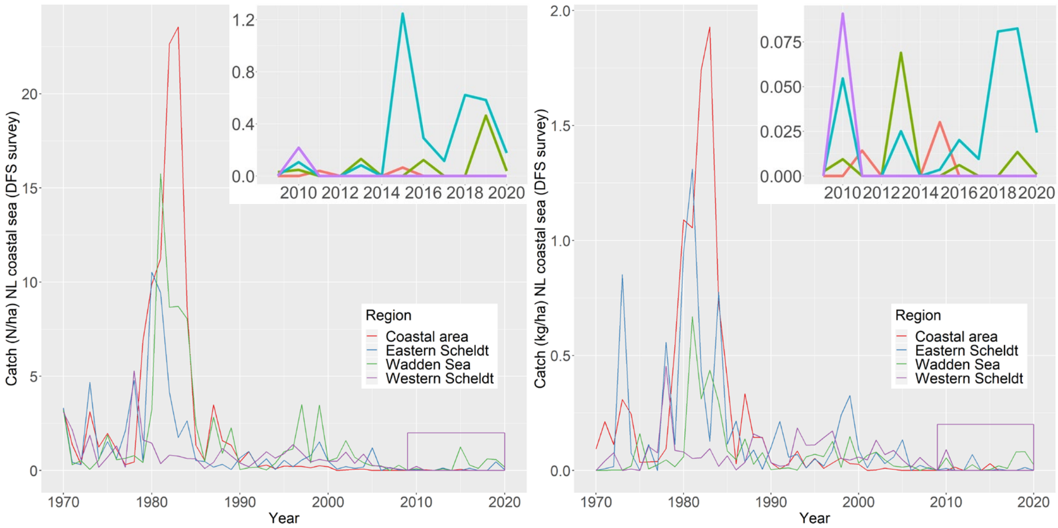

Figure 21 Trends in coastal survey catch 1970-2020. Left graph: n/ha; right graph: kg/ha. Most of the Wadden Sea belongs to RBD Rhine; Eastern Scheldt is mixed RBD Scheldt and Meuse; Western Scheldt belongs to RBD Scheldt (with an extra inflow from Meuse), the coastal area belongs to RBD Rhine (data: Wageningen Marine Research).

5.2 Diseases, Parasites & Pathogens or Contaminants

The swim bladder nematode *Anguillicoloides crassus* was introduced from South-East Asia in wild stocks of European eel in The Netherlands in the early 1980s. The market sampling before 2009 for Lake IJsselmeer collects information on eels showing *A. crassus* infection based on inspection of the swim bladder by the naked eye. We scored an infection as 'present' when either we observed one or more *A. crassus* or a thickened swim bladder. As part of the extended market sampling program in 2009, data on *A. crassus* infection rates have also been collected in two other areas (Friesland and Rivers), and since 2011 the market sampling was conducted in most of the Netherlands. Untill 2017, infection rates appear to decrease for all areas, but strongly fluctuates per year with a decrease in 2020 for all areas except Friesland (Table 14, Figure 22).

Table 13 Infection rates of eels with A. crassus, in the Netherlands. Median infection rates of all sampled locations.

	Friesland			IJsselmeer			Markermeer			Rest NL		
	N eels	N infected	%	N eels	N infected	%	N eels	N infected	%	N eels	N infected	%
2010	534	243	46	390	192	49	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	529	186	35
2013	35	12	34	159	88	55	93	41	44	265	102	38
2014	49	31	63	202	100	50	46	12	26	321	127	40
2015	61	24	39	267	111	42	77	27	35	297	112	38
2016	65	14	22	261	89	34	151	25	17	258	79	31
2017	74	34	46	172	33	19	49	17	35	291	73	25
2018	85	22	26	245	78	32	97	38	39	302	91	30
2019	78	15	19	217	77	35	144	28	19	297	122	41
2020	111	34	31	109	23	21	225	108	48	255	38	15

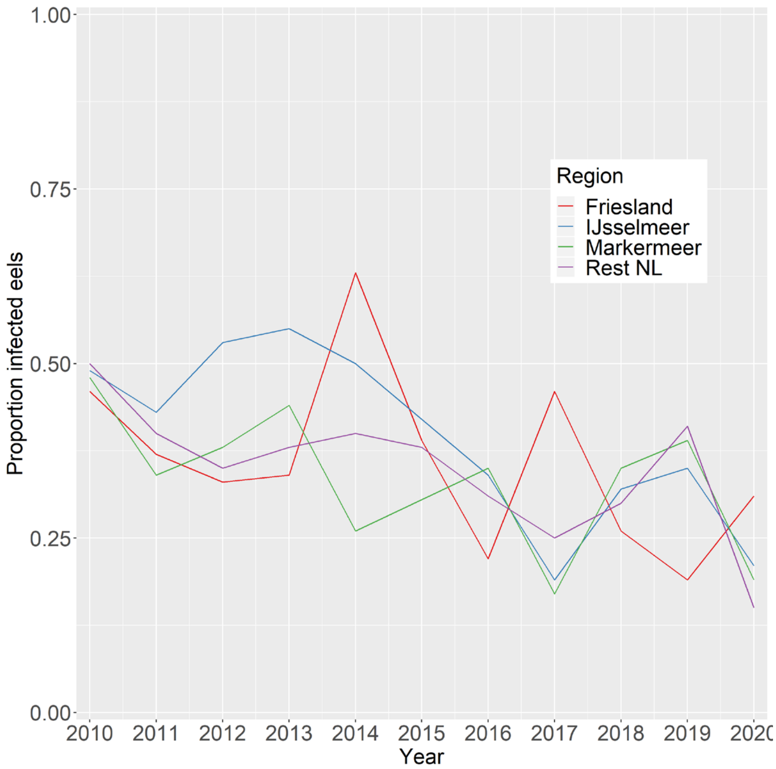

Figure 22 Proportion eels infected with *Anguillicoloides crassus* per region in the Netherlands.

5.3 Contaminants

In 2020, 18 locations were sampled to assess contaminant levels (sum TEQ and sum non-dioxin-like PCBs) in eel (Table 15, 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 53-76 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 fisherman).

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 300 ng/g sum Non-dioxin-like PCBs[4], plus 10% uncertainty, Table 15). 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 23. Concentrations in 2020 were similar to those in previous years for both locations (Lake IJsselmeer and River Waal, 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 nine different locations since 2016. Figure 24 shows the sum TEQ, sum non-dioxin-like PCBs and PCB153 of these larger eels

[4] Sum of 6 PCBs including PCB153. These are non-toxic indicator PCBs that can be measured easily.

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. After another increase in 2019, 2020 is showing a decrease of non-dioxin-like PCBs and PCB-153 except for the location of Volkerak Steenbergen where we see an increase of non-dioxin-like PCBs and PCB-153 in 2020. For sum TEQ in 2020, some location shows an increase compared to 2019 while others show a decrease.

Table 14 Sum-TEQ, sum Non-dioxin-like PCBs, and PBC-153 in eel (2020) (data: Wageningen Marine Research and Wageningen Food Safety Research). PCB-153 is plotted in Figure 23. Values of Sum-TEQ above the regulatory limit of 11pg/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.

Location	Size (cm)	Lipid level (%)	Sum-TEQ	Sum-ndl-PCB	PCB 153
Lek, Culemborg	30-40	5.7	**8.7**	**382**	170
Lek, Culemborg	>53	18.0	**23.7**	**801**	344
IJsselmeer, Medemblik	30-40	7.1	1.8	27	13.2
IJsselmeer, Medemblik	>53	23.9	5.1	63	30
Waal, Tiel	30-40	6.0	6.7	262	117
Waal, Tiel	>53	22.0	**20.1**	**565**	236
Ijssel, Deventer	>53	20.0	**22.1**	**546**	227
Hollands Diep	>53	23.1	**22.5**	**682**	300
Volkerak, Volkeraksluizen	>53	17.6	**13.0**	**364**	161
Rijn, Lobith	>53	21.3	**21.0**	**560**	245
IJsselmeer, Urk	>53	19.9	9.8	211	95
Volkerak, Steenbergen	>53	10.8	6.0	151	72.5
IJsselmeer, nabij Lelystad	>53	23.2	9.1	192	88.6
IJsselmeer, Ketelbrug	>53	25.5	**17.9**	**435**	185
IJsselmeer, Urkerbos	>53	19.4	6.6	110	50.5
Maas, Maashees-Wanssum	>53	9.9	7.5	**548**	225
Ketelmeer, Schokkerhaven	>53	13.8	**11.6**	305	130
Ramsgeul, Ramspolbrug	>53	17.7	9.8	235	105
IJ, meertje nabij Spaarndam	>53	14.4	**12.8**	**534**	240
Linge nabij Heukelum	>53	18.3	7.4	221	100
Noordzeekanaal, Velsen, nabij sluizen	>53	17.6	10.7	266	105

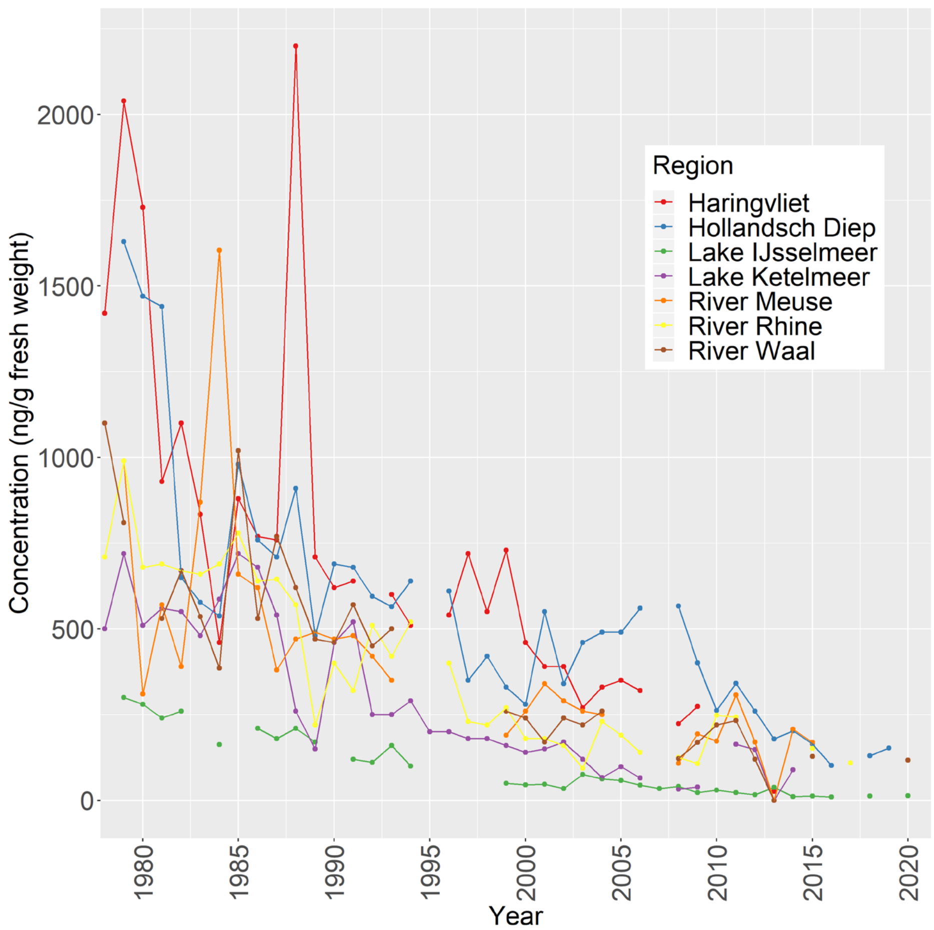

Figure 23 Trend in PBC-153 in 30-40 cm eel. Only data for two locations for this size class are available for 2020 (Lake IJsselmeer and River Waal), see Table 15. Only consecutive years are connected with a line (data: Wageningen Marine Research and Wageningen Food Safety Research).

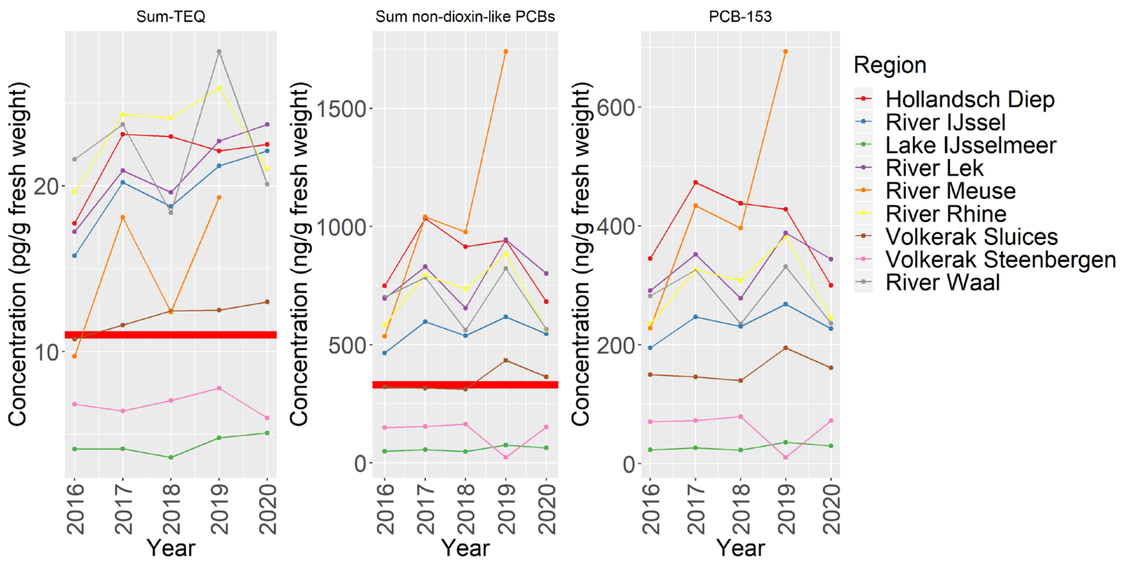

Figure 24 Trends in sum TEQ, sum non-dioxin-like PCBs and PCB153 of eels between 53-76 cm. The red horizontal lines indicate the regulatory limits including 10% uncertainty (11 for Sum-TEQ and 330

for sum non-dioxin-like PCBs). Data: Wageningen Marine Research and Wageningen Food Safety Research.

5.4 Predators

Cormorants (*Phalacrocorax carbo*) are known to predate on eel. The number of cormorant breeding pairs increased rapidly until the early 1990s, then stabilised and even decreased in recent years (Figure 25, Figure 26). For Lake IJsselmeer, food consumption by cormorants has been quantified (van Rijn & van Eerden 2001; van Rijn 2004); eel constitutes a minor fraction of the diet of cormorants. In other areas, neither the abundance, nor the food consumption by cormorants is known.

Figure 25 Natura 2000 areas with cormorant breeding colonies adjacent to the IJsselmeer and Markermeer: (72) IJsselmeer (73) Markermeer & IJmeer (78) Oostvaardersplassen (79) Lepelaarsplassen (94) Naardermeer.

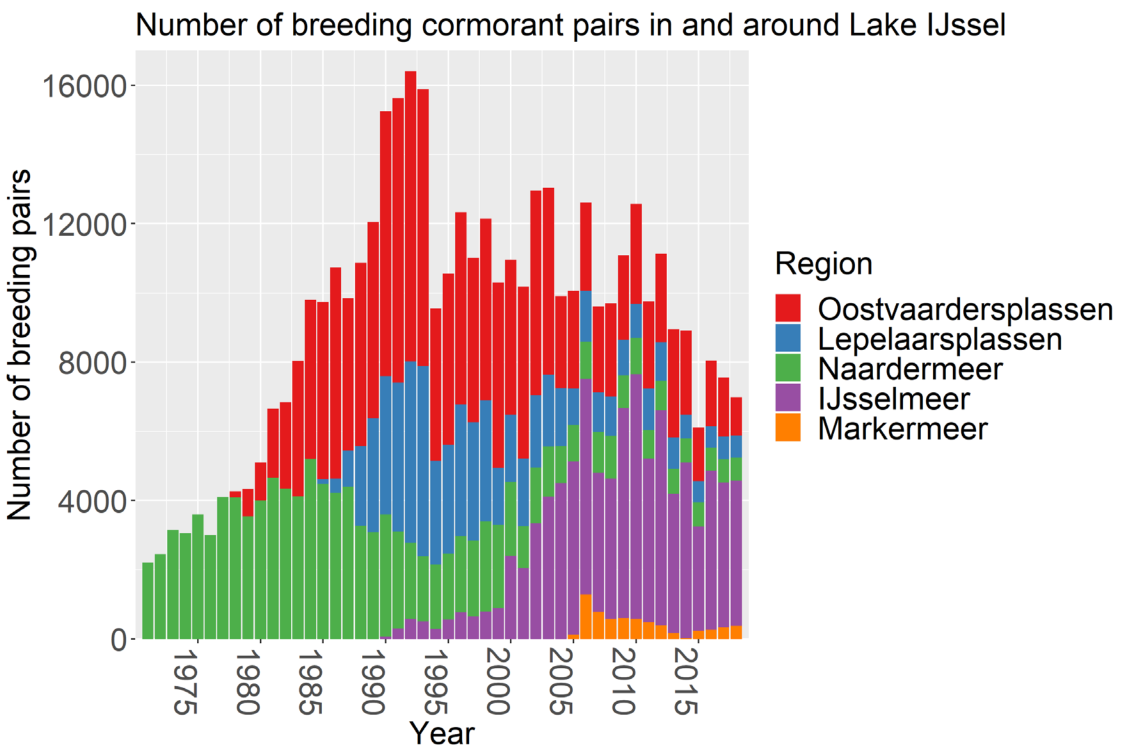

Figure 26 Trends in the number of breeding pairs of cormorants in and around Lake IJsselmeer/Markermeer (Source: Netwerk Ecologische Monitoring, Sovon & CBS).

6 New Information

<u>Glasseel detectors</u>

Due to the low catchability of glass eels with liftnets, sampling with glasseel detectors has been carried out at the ICES locations (Den Oever, Katwijk, Stellendam, Lauwersoog and IJmuiden) since 2019. Monitoring with glasseel detectors is continuous, and much more glass eels are caught compared to the liftnet sampling, which gives a higher precision. The liftnet sampling must run for several years at the same time as the new sampling in order to properly calibrate the new sampling.

<u>Eel migration</u>

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. Because of the drought in the summer of 2018, only one sluice was actually opened which occurred on 16th January 2019. On 12th February 2019 the sluices were opened for a second time; five sluices were opened during the first tide and three sluices were opened during the second tide. After that, the sluices were open on a regular base according to Rijkwaterstaat (about a 1000 times up to December 2020). The sluices were foreseen to 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). However, Rijkswaterstaat has conducted research on salt water movement at the Haringvliet sluices in October 2019. On 10th October at high tide, sea water was led into the Haringvliet and from 10th-21st October, river water from the Haringvliet was led out into sea to test whether the Haringvliet would become fresh again after the salt water inlet. From 21st October, the sluices were closed again. The opening of the sluices in October might have created opportunities for migrating silver eels.

The Afsluitdijk is a hard barrier (dike) 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) is being 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.

7 References

Bierman, S.M., N. Tien , K.E. van de Wolfshaar., H.V. Winter and M. de Graaf (2012). Evaluation of the Dutch Eel Management Plan 2009 – 2011. Imares report C067/12.

Dekker, W. (ed.) (2002). Monitoring of glass eel recruitment. Netherlands Institute of Fisheries Research, IJmuiden, Report C007/02-WD, 256 pp.

Dekker, W. (1991). Assessment of the historical downfall of the IJsselmeer fisheries using anonymous inquiries for effort data. — In: I.G. Cowx (ed.): Catch Effort Sampling Strategies, their Application in Freshwater Management, pp. 233-240. Fishing News Books, Oxford. 420 pp.

Dekker, W. (2009). Bottom trawl surveys in the southern North Sea. Working document presented to the Study Group on Anguillid Eels in Saline Waters, Goteborg Sweden, 3-5 September 2009, 11 pp.

Eijsackers H, Nagelkerke LAJ, van der Meer J, Klinge M, van Dijk J (2009). Streefbeeld Aal, een deskundigenoordeel. Adviesrapport op verzoek van de Minister van L.N.V., Den Haag

Griffioen AB, De Vries P, Twijnstra RH, De Graaf M (2017) Glass eel monitoring in the Netherlands (http://library.wur.nl/WebQuery/wurpubs/519629). Wageningen Marine Research. Report C010/17.

Griffioen, A.B. & Winter, H.V., Van Hal, R., 2018. Prognose visstand in en rond het Haringvliet na invoering van het kierbesluit in 2018. Wageningen University and Research rapport C081/17.

ICES. 2013. Report of the Joint EIFAAC/ICES Working Group on Eels (WGEEL), 18–22 March 2013 in Sukarietta, Spain, 4–10 September 2013 in Copenhagen, Denmark. ICES CM 2013/ACOM:18. 851 pp

ICES (2020) Joint EIFAAC/ICES/GFCM Working Group on Eels (WGEEL). ICES Scientific Reports. 2:85. 223 pp. http://doi.org/10.17895/ices.pub.5982

Klein Breteler J, Vriese T, Borcherding J, Breukelaar, A, Jörgensen L, Staas S, de Laak G, and Ingendahl D (2007) Assessment of population size and migration routes of silver eel in the River Rhine based on a 2-year combined mark-recapture and telemetry study. – ICES Journal of Marine Science, 64: 1450–1456.

Rabbinge R, van der Meer J, Quak J, Verreth JAJ, van der Waal AG, Nagelkerke LAJ (2013) Herberekening Streefbeeld Aal: Een analyse van het bestaande Nederlandse streefbeeld in relatie tot de buurlanden. Een advies op verzoek van de Minister van Economische Zaken, pp. 87.

Tien, N. and W. Dekker (2004). Trends in eel habitat abundance in the Netherlands during the 20th century. ICES C.M. 2004/S:12 (mimeo).

Van der Hammen, T. (2019). Recreational fisheries in the Netherlands: Analyses of the 2017 screening survey and the 2016 – 2017 logbook survey. CVO report: 18.025. DOI: https://doi.org/10.18174/466439

Van der Hammen, T., Soudijn, F., Volwater, J., van Rijssel, J.C., Griffioen, A.B., Chen, C. ,Winter, H.V. (in prep). European Eel (*Anguilla anguilla*) stock size, anthropogenic mortality and silver eel escapement in the Netherlands 2006-2020. Wageningen Marine Research rapport, in preparation.

Van der Meer, J., H.W. van der Veer. and J.IJ. Witte (2011).The disappearance of the European eel from the western Wadden Sea. Journal of Sea Research 66; 434–439.

Van Keeken O.A., de Bruijn P.J.A., Griffioen A.B., van Os-Koomen E., Wiegerinck J.A.M. (2020). Vismonitoring Zoete Rijkswateren en Overgangswateren t/m 2019: Deel II, Toegepaste methoden. Wageningen Marine Research rapport C047/20.

Van Rijn S. and M.R. van Eerden (2001). Aalscholvers in het IJsselmeergebied: concurrent of graadmeter? [Cormorants in the IJsselmeer area: competitor or indicator?] RIZA report 2001.058.

Van Rijn, S. (2004). Monitoring Aalscholvers in het IJsselmeergebied [Monitoring cormorants in the IJsselmeer area]. Voortgangsverslag 2004. RIZA working document 2004.187x.

Winter, H. V., and S. M. Bierman. 2010. De uitrekmogelijkheden voor schieraal via de haringvlietsluizen IMARES rapport nr C155/10.

Winter, H.V,. A.B. Griffioen and K.E. van de Wolfshaar (2013a). Knelpunten inventarisatie voor de uittrek van schieraal t.b.v. 'Paling Over De Dijk' Report C134/13.

Winter, H.V., Griffioen, A.B., van de Wolfshaar, K.E. (2013b). Inventarisatie van de belangrijkste knelpunten voor de uittrek van schieraal in Nederland. IMARES Rapport C107/13.

Contents

i Report on the eel stock, fishery and other impacts in Norway, 2020–2021

Authors

Caroline Durif, Institute of Marine Research (IMR), NO-5392 Storebø, Norway.

Tel: +47 976 27 269.

e-mail: caroline.durif@hi.no

Eva B. Thorstad, Norwegian Institute for Nature Research (NINA), NO-7485 Trondheim, Norway.

Tel: +47 73 80 14 00 / +47 91 66 11 30. FAX +47 73 80 14 01.

eva.thorstad@nina.no

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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
2016	NO_total	2387	No data	36021	39612	No data	0.095	No data	0.095
2017	NO_total	12375	No data	36346	47244	No data	0.26	No data	0.26
2018	NO_total	5406	No data	45681	49084	No data	0.072	No data	0.072
2019	NO_total	6821	No data	54158	58158	No data	0.071	No data	0.071
2020	NO_total	7587	No data	50225	54225	No data	0.077	No data	0.077

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) (Figure 1 and 2, table 1, 2 and 3). The 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 data series 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.

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 .

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 program was initiated at the Norwegian Skagerrak coast (southern Norway).

The first hauls of the Skagerrak monitoring program 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 is from Imsa.

Silver stage is evaluated using Durif et al. (2005) wherever eye and fin measurements are available.

5.4 Diseases, Parasites & Pathogens or Contaminants

Prevalence of Anguillicola crassus in Norway. FW: freshwater; BW: brakish water; SW: saltwater

YEAR		SALINITY	N SAMPLED	% PREVALENCE
2016	Flødevigen	SW	123	18%
2017	Flødevigen	SW	106	19%
2018	Grimstad	FW	25	64%
		SW	58	3%
2019	Etne	FW	30	30%
		SW	30	30%
	Fister	SW	36	0
	Bjugn	FW	30	0
	Smøla	SW	30	0
	Orkla	FW	3	0
2020	Arendal	BW	8	75
		FW	22	82
2020	Austevoll	FW	45	0
		SW	33	0
2020	Hardangerfjord	SW	42	0

6 New Information

Nothing to report

7 References

Diserud, O. H., et al. (2017). Oppvandring og bestandsstruktur hos ål i Imsa, 1975-2016, NOTAT til Miljødirektoratet**:** 13.

Durif, C. M. F. and A. B. Skiftesvik (2017). Forskningsfangst av ål- Sluttrapport HI prosjekt 81333. Rapport fra Havforskningen, Havforskningsinstituttet**:** 50.

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i Report on the eel stock, fishery and other impacts, in POLAND 2020–2021

Authors

Tomasz Nermer, National Marine Fisheries Research Institute (NMFRI), Poland. Tel: 48 (0) 58 73 56 211. Fax: +48 (0) 58 73 56 110. nermer@mir.gdynia.pl;

Katarzyna Nadolna-Ałtyn, National Marine Fisheries Research Institute (NMFRI), Poland. Tel: 48 (0) 58 73 56 215. Fax: +48 (0) 58 73 56 110. knadolna@mir.gdynia.pl;

Reporting Period: This report was completed in September 2021, and contains data up to 2020

1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

Table 1.1.1 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
2011	PL_Oder	253400	797000	29000	73000	4%	1.31	0.51	1.82
2011	PL_Vist	184000	721000	20000	66000	3%	2.11	0.8	2.91
2012	PL_Oder	253400	797000	31000	73000	4%	1.19	0.51	1.70
2012	PL_Vist	184000	721000	19000	66000	3%	1.92	0.8	2.72
2013	PL_Oder	253400	797000	67000	73000	8%	1.58	0.51	2.09
2013	PL_Vist	184000	721000	31000	66000	4%	1.88	0.8	2.68
2014	PL_Oder	253400	797000	61000	73000	8%	1.55	0.51	2.06
2014	PL_Vist	184000	721000	22000	66000	3%	1.68	0.8	2.48
2015	PL_Oder	253400	797000	107000	73000	13%	1.16	0.51	1.67
2015	PL_Vist	184000	721000	30000	66000	4%	1.37	0.8	2.17
2016	PL_Oder	253400	797000	48000	73000	6%	1.23	0.51	1.74
2016	PL_Vist	184000	721000	14000	66000	2%	1.45	0.8	2.25
2017	PL_Oder	253400	797000	43000	73000	5%	1.10	0.51	1.61
2017	PL_Vist	184000	721000	12000	66000	2%	1.19	0.8	1.99
2018	PL_Oder	253400	797000	31000	73000	4%	0.73	0.51	1.25
2018	PL_Vist	184000	721000	20000	66000	3%	0.77	0.8	1.56
2019	PL_Oder	253400	797000	26000	73000	3%	0.63	0.51	1.14
2019	PL_Vist	184000	721000	31000	66000	4%	0.72	0.8	1.52
2020	PL_Oder	253400	797000	28000	73000	4%	0.42	0.51	0.93
2020	PL_Vist	184000	721000	48000	66000	7%	0.42	0.8	1.22

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 permits 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.

Fot. 1.2.1 Location of Eel traps in Poland.

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.

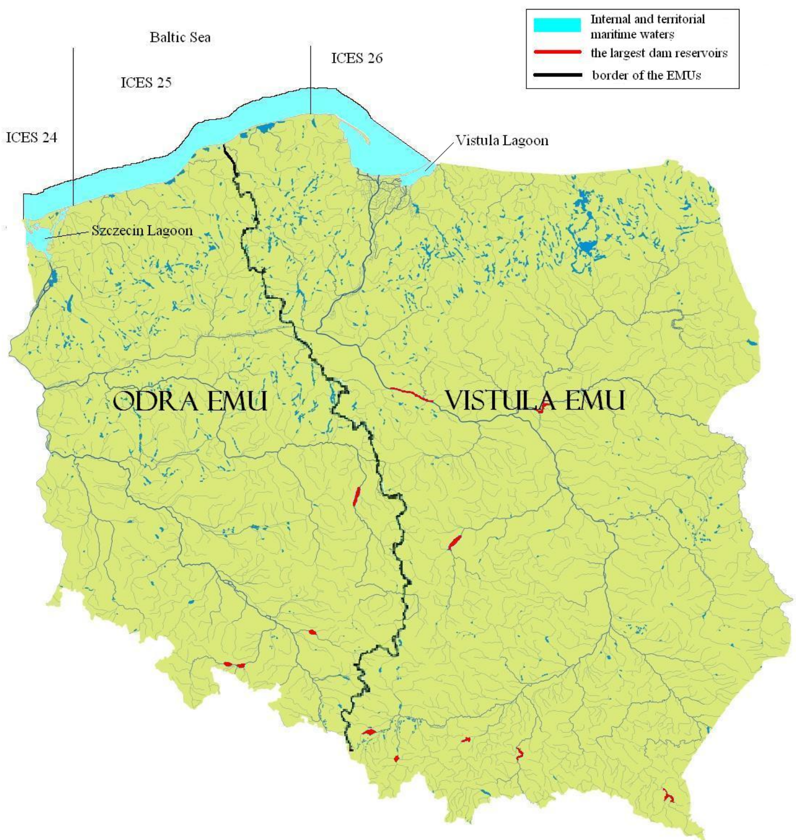

Figure 2.1.1 EMUs in Poland according to the Polish EMP.

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 is presented as total landings.

Table 3.1.2. Commercial catches (kg) of eel fin Poland reported from 2005 to 2020

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

Year	PL_ODER	PL_VIST
2019	64301	103233
2020	44414	59218

3.1.3 Silver eel fisheries

Data is 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 2011–2019 was determined using data obtained from the users of fisheries districts and from Inland Fisheries Institute database.

Table 3.2.1 Restocking (indiv.) of ongrown eels x reported from 2005 to 2019

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
2018	950324	1486504
2019	420000	560000
2020	313000	636554

3.3 Aquaculture

Table 3.3.1 Production of ongrown and eels and reported from 2015 to 2018

Year	Production(kg)
2015	600
2016	981
2017	2810
2018	3090

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 was 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 recruit-ment 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 assu-med at 1. 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 distribu-tion 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 squ-ared 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 2021 compared with previous fit were as follows:

- New recruitment indices provided by GLM estimates presented in WGEEL Report in 2020 were used; on average in 1960-2017 they were ca. 10% lower from previous estimates, but after 2000 the difference was much higher and new estimates were on average 70% higher than previous ones (For existing data series in 2020 from the Baltic Sea).
- New data on catch, restocking, and age structure of catches covering 2018–2020 were included in the analysis.
- the model was fitted to total catch and average fishing mortality estimated from catch-curve

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 program 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 fyke nets 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

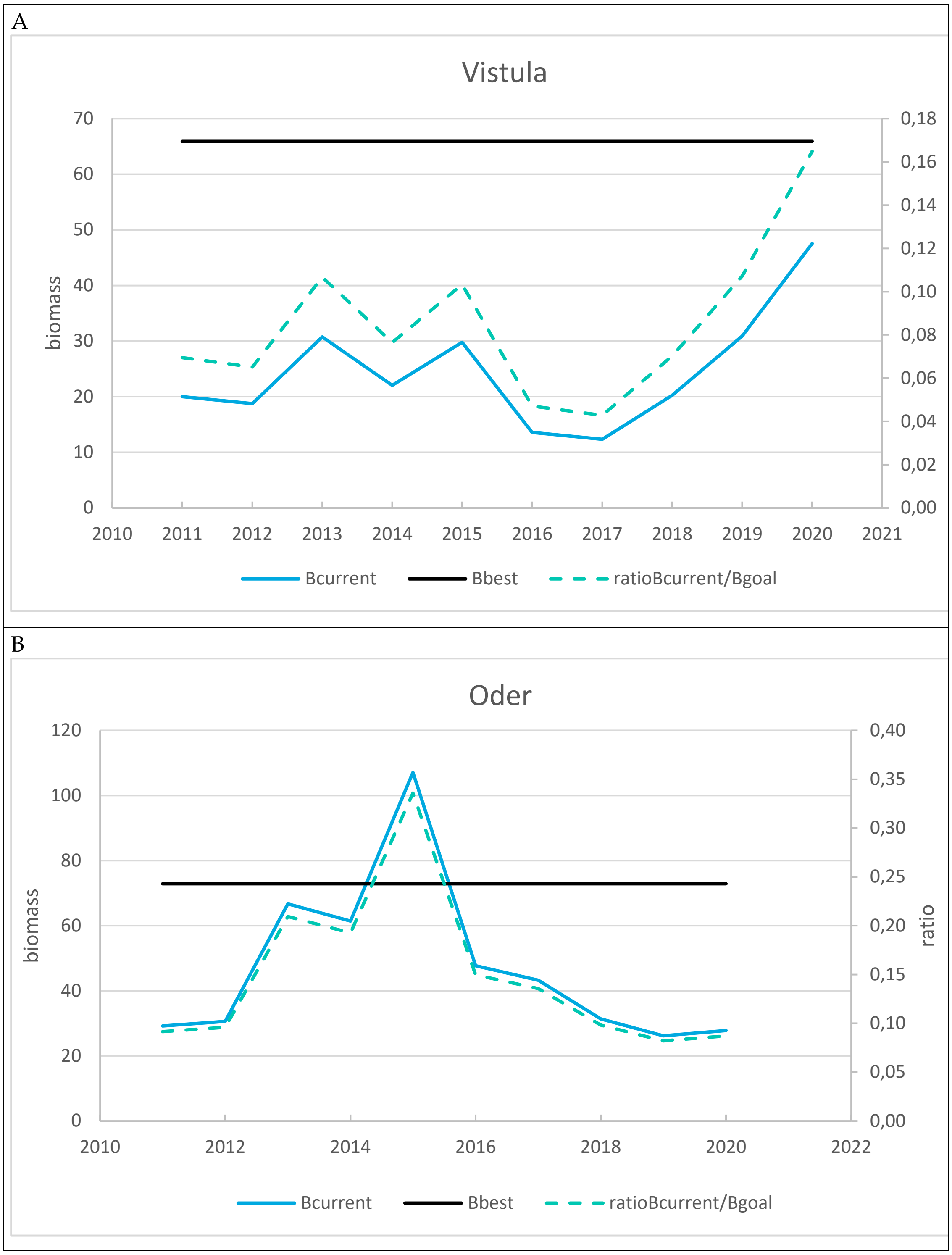

Fig. 4.2.1 Stock dynamics in Vistula RBD (A) and Oder RBD (B) presented as a Bcurrent in 2011 – 2020

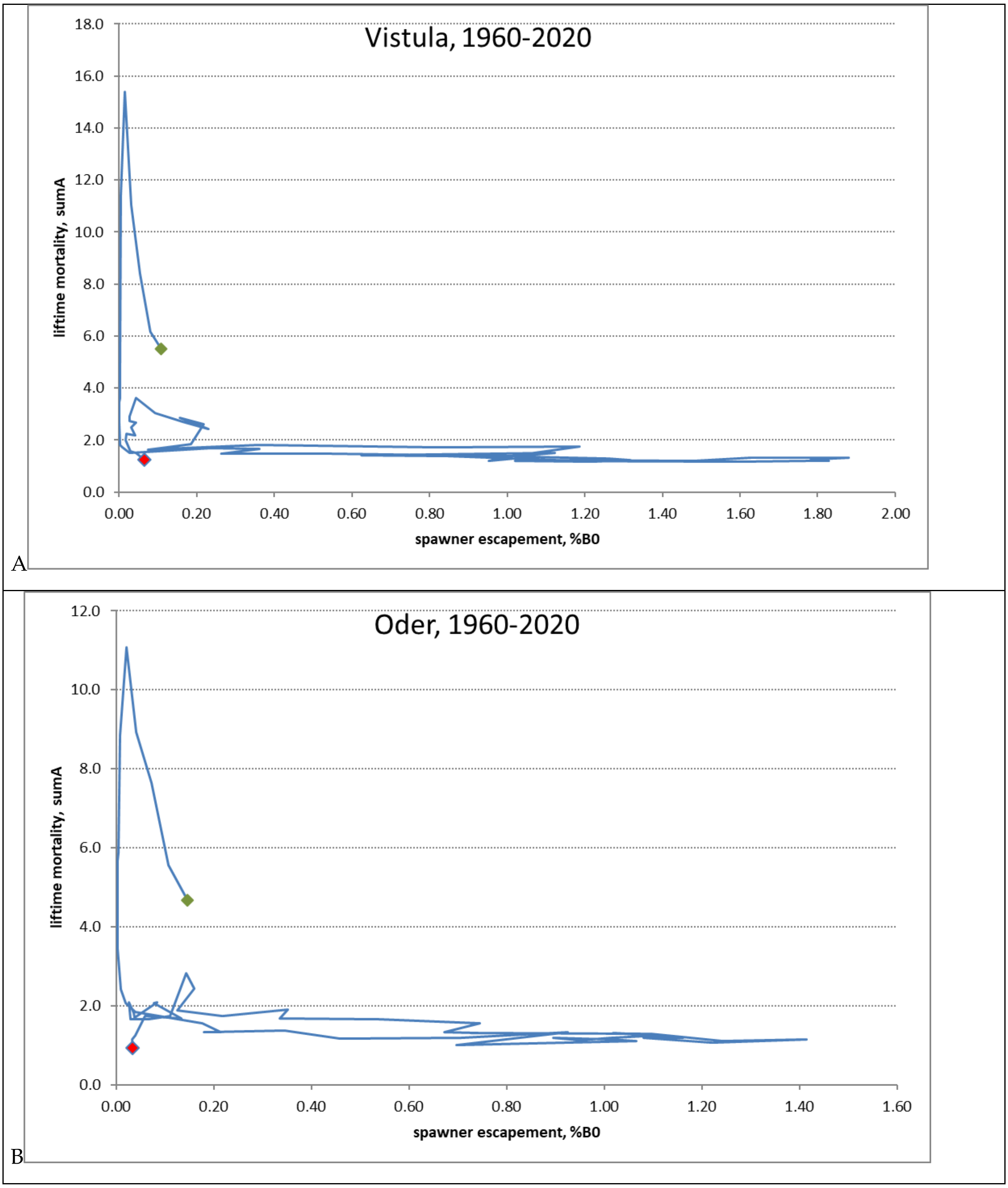

Fig. 4.2.2 Lifetime mortality (sumF+sumH) plotted against spawner escapement (fraction of B_0) for 1960 – 2020 (A= Vistula river basin district, B= Oder river basin district).

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 fyke-nets 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 290 eels were caught with a total weight of 110 kg. The distribution of the length of the eel caught is presented in the figure

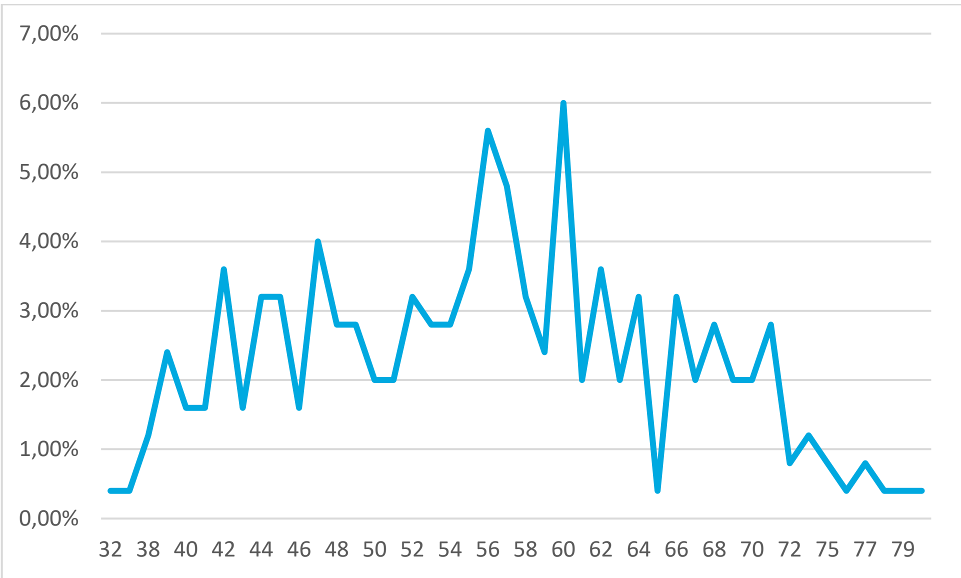

Fig. 5.1.1 Length distribution of eels caught in the Vistula Lagoon in non-selective fyke net.

More than half eels (70%) measured more than protective size (50 cm). Compared to 2017 (1.5 indiv/day/fyke), CPUE dropped to 0.8 indiv /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 is 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 was also included.

In inland waters age groups ranging from 6 to 26 in the Oder EMU, and from 4 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 & Pathogens or Contaminants

The aim of the studies was to check the level of eel infection in the Polish EEZ, southern Baltic Sea.

Fish has been sampled in 3 areas of the Polish EEZ (Fig 5.4.1) and examined each year between 2014 and 2020. Parasitological analysis focused on the presence of nematode A. crassus has been performed (the total number of investigated eels was 2819). Prevalence of infection was calculated according to definitione given by Bush et al. (1997).

Fig. 5.4.1 Sampling area - southern Baltic Sea

The total number of found parasites was 15681. The correlation between infection intensity and host length, Fulton condition factor, age of the fish, area and time of sampling have been analyzed. The prevalence and intensity of infection have been calculated. Intensity of infection varied from 1 to 95 parasites per fish. We observe decreasing value of the mean prevalence of A. crassus infection: from 72-73% in 2014-2015 to 53% in 2019-2020. Mean prevalence of infection reported previously from Polish waters in 2000-2002 was 73.6-76.2% (Rolbiecki & Rokicki, 2005).

6 New Information

No data available

7 References

Bush,A.O., Lafferty,K.D., Lotz,J.M., ShostakA.W. (1997) Parasitology Meets Ecology on Its Own Terms: Margoliset al. Revisited The Journal of Parasitology 83, 575-583.

Koops,H., Hartmann,F. (1989) Anguillicola infestations in Germany and in German eel imports. Journal of Applied Ichthyology 1, 41-45.

Rolbiecki,L, Rokicki,J (2005) Anguillicola crassus analien nematode species from the swim bladder of eel (Anguilla Anguilla) in the polish zone of the southern Baltic and in the waters of northern Poland. Oceanological and Hydrobiological Studies Vol.XXXIV(1):121-136.

Contents

i Report on the eel stock, fishery and other impacts in Portugal, 2020–2021

Authors

Isabel Domingos, Marine and Environmental Sciences Centre (MARE), Faculty of Sciences, University of Lisbon, Campo Grande, 1749-016, Lisboa, Portugal

idomingos@fc.ul.pt

Carlos Antunes, Centre of Marine and Environmental Research (CIMAR), Rua dos Bragas 289, 4050-123, Porto, Portugal

cantunes@ciimar.up.pt

Reporting Period: This report was completed in September 2021, contains data up to 2020 and some provisional data for 2021.

Contributors to the Report:

Rui Monteiro, Marine and Environmental Sciences Centre (MARE), Faculty of Sciences, University of Lisbon, Campo Grande, 1749-016, Lisboa, Portugal

Maria João Correia, Marine and Environmental Sciences Centre (MARE), Faculty of Sciences, University of Lisbon, Campo Grande, 1749-016, Lisboa, Portugal

Teresa Portela, Marine and Environmental Sciences Centre (MARE), Faculty of Sciences, University of Lisbon, Campo Grande, 1749-016, Lisboa, Portugal

José Lino Costa, Marine and Environmental Sciences Centre (MARE), Faculty of Sciences, University of Lisbon, Campo Grande, 1749-016, Lisboa, Portugal

Teresa Taborda, *General Directorate of Natural Resources, Maritime Safety and Services (DGRM)*, Av. Brasilia, 1449-030 Lisboa, Portugal

Capitania do Porto de Caminha

Conselleria del Medio Ambiente e Ordenación do Territorio, Xunta de Galicia

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 most recent stock indicators of silver eel escapement biomass, mortality rates, and assessed habitat area, for the two Eel Management Units (EMUs) reported by Portugal: PT_Port and ES_Minh, are presented in Table 1.1. The pristine escapement estimate (B0) for the EMU PT_Port has been improved compared to the estimate reported in 2018.

Table 1.1. Stock indicators of silver eel escapement biomass and mortality rates, and assessed habitat area for two EMUs, PT_Port and ES_Minh (transboundary EMU shared with Spain), by year, from 2017 to 2020.

EMU_code	Year	Assessed Area (ha)	B_0 (kg)	B_{curr} (kg)	B_{best} (kg)	Bcurr/B_0 (%)	∑F	∑H	∑A
PT_Port	2017	135487	**1364571**	698826	1026094	51.21	0.38	0.00	0.38
	2018	135487	1625215	423682	1008549	26.07	0.87	0.00	0.87
	2019	135487	1625215	1018614	1289054	62.68	0.24	0.00	0.24
	2020	135487	1625215	856344	1336535	52.68	0.45	0.00	0.45
ES_Minh	2017	1823,69	36474	4278	36474	11.7	2.73	0.00	2.73
	2018	1823,69	36474	831	34400	2.28	3.72	0.00	3.72
	2019	1823,69	36474	2816	35564	7.72	2.54	0.00	2.54
	2020	1823,69	36474	5008	27221	13.73	1.69	0.00	1.69

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 (combining estuaries and coastal lagoons). and inland waters.

1.2 Recruitment time series

The WGEEL uses 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 Portuguese recruitment time series (MiPoG) that has been used in the international assessment by the WGEEL to analyse the trends in recruitment is the commercial glass eel fishery from the Portuguese part of River Minho (Figure 1.1). There were, however, some changes in the number of licenses over time as well as in the extension of the fishing season (number of days) and the fishing area, especially after the implementation of Council Regulation (EC) Nº 1100/2007.

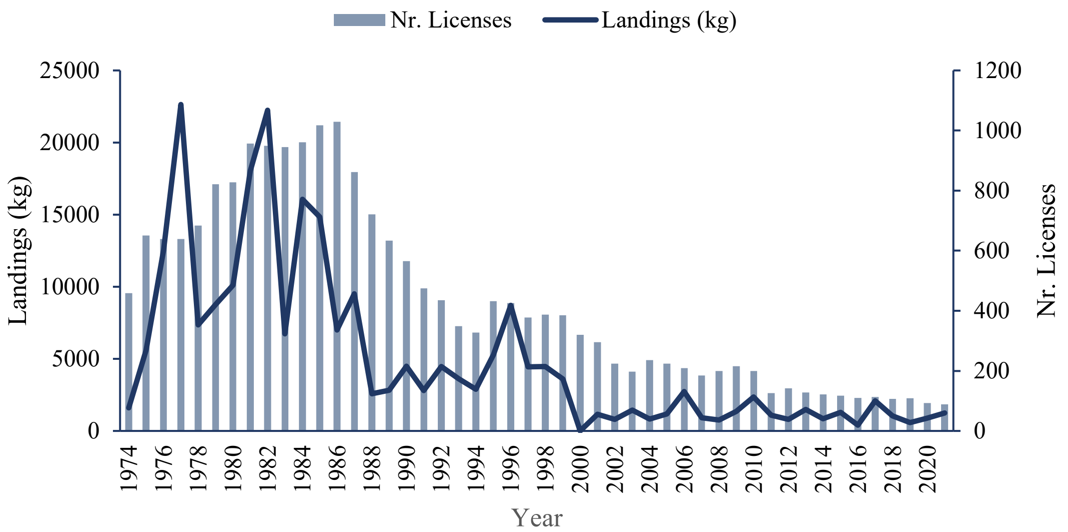

Figure 1.1. Glass eel recruitment and number of licenses issued to Portuguese fishermen in the River Minho from 1974 to 2021 (Source: Capitania do Porto de Caminha).

Since 2017, within the framework of DCF, two new glass eel 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 started 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 Council Regulation (EC) Nº 1100/2007, Portugal has considered **two EMUs** in accordance with Article 2 of the Eel Regulation: one that includes the entire territory (mainland), and another that includes the International River Minho. Therefore, Portugal submitted **2 EMPs**: one **national EMP** and a **transboundary EMP**, shared with Spain, for the River Minho.

The **Portuguese Eel Management Plan** (**PT_Port**) 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 5 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.

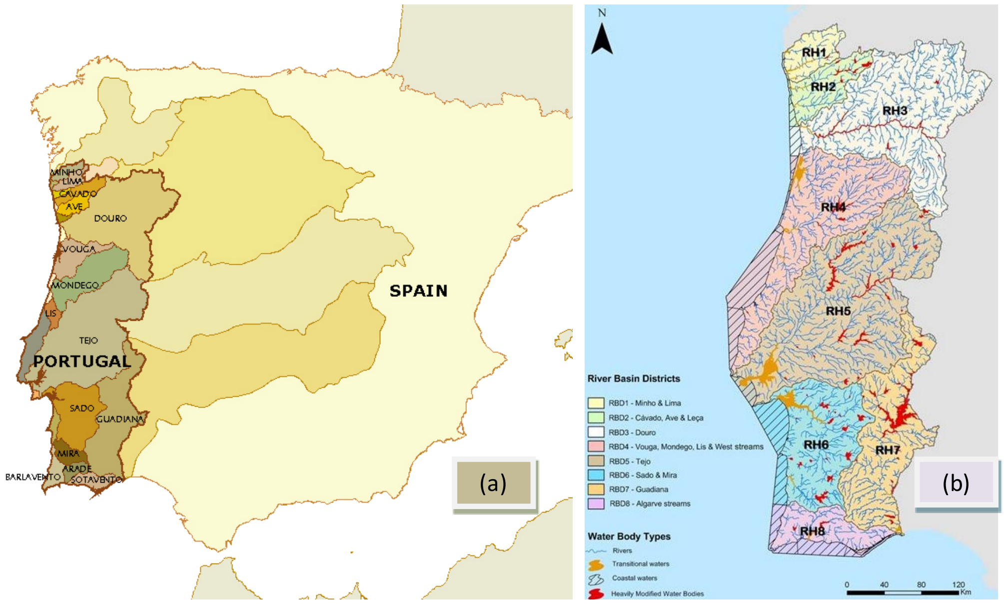

Figure 2.1. Map showing Portuguese River basins including the catchment area extending to Spain (a), and limits of the 8 Portuguese River Basin Districts defined according to the Directive 2000/60/EC (b). RBD is labeled as RH in the map.

A first version of the **Transboundary EMP for River Minho** (**ES_Minh**), 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 on time, Portugal had to reduce the fishing effort until the implementation of the EMP on that river. Thus, 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 from 2004 to 2006. These measures included reducing the number of fishing licenses to fish for glass eels, reducing the fishing area for glass eels, shortening the fishing period, and banning the fishery for other eel stages (yellow and silver).

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 three ministries: the first under Ministry of Sea, and the second, under Ministry of Agriculture, and Ministry of Environment and Energy Transition. The exception is River Minho because being an international river with a common stretch bordering the two countries, it is co-managed by a Commission (**Standing Transboundary Commission of the River Minho**), which includes representatives from both countries who establish specific rules that are applied to the fishery conducted in the international section of that river basin. Licenses to fish in inland waters are issued by ICNF, whereas licenses to fish in transitional and coastal waters are issued by DGRM. Licenses for Portuguese fishermen to fish for glass eels in the Minho River are issued by **Capitania do Porto de Caminha.**

The management of water bodies is the responsibility of **APA** (Portuguese Environment Agency) and 5 regional administration authorities for inland waters, which are under the Ministry of Environment and Energy Transition. 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 9 other byelaws that are applied to specific fishing areas designated ZPPs (Zonas de Pesca Profissional / Professional Fishing Zones) (See Figure 2.2a), which are the only areas where professional eel fishery is allowed in freshwater. These byelaws set the number of fishermen, the rules for types and characteristics of fishing gears permitted, and in most cases, limit the maximum number of gears per fishing licence. Although professional fishing in freshwater is regulated by Decree-Law 112/2017 (6 September 2017), this legislation applies to the stretches represented in green, while in sections represented in yellow (ZPPs) the fishery is ruled by the 9 above mentioned 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. Following Decree-Law 112/2017, professional fishermen are required to hold a special a special license to fish eels, and they are obliged to report their catch. If these catches are not reported, their fishing license will not be renewed for the following year. Minimum legal size is 22 cm in both areas of jurisdiction. The yellow fishery is permitted from January 1st until September 30th.

To promote **silver eel** escapement, a three months closure was implemented from October to December. This prohibition to fish eels (yellow and silver) 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.

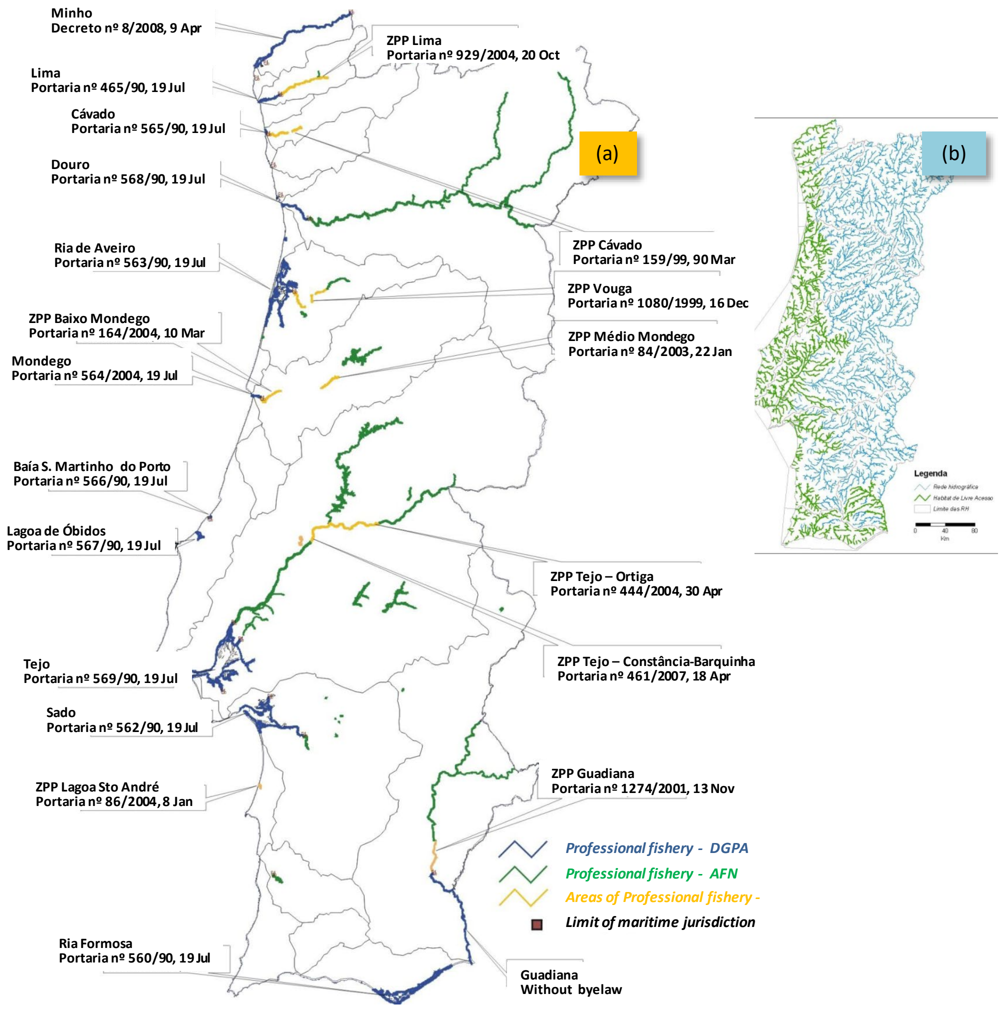

Figure 2.2. Map showing areas where professional fisheries can be conducted both in estuaries and coastal lagoons (jurisdiction of DGRM, previous DGPA) and in inland waters (jurisdiction of ICNF, previous AFN) (a). The limit of maritime jurisdiction and the byelaws that rule the fisheries at each area are presented in the map (a). (Source: ICNF). The habitat that is accessible for the eel is also represented in green (b).

Finally, the recreational eel fishery was banned throughout the country, first in maritime jurisdiction (Portaria No. 14/2014) and second in freshwater jurisdiction (Portaria No. 108/2018). In the international part of River Minho, recreational fishing was prohibited in 2011 by Edital nº 32/2011 from the Capitania do Porto de Caminha.

2.1.4 Management actions

The main objective of the Portuguese Eel Management Plan (PT_Port EMU), which considered the entire country as one Eel Management Unit (EMU), 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 (EC) Nº 1100/2007. These measures can be classified into 4 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 in the Portuguese EMP is presented in Table 2.1.

Table 2.1. List of the management measures foreseen within the scope of the Portuguese EMP (PT_Port) and state of implementation. ☺ - Fully implemented; 😐 - Partially implemented.

Measure Type	Measure Description	Life Stage	Planned	Progress	Date
Commercial fishery	Prohibit the eel fishery outside the professional fishing areas in freshwater jurisdiction	Y	After 2011	☺	Decree-Law 112/2017
	Set maximum number of fishing gears and licenses per professional fishing area, in freshwater	Y	After 2011	☺	2017
	Introduce obligation to report catches in freshwater to obtain a licence the following year	Y	After 2011	☺	2017
	Introduce a specific annual license for eel fishery in freshwater jurisdiction	Y	After 2011	☺	2017
	Introduce closed fishing season (1st October to 31st December) in freshwater jurisdiction	Y/S	After 2011	☺	Portaria nº 180/2012
	Introduce closed fishing season (1st October to 31st December) in marine jurisdiction	Y/S	until 2012	☺	Portaria nº 928/2010
	Reduce the number of licenses for marine water jurisdiction	Y	2009-	☺	ongoing
Recreational fishery	Prohibit recreational eel fishery in marine (M) jurisdiction	Y	After 2011	☺	Portaria nº 14/2014
	Prohibit recreational eel fishery in freshwater (F) jurisdiction	Y	After 2011	☺	Portaria nº 108/2018
Hydropower & Pumps	Mitigate the impact of existing obstacles (upstream migration)	G/Y	After 2011	😐	ongoing
Restocking	0	na	na	na	na
Scientific monitoring	Collect data and conduct studies on the stock (Recruitment/Production/Escapement)	All	Until 2012	☺	DCF 2017- ongoing
Illegal fishery	Monitoring and control of glass eel poaching	G	2009-	☺	ongoing

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 license for the eel fishery was implemented in 2018, under the designation of species of relevant interest for the professional fishery (Decree-Law nº 112/2017).

The reinforcement of actions to reduce poaching was carried out when the Portuguese EMP was approved, both 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 (Coastal Control Unit) acts close to the coast and has also been involved in these actions.

In recent years, 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, as well as Europol and Interpol, have also been improved within the scope of the illegal trade on glass eels.

According to the GNR, as part of the "Operation LAKE" by Europol, 28 searches were conducted and several fishing gear and equipment for conservation, transport, and marketing were seized: 60 kilos of glass eel, 21 nets, three boats, a vehicle, several materials related to eel fishing and conservation, 1249 euros in cash, 27 mobile phones, nine computers, two video cameras, a carbine and a white weapon, in the fishing season 2020/21 (More information about the operation at https://www.jn.pt/justica/tres-detidos-por-captura-ilegal-de-meixao-em-operacao-internacional-13568195.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 (ES_Minh) and state of implementation. ☺ - Fully implemented.

Measure Type	Measure Description	Life Stage	Planned	Outcome
Commercial fishery	Prohibit the eel fishery	Y/S	EMP	☺
	Reduce fishing effort	G	EMP	☺
	Introduce obligation to fill in logbooks	G	After approval	☺
Recreational fishery	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

In the international hydrographic basin of River Minho, and within the scope of the MigraMiño-Minho project (http://migraminho.org/) some actions were undertaken to improve the connectivity for migratory fish in two of its Portuguese tributaries.

2.2 Significant changes since last report

New data obtained between 2018 and 2020 was used to improve estimates of stock indicators. This affected the estimate of B_0, which has implications for the comparability between stock indicators estimated for 2017, and the most recent stock parameters estimated for the EMU PT_Port.

3 Impacts on the national stock

3.1 Fisheries

3.1.1 Glass eel fisheries

There has never been recreational glass eel fishery in Portugal. The glass eel fishery is prohibited in all rivers in 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.

The total landings and the number of licenses issued annually to fish for glass eels, between 2005 and 2021, are presented in Table 3.1. There have been some changes in the number of licenses throughout time, as well as in the extension of the fishing season and the fishing area.

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 licenses to be issued by each country would be 200, and that the fishing area of the glass eel fishery would decrease by 25 km in the river length. In the same year a new change was introduced in the licensing process, and licenses started to be issued to the owners of the boats and not to fishermen, implying that the drop to 126 licenses 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.

Table 3.1. Commercial catches (kg) of glass eel caught in the Portuguese part of the River Minho and number of fishing licenses issued from 2005 to 2021. (Source: Capitania do Porto de Caminha).

Year	Landings	Number of fishing licenses
2005	1174	224
2006	2736	209
2007	905	185
2008	750	200
2009	1350	216
2010	2360	200
2011	1085	126
2012	808	142
2013	1497	128

2014	854	122
2015	1284	117
2016	409	110
2017	2094	113
2018	1049	107
2019	587	109
2020	891	93
2021	1236	89

Glass eel fishery in the River Minho was permitted between November and April for many years, but after the fishing season 2005/06, 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 8 days before and 8 days after each New Moon, in a total of ≅ 60 fishing days. In the last fishing season (2020/21) fishing occurred between the 8^{th} November and the 18^{th} February, with 2 weeks of fishing around each New Moon. A daily **fishing quota** has been set for this fishery. Maximum catch of glass eel in 2020/21 was: 2Kg/fisherman/night.

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 9 byelaws, which define the river sections where fishermen are allowed to 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 licenses issued by DGRM for local fishery in estuarine and coastal waters are linked to fishing boats. The same fishing boat can be licensed 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 11 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 fyke nets in the River Minho was banned by Decree 8/2008 (April 9^{th}) 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) are shown in Table 3.2. There was a decline in catches after 2010, which has continued to date. 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.

Table 3.2. Annual landings of yellow eel fishery in coastal waters (estuaries and coastal lagoons), from 2005 to 2020. (Source: DGRM). (*) An eel fishing ban was set between October and December, starting in 2011, to increase silver eel escapement.

YEAR	LANDINGS	NUMBER OF BOATS THAT LANDED EEL
2005	7022	114
2006	10131	170
2007	10512	149
2008	6954	87
2009	8169	110
2010	11031	111
2011 (*)	5866	94
2012 (*)	3814	69
2013 (*)	2736	48
2014 (*)	3348	60
2015 (*)	2885	49
2016 (*)	2435	40
2017 (*)	1539	38
2018 (*)	3572	55
2019 (*)	1894	41
2020 (*)	3157	52
2021 (*)	7022	114

3.1.3 Silver eel fisheries

There has never been a fishery for silver eels in Portugal. 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 some professional fishing zones of freshwater jurisdiction, if fishermen catch silver eels outside the national closure period (October to December), 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 3.3. The increase in the production of eels recorded in 2017 was due to an intensive eel aquaculture facility that only produced in 2017, but that facility is now closed.

Table 3.3. Aquaculture production of eels (Kg) between 2010 and 2019 from the EMU PT_Port (Source: DGRM)

Year	Production
2010	285
2011	562
2012	886
2013	1383
2014	917
2015	890
2016	1060
2017	32963
2018	456
2019	765

3.4 Entrainment

Anthropogenic impacts identified in the two Eel Management Plans (PT_Port and ES_Minh EMU) were mainly related to fisheries and obstacles to migration that have reduced the habitat available for growth. 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. Furthermore, because these EMPs do not include stocking of upriver sections that are inaccessible to the eel, these facilities are 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 PT_Port EMU. The improvement of water quality was a measure set in the Portuguese EMP to be achieved by the implementation of WFD, but it has never been identified as a problem. 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 prevents 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 3.9 tonnes of eels between 2011 and 2019 (Table 3.4). Under the MigraMiño-Minho project there was intervention at 2 obstacles in the Gadanha river and 1 obstacle in the Mouro river, both tributaries of the Minho river, to improve river connectivity for migratory fish. However, there is no monitoring of eel passage.

Table 3.4. Quantity of eels (kg) captured below the Frieira dam both in the salmonid ladder and in the ramp. (Source: Conselleria del Medio Ambiente)

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
2019		216	216
TOTAL	922.78	2973.12	3895.915

3.6 Other impacts

Nothing to report.

4 National stock assessment

4.1 Description of Method

4.1.1 Data collection

Surveys to estimate stock parameters are currently performed under the DCF, which started to include the eel in 2017. 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.

These data are used to assess the biomass of silver eel escaping from each EMU

Data collected from electric fishing surveys and fyke nets are used to estimate silver eel production. The index river chosen to represent the PT_Port EMU was River Mondego (estuary and freshwater) to compare with data from the 1990s. The selection of this river is in line with the recommendations from the WKESDCF (ICES, 2012). However, 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 May) 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

EMU PT_Port

Estimates of the silver eel biomass were improved compared to the estimated biomass provided in the Portuguese EMP (**EMU PT_Port**) 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 1988-90 (Domingos, 2003 and unpublished data) were 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 = [[(YE densities 1988)*(silvering rate)]*mean SE weight] * wetted area

$B_{current}$ = [[(YE densities 2017)*(silvering rate)]*mean SE weight] * wetted area

B_{best} = $B_{current}$ + 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 109g.

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 135487ha (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 (Briand, 2009) and annual mortality of 0.138 were considered (Dekker, 2000); we assumed yellow eel average weight of 23.6g and silver eel average weight of 109g for 2017 (Table 4.1).

Since glass eel fishery is 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

Year	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
2017	0.28	23.6	109	3	5	80%	0.138
2018	0,29	27,4	111	3	5	80%	0.138
2019	0,27	22,4	83	3	5	80%	0.138
2020	0,33	21,8	90	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 (Bcurrent/(Bcurrent+kg SEE)).

In the 2021 post evaluation report, the stock indicators were calculated for the PT_Port EMU, extrapolating the silver eel production obtained for the River Mondego, but spliting densities into freshwater density and estuary density, according to the following expressions:

B_0 = [[[(YE estuarine density 1988)*(silvering rate)]*mean SE weight] * wetted area] + [[[(YE freshwater density 1988)*(silvering rate)]*mean SE weight] * wetted area]

$B_{current}$ = [[[(YE estuarine density YEAR)*(silvering rate)]*mean YEAR SE weight] * wetted area] + [[(YE freshwater density YEAR)*(silvering rate)]*mean YEAR SE weight] * wetted area]

B_{best} YEAR = $B_{current}$YEAR + YEARAnthropogenic mortality in Silver Eel Equivalents (SEE)

Data used to estimate the annual anthropogenic mortality in SEE for the PT_Port EMU, are presented in Table 4.1. The annual stock indicators for the years 2018, 2019 and 2020 are presented in Table 1.1.

EMU ES_Minh

For the calculation of B_0 in the Minho River (**ES_Minh**), an average area production rate (20kg /ha) (ICES, 2001) has been applied to the pristine habitat. The pristine habitat has been estimated using order number of tributaries of international catchment area adding area of international main river. Only the international area was considered due to the presence of an impassable dam $Bcur_{ent}$ = Extrapolation of the Silver eel productivity per hectare obtained in electrofishing surveys in tributaries and extrapolated to available wet area. The eel density, available wet area, silvering rate, mean weight at silvering, were also considered for the estimate. B_{best} == $B_{current}$+ Antropogenic mortality in SEE. A likely error is associated with the new $B_{current}$ calculation and that will need to be mitigated in the future because only Portuguese tributaries have been considered and the eel length classes have been reduced due to translocations of eels 12-15 cm from Frieira dam over the last few years. Although CPUE data for yellow and silver eels are available for the main river (fyke nets) they were not considered. The mortality was calculated on the basis of biological data from yellow and silver eels caught by electrofishing surveys in tributaries (average weight) and glass eels caught by experimental fishing (average weight). The assigned age for this system was 5 years for yellow eels and 8 years for silver eels. For the calculation of F glass eel in SEE (Kg) the fishing mortality of glass eels 8 years ago, was taken into account.

4.1.3 Reporting

The stock indicators are included in the 2021 EMPs progress reports (PT EMU and PT Minho EMU) to deliver to the EC, as required by the EU Eel Regulation (1100/2007).

The data, which started to be collected recently (from 2017 onwards) under the DCF, is regularly reported to the EC, and is used/included in the annual ICES data call from the WGEEL. It strongly contributes to estimate the indicators and to improve the stock assessment.

4.1.4 Data quality issues and how they are being addressed

As it refers to PT_Port, the following quality issues need to be addressed in a near future:

• Anthropogenic mortality indices, namely glass eel illegal fishing, are still missing in this EMU;

• Density from the Mondego estuary was used to extrapolate for all transitional waters (estuaries + coastal lagoons) for the most recent estimates of biomass indicators (2018-2020). 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 this EMU;

• Silver eel biomass indicators represent total production and not actual escapement. As silver eel fishery is forbidden, silver eel escapement was measured for two consecutive years (2014-16) in the River Mondego using telemetry. In total, 42% silver eels escaped successfully to the sea, but the success increased to 90% when only the estuary was considered. A less cost-effective solution needs to be found.

4.2 Trends in Assessment results

The assessment results presented in chapter 1 include only 4 years, thus it is difficult to report changes or trends over time. However, there is a difference between PT_Port and ES_Minh, with the first EMU showing compliance with the EU target of 40% of the pristine biomass.

5 Other data collection for eel

5.1 Recruitment time series

The recruitment time series that has been used by the WGEEL to analyse the trends in recruitment is the commercial glass eel fishery from River Minho. There have been some changes in the number of licenses throughout time (Table 3.1), as well as in the extension of the fishing season.

There are no other recruitment series, but within the scope of DCF, two new fishery independent series were started in 2017: one in River Minho and another in River Mondego. The methodology and sampling location used in the Mondego estuary are the same as those used by Domingos (1992), which will allow to compare current recruitment with data from the late 1980s, when recruitment started to decline.

5.2 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. The same was done in River Minho tributaries and River Mondego, under SUDOANG project following a common sampling protocol. These data will contribute to improve the quality of estimates of production in coastal lagoons and rivers presented in the two EMUs. These surveys have been continued within the framework of DCF for the period 2020-2021.

5.3 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 in the aquatic systems studied along the water course 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 of 42% silver eel escapement obtained for the Mondego River (Monteiro et al., 2020) will be compared with new data from the SUDOANG project (SOE2/P5/E0617), funded by Interreg, aiming at calibrating a model for escapement.

Scientific surveys on silver eel abundance in River Minho basin have been conducted within the scope of SUDOANG and MigraMinho projects using electric fishing surveys in tributaries and fyke-nets in the River Minho using.

5.4 Life-history parameters

Biological parameters are being collected under DCF since 2017. River Mondego, River Minho and Santo André Lagoon were selected as representative of all type of habitats present in the PT_Port EMU, which comprises the entire country. River Minho has also been included to sample biological parameters from ES_Minh EMU. A total of 100 eels per habitat type has been annually sampled since 2017.

Biological parameters collected include: - For yellow/Silver eels: total length, total weight, sex, life stage, age and Anguillicola crassus infection. Silver stage is being identified according to Durif *et al*. (2009). - For glass eels: total length, total weigth and pigmentation stage.

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 10 minutes before being examined under a stereoscope microscope. The otoliths were read by more than one person (Gordo & Jorge, 1991), or by the same person who read them twice (Costa, 1989; Domingos, 2003; Lopes 2013, Monteiro 2015, Santos 2016). In the lack of agreement between both readings, a third reading was performed and if inconsistent, otoliths were excluded from analyses.

Within SUDOANG, otoliths from the Mondego pilot basin have been prepared according to the protocol established within the project, which followed the recommendations from ICES (2009; 2020).

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.

5.5 Diseases, Parasites & Pathogens or Contaminants

5.5.1 Parasites & Pathogens

There is not a national programme to monitor parasites or pathogens. *Anguillicola crassus* is however probably spread throughout the country. Despite not mandatory, the assessment of the infection by the parasite *A. crassus* is being carried out under DCF and includes several river basins. Preliminary results from the Mondego basin show that prevalence in freshwater and brackish water, i.e., the estuary, are similar, with 50% and 40%, respectively. 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 ranged from 0.4 to 5.8. 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).

5.5.2 Contaminants

There is no routine sampling for contaminant analysis in eel. No new data is available for 2021, however, there is some information from previous years.

Samples of eels caught from five brackish water systems (Aveiro Lagoon, Óbidos Lagoon, Tagus estuary, Santo André Lagoon and Mira estuary), were analysed for some trace metals (Hg, PB, Zn, Cu, Cd) revealing low contamination loads when compared to their European congeners (Passos, 2008; Neto, 2008; Neto *et al.* 2011a). The most contaminated eels were obtained from the Tagus estuary. However, in this estuary no clear relationships could be established between contaminant concentrations in eel tissues (liver and muscle) and in sediment, probably because of the general heterogeneity in environmental conditions (Neto *et al.*, 2011b). In the River Minho, significant increases in the levels of metals (Zn, Pb and Cr) were found when comparing glass eels with muscle of yellow eels between 15 and 30 cm. However, the whole sample of yellow eels (muscle and liver) revealed low contamination levels (Braga, 2011).

A comparative study about the effects of pollution on glass and yellow eels from the estuaries of Minho, Lima and Douro rivers was developed by Gravato *et al.* (2010). Fulton condition index and several biomarkers indicated that eels from polluted estuaries showed a poorer health status than those from a reference estuary, and adverse effects became more pronounced after spending several years in polluted estuaries.

6 New Information

Correia M.J., I. Domingos, G. A. De Leo, J. L. Costa (2021). A comparative analysis of European eel's somatic growth in the coastal lagoon Santo André (Portugal) with growth in other estuaries and freshwater habitats. *Environmental Biology of Fishes*, 104: 837-850. https://doi.org/10.1007/s10641-021-01123-6.

Drouineau H., Vanacker M., Diaz E., Mateo M., Korta M., Antunes C., Fernández-Delgado C., Domingos I., Zamora L., Beaulaton L., Lambert P., Briand C. (2021). Incorporating Stakeholder Knowledge into a Complex Stock Assessment Model: The Case of Eel Recruitment. *Water* 2021, 13, 1136. https://doi.org/10.3390/w13091136

Félix P.M., J.L. Costa, B.R. Quintella, P.R. Almeida, R. Monteiro, J. Santos, T. Portela, I. Domingos (2021). Early settlement and growth of stocked European glass eels in a fragmented watercourse. *Fisheries Management and Ecology*, 28: 91-100. DOI: 10.1111/fme.12461.

Monteiro R.M., I. Domingos, P.R. Almeida, J.L. Costa, C.M. Alexandre, B.R. Quintella (2020). Migration and escapement of silver eel males, *Anguilla anguilla*, from a southwestern European river. *Ecology of Freshwater Fish*, 29: 679–692. DOI: 10.1111/eff.12545.

7 References

Antunes C. 1999. *Anguillicola* infestation of eel population from the Rio Minho (North of Portugal). ICES-EIFAC, 20-24 September, Silkeborg, Denmark.

Braga A.C.R. 2011. Susceptibilidade da enguia europeia, *Anguilla anguilla* e do parasita *Anguillicoloides crassus*, às concentrações de metais pesados no rio Minho internacional. [*Vulnerability of the European eel, Anguilla anguilla and the parasite Anguillicoloides crassus to metal concentrations in the River Minho*]. Master Thesis, ICBAS, University of Porto, Portugal.

Briand, C. 2009. Dynamique de population et de migration des civelles en estuaire de vilaine. Theses , PhD thesis, Agrocampus Ouest.

Costa J.L. 1989. *Estudo da biologia e ecologia da enguia europeia Anguilla anguilla (Linnaeus, 1758) no estuário do Tejo e tributários*. Final degree in Biology, Faculdade de Ciências da Universidade de Lisboa.

Dekker, W. 2000. A Procrustean assessment of the European eel stock. *ICES Journal of Marine Science*, 57: 938–947.

Domingos I.M. (1992). The fluctuation of glass eel migration in the Mondego estuary (Portugal). Irish Fisheries Investigations, Series A (Freshwater), 36: 1-4.

Domingos I. 2003. *A enguia-europeia, Anguilla anguilla (L., 1758), na bacia hidrográfica do Rio Mondego.* [*The European eel (Anguilla anguilla (L.1758) in the Mondego River catchment*]. PhD dissertation, Universidade de Lisboa.

Durif C., Guibert, A., & Pierre, E. (2009). Morphological discrimination of the silvering stages of the European eel. In J. M. Casselman & D. K. Cairns (Eds.), Eels at the Edge. Science, Status, and Conservation Concerns (pp. 103–111). Bethesda, MA: American Fisheries Society Symposium 58.

Gordo L.S. & Jorge I.M. 1991. Age and growth of the European eel, *Anguilla anguilla* (Linnaeus, 1758) in the Aveiro Lagoon, Portugal. *Scientia Marina*, **55**:389-395.

Gravato C., Guimarães L., Santos J., Faria M. & Alves A. 2010. Comparative study about the effects of pollution on glass and yellow eels (*Anguilla anguilla*) from the estuaries of Minho, Lima and Douro Rivers. *Ecotoxicology and Environmental Safety*, **73**:524–533.

ICES 2009. Workshop on Age Reading of European and American Eel (WKAREA). ICES CM 2009\ACOM: 48. 63p.

ICES. 2012. Report of the Workshop on Eel and Salmon DCF Data (WKESDCF), 3–6 July 2012, ICES HQ, Copenhagen, Denmark. ICES CM 2012/ACOM:62. 67 pp.

ICES 2020. Third Workshop on Age Reading of European and American Eel (WKAREA3). ICES Scientific Reports. 2:84. 34 pp. http://doi.org/10.17895/ices.pub.7483. ISSN number: 2618-1371.

Lopes V.C.P. 2013. *A enguia na lagoa de Santo André - Contributo para a gestão da sua pesca.* [*The eel in the Santo André Lagoon – a contribution to the management of its fishery*]. Master Thesis, Faculty of Sciences, University of Lisbon.

Marques J.P. 2016. Ecologia e migração da enguia prateada na Lagoa de Santo André: um contributo para a gestão da pesca e da abertura da lagoa ao mar. [*Ecology and Migration of silver eels in Santo André Lagoon: a contribution for the management of the fishery and the opening of the lagoon*]. Master Thesis, Faculty of Sciences, University of Lisbon.

Monteiro R.M.C. 2015. A enguia-europeia no Rio Mondego: estrutura populacional, taxa de prateação e fuga de reprodutores [*The eel in River Mondego – population structure, silvering rate and silver eel escapement*]. Master Thesis, Faculty of Sciences, University of Lisbon.

Monteiro R.M., I. Domingos, P.R. Almeida, J.L. Costa, C.M. Alexandre, B.R. Quintella (2020). Migration and escapement of silver eel males, *Anguilla anguilla*, from a southwestern European river. *Ecology of Freshwater Fish*, 29: 679–692. DOI: 10.1111/eff.12545.

Neto A.F. 2008. *Susceptibilidade da enguia-europeia (Anguilla anguilla) à degradação ambiental no estuário do Tejo: contaminação biológica pelo parasita Anguillicola crassus e contaminação química por metais pesados.* [*Susceptibility of the European eel (Anguilla anguilla) to environmental degradation in the Tagus estuary: biological contamination by Anguillicola crassus and chemical contamination by heavy metals*]. Master Thesis, Faculty of Sciences, University of Lisbon.

Neto A.F., Costa J.L., Costa M.J. & Domingos I. 2010. Epidemiology and pathology of *Anguillicoloides crassus* in the European eel, *Anguilla anguilla*, from the Tagus estuary (Portugal). *Journal of Aquatic Diseases*, **88**:225-233.

Neto, A.F., Passos, D., Costa, J.L., Costa, M.J., Caçador, I., Pereira, M.E., Duarte, A.C., Pacheco, M. and Domingos, I. 2011a. Metal concentrations in the European eel, *Anguilla anguilla* (L., 1758), in estuaries and coastal lagoons from Portugal. *Vie et milieu - life and environment*, **61**: 167-177.

Neto, A.F., Passos, D., Costa, J.L., Costa, M.J., Caçador, I., Pereira, M.E., Duarte, A.C., Pacheco, M. and Domingos, I. 2011b. Accumulation of metals in *Anguilla anguilla* from the Tagus estuary and relationship to environmental contamination. *Journal of Applied Ichthyology*, **27**:1265-1271.

. Passos D.M. 2008. *Concentração de metais pesados na enguia europeia, Anguilla anguilla (Linnaeus, 1758), em estuários e lagoas costeiras de Portugal* [*Metal concentration in the European eel, Anguilla anguilla (Linnaeus, 1758), in Portuguese estuaries and coastal lagoons*]. Biology Degree Thesis, University of Aveiro.

Santos J.F.T. 2016. Ecologia da enguia e gestão da sua pesca na Lagoa de Santo André. [*Ecology and Management of the European eel in Santo André Lagoon*]. Master Thesis, Faculty of Sciences, University of Lisbon.

Vollestad L.A. 1985. Age determination and growth of yellow eels, *Anguilla anguilla* L. from a brackish water, Norway. *Journal of Fish Biology*, **26**:521-525.

Contents

i Report on the eel stock, fishery and other impacts Spain, 2020-2021

Authors

Maria Korta , Estíbaliz Díaz,

AZTI-Tecnalia, Txatxarramendi ugartea z/g - 48395 Sukarrieta, Bizkaia, Spain. Tel: +34 94 657 40.00. FAX: +34 94 6572555.

* ediaz@azti.es

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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 (2021).

In the 2021 report there have been several changes in the reported indicator values, as several have changed their way of estimating the indicators (Table 1). More specifically, several of the regions have started to use the EDA model to estimate current biomass. SUDOANG has provided annual biomass estimations up to 2018 using EDA. For this reason, a correction factor has been applied with the abundance data of these EMUs to estimate those of 2019 and 2020. However, it should be bear in mind that this is the first time EDA is implemented and in the future it may be necessary to adjust the model; in particular, the estimates for transitional waters need to be improved.

To calculate the pristine situation most EMUs have used 20 kg per hectare as pristine productivity for freshwater (ICES 2001). In the case of transitional waters, the 20 kg have been multiplied by 1.29 (25.8 kg/ha), because in a comparison using real data on the productivity of both systems in French basins, this is the productivity ratio that has been obtained (Mateo et al., 2021). However, during the SUDOANG project, it has been observed that the percentage of habitat loss in surface area does not correspond to the same eel loss. Clavero and Hermoso (2015) estimated that 80% of the area had been lost due to obstacles in the Iberian peninsula. However, when removing the effect of the obstacles, EDA estimated only 10% of eels would be lost. This is because the eel's production in the upper part of the catchment is very low (Mateo et al., 2021). **Thus, it is likely that pristine biomass is overestimated in Spain.**

To calculate fishing mortality, first landings were transformed into SEE (Silver Eel Equivalents). To do so, first, the weight in catches of each stage was transformed into numbers. For glass eel a settlement mortality of 80% (Briand, 2009) was applied and from then on an annual mortality of 0.138 was considered (Dekker, 2000). The applied generation length was different depending on the EMU. Fishery life mortality was estimated as = - Ln (Bcurrent / (Bcurrent + Catches in SEE).

Table 1.Methods used by the Spanish EMUs to estimate indicators in 2020.

EMU_code	B_0 (kg)	BCur	BBest
ES_Anda	NR	NR	NR
ES_Astu	Application of a conversion factor to Bcur	Extrapolation of area production rate (surveys)	Bbest == Bcurr+ A(in SEE)
ES_Bale	NR	NR	NR
ES_Basq	Extrapolation of pristine area production rate	EDA	Bbest == Bcurr+ A(in SEE)
ES_Cant	Extrapolation of pristine area production rate	EDA	Bbest == Bcurr+ A(in SEE)
ES_Cast	Extrapolation of pristine area production rate	NP	NP
ES_Cata	Extrapolation of pristine area production rate	EDA	Bbest == Bcurr+ A(in SEE)
ES_Gali	Extrapolation of pristine area production rate	Extrapolation of area production rate (surveys)	Bbest == Bcurr+ A(in SEE)
ES_Inne	Extrapolation of pristine area production rate	NP	NP
ES_Murc	Application of a conversion factor to Bcur	Based on fishery data and surveys (Martinez Baños, 2010) and updated with annual CPUE	Bbest == Bcurr+ A(in SEE)
ES_Nava	Extrapolation of pristine area production rate	Extrapolation of area production rate (surveys)	NR
ES_Vale	Extrapolation of pristine area production rate	EDA	Bbest == Bcurr+ A(in SEE)

$B_{current}$ and B_0 can be used to assess the compliance with the Regulation aim (defined as 40% of the pristine escapement). But as indicated above, there is not enough scientific evidence to calculate B_0 ; for this reason an anthropological mortality limit can be used to determine compliance with the recovery plan; 40% pristine escapement implies a maximum ΣA of 0.92.). Only Galicia and Asturias provided HPP mortality. In both cases, HPP mortality is very low compared to fishing mortality. According to the 2021 report (Table 2) there are several EMUs that exceed this mortality limit. In this regard, it should be noted that the calculation of mortality has been carried out using different methods in different EMUs, for that reason they are not comparable. It is expected to have some guidance to calculate anthropogenic mortality in a more appropriate and harmonized way and that these values may change.

Table 2. Stock indicators of silver eel escapement, biomass and mortality rates for 2020.

Year	EMU_code	B_0 (kg)	B_{curr} (kg)	B_{best} (kg)	Bcurr/B_0 (%)	∑F	∑H	∑A
2020	ES_Anda	6057545	NC	NC	NC	NC	NC	NC
2020	ES_Astu	63495	28596	NC	45,0	0,765	0,003	0,765
2020	ES_Bale	330883	NC	NC	NC	NC	NP	NC
2020	ES_Basq	75112	16705	57548	**22,2**	0,982	NC	1,251
2020	ES_Cant	132450	25142	63771	**19,0**	0,931	NC	0,931
2020	ES_Cast	23488	0	0	0	0	0	0
2020	ES_Cata	364607	70075	429423	**19,2**	1,813	NC	1,813
2020	ES_Gali	110700	19583	105013	**17,7**	1,671	0,042	1,714
2020	ES_Inne	2420205	0	0	0	NC	0	NC
2020	ES_Murc	26270	21275	72811	81,0	1,230	NP	1,230
2020	ES_Nava	5448	57	NC	1,0	NP	NC	NC
2020	ES_Vale	307162	98895	124785	**32,2**	0,233	NC	0,233

A general yearly decrease in current silver eel biomass is observed (Fig. 1). In the case of the EMUs that have used the EDA model, the trends are clearer as the GAM model smoothes the annual variability.

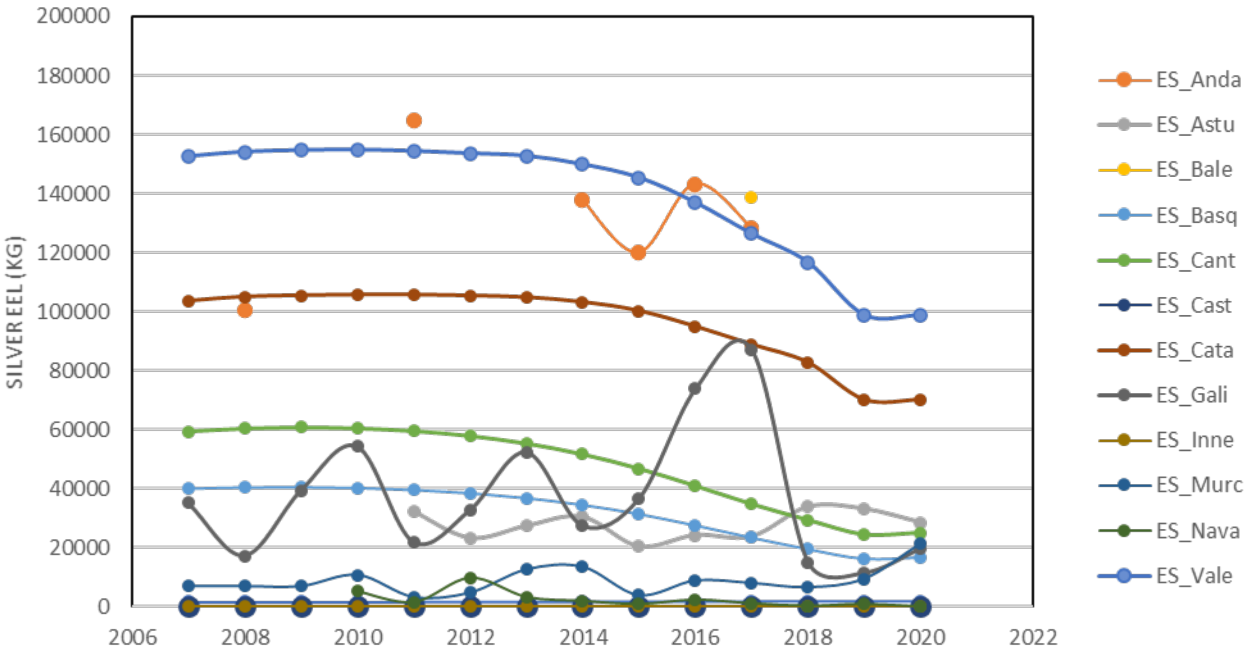

Figure 1. Silver eel biomass (B_{curr}) trends of the Spanish EMUs (Spanish post evaluation report 2021)

Fishing mortality is highly variable over time and shows no trend (Fig. 2).

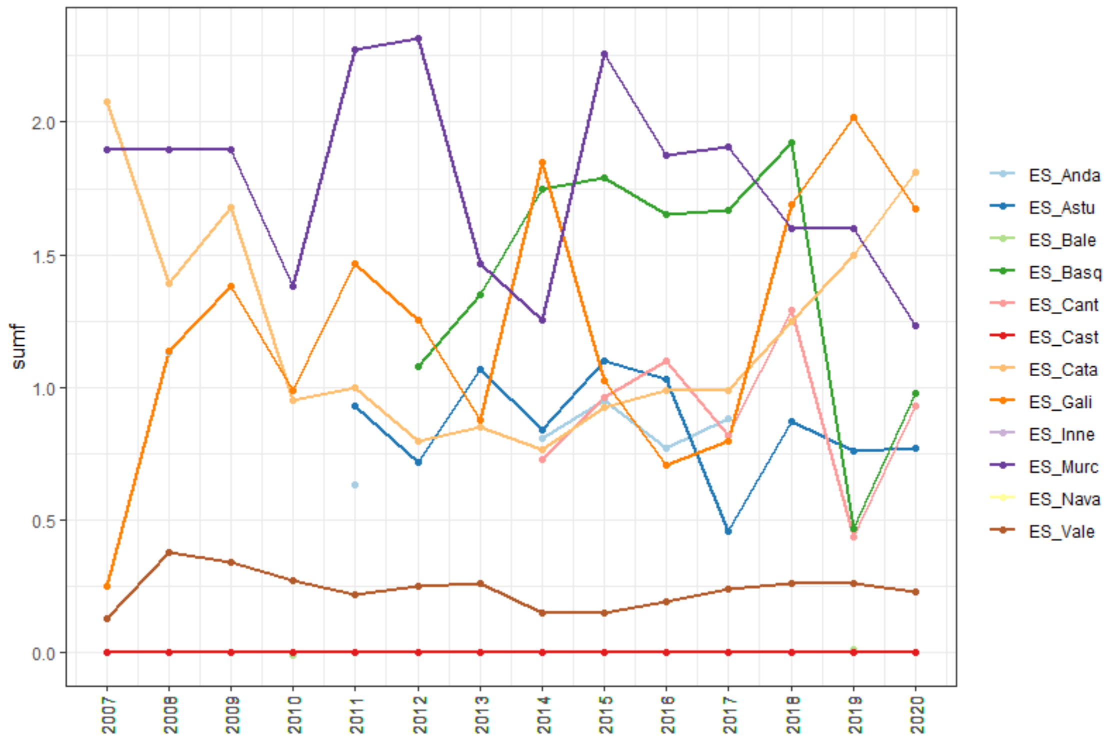

Figure 2. Fishing mortality trends in the Spanish EMUs (Spanish post evaluation report 2021)

1.2 Recruitment time series

Spain provides four series with pre-(0ies data. These are the characteristics of those fishery dependent series:

- San Juan de la Arena fish market in Asturias: It includes almost all the catches from the Nalón River. Until the 70's only land fishing existed, then fishermen started to fish in boats, and the catches increased notably.
- The Albufera in C. Valenciana: During the 1949-2000 period, data were collected from fishermen 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 data series, the Pujol, Perelló and Perrellonet data will be considered for the historical data series of the Albufera. As this series contains also effort data, both the catch series and the catch-per-unit-effort series are provided.
- 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 also compiles information from the rest of Catalonian rivers.
- The Miño: the Miño River command compiles the Spanish catches data.

In addition, Spain contributes with other shorter three historical series to WGEEL recruitment index:

- AICPG: ALbufera de Valencia comercial CPUE.
- OriaG: Oria scientific monitoring.
- GuadG: Guadalquivir scientific monitoring.

The Spanish historical series show a decrease in catches since late 70ies. During the last years, the catches remained low showing some interannual variability without any clear trend (Fig. 3). In 2021 catches decreased in San Juan de la Arena and Ebro and Ebro series and increased in the Oria, Miño and Albufera series compared to 2020 Anyway, put in historical context, the conclusion is that recruitment remains at very low levels.

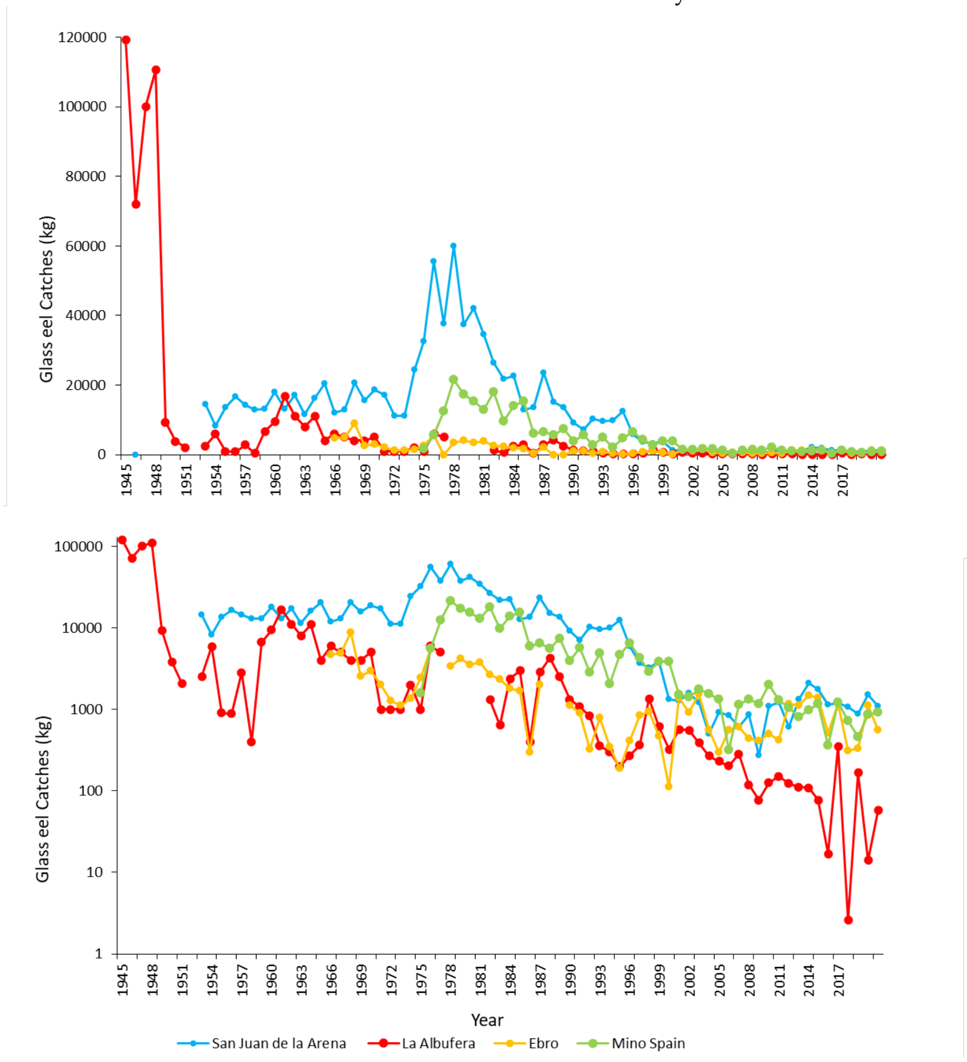

Figure 3. Evolution of the four Spanish fisheries dependent historical recruitment series in natural and logarithmic scale.

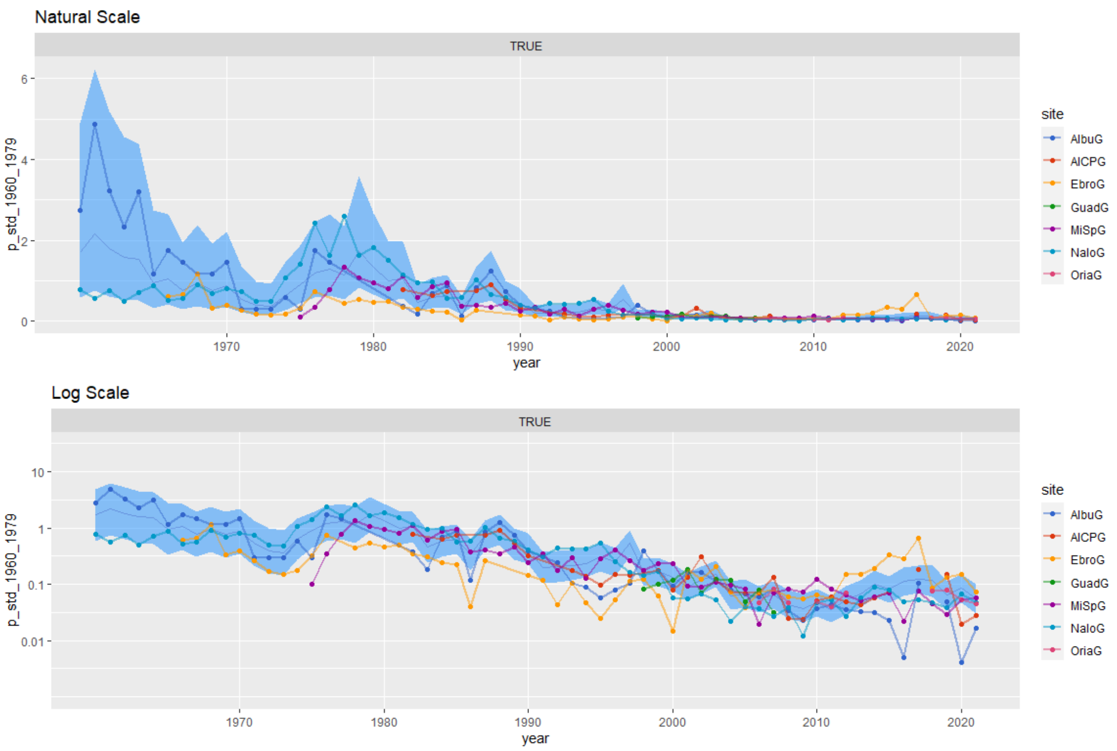

Figure 4. Evolution of the seven Spanish recruitment series used in the calculation of the WGEEL recruitment index in natural and logarithmic scale.

2 Overview of the national stock and its management

No new information since 2018 report (Korta and Díaz, 2018).

3 Impacts on the national stock

3.1 Fisheries

For details about data gathering check Spanish Country report 2017 (Díaz and Korta, in 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.

In Spain different regions exploit different stages of the eel and use different fishing techniques and gears.

3.1.1 Glass eel fisheries

Commercial glass eel fishery is very traditional is Spain. The evolution of catches must be analysed with caution as the amount of information available has been increasing over the years (Fig. 5), which may lead to think that catches have increased when, as shown in the individual series in the recruitment section, the opposite has been the case.

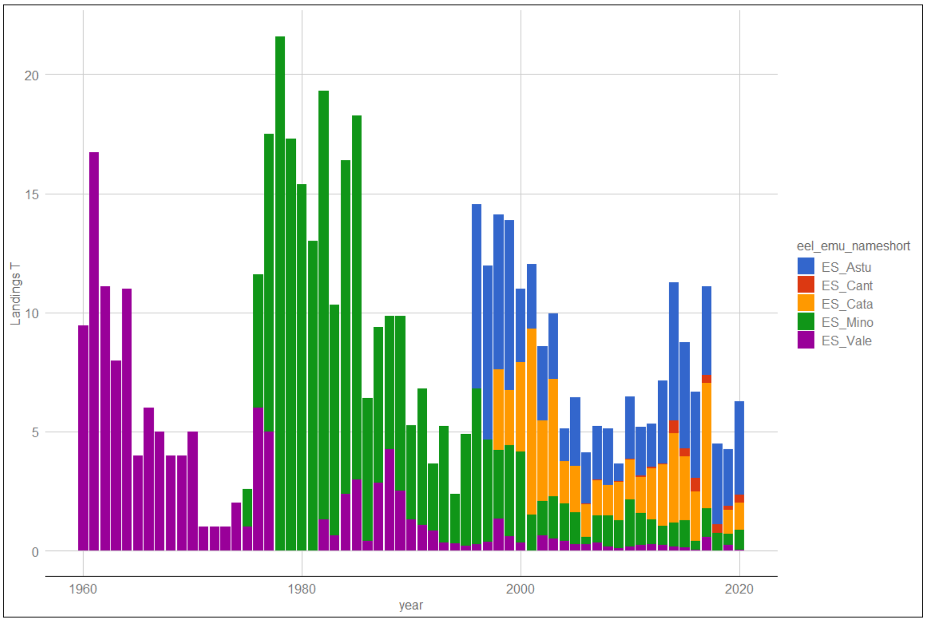

Figure 5. Total glass eel catches in Spain since 1960.

Recreational glass eel fishery only takes place in the Basque Country nowadays, Cantabria used to allow this fishery but prohibited it from 2014 on (Fig. 6). 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. Due to the restrictions imposed by COVID in the Basque Country, only professional workers were allowed to go out after curfew at night, which is why recreational glass eel fishermen were not allowed to fish in 2021.

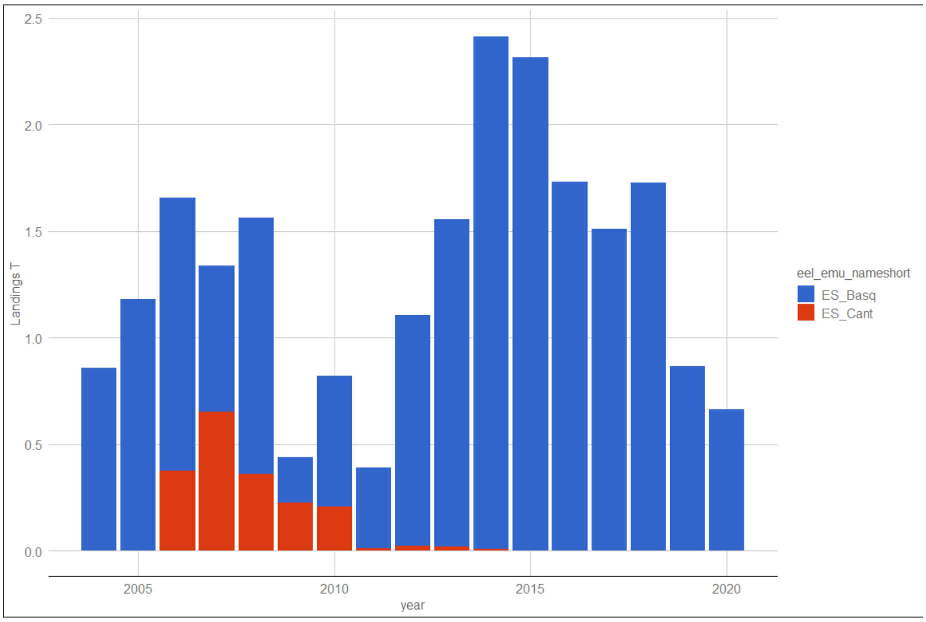

Figure 6. Catches of glass eel recreational fishery in Spain.

3.1.2 Yellow eel fisheries

Only the Albufera catches data are split up into yellow and silver and since 2014 catches from the Mar Menor (Murcia) are also separated in the two stages during the last years (Fig. 7). Additionally, aggregated information exits for other EMUs. The data sources are described in the 2018 Spanish Country report (Korta and Díaz, 2018). The combined yellow and silver eel catches show great variability among regions; but in general, there is a decreasing trend in catches (Fig. 8).

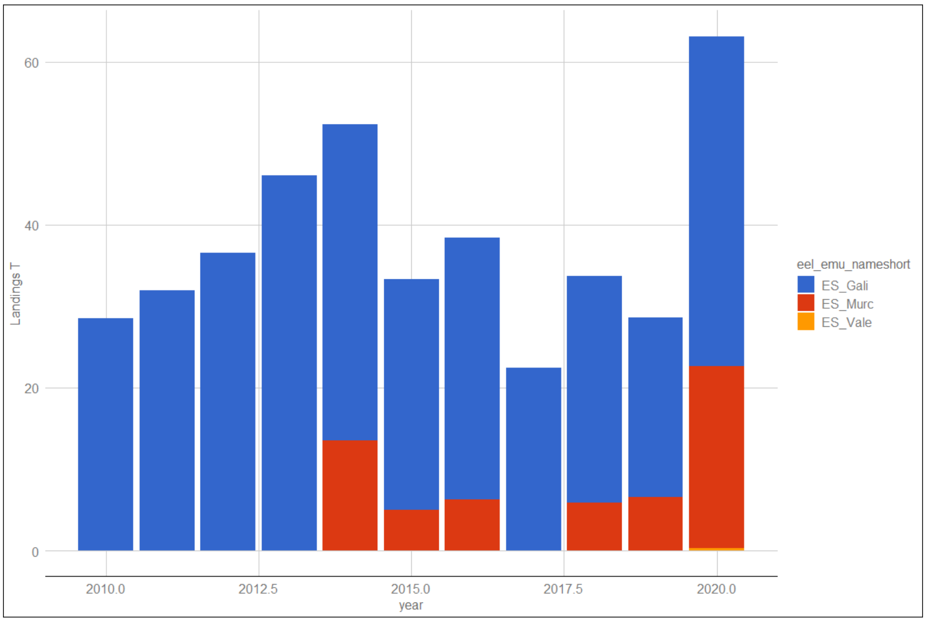

Figure 7. Commercial yellow eel catches (kg) by EMU corresponding to Galicia, Albufera (Valencia) and Mar Menor (Murcia).

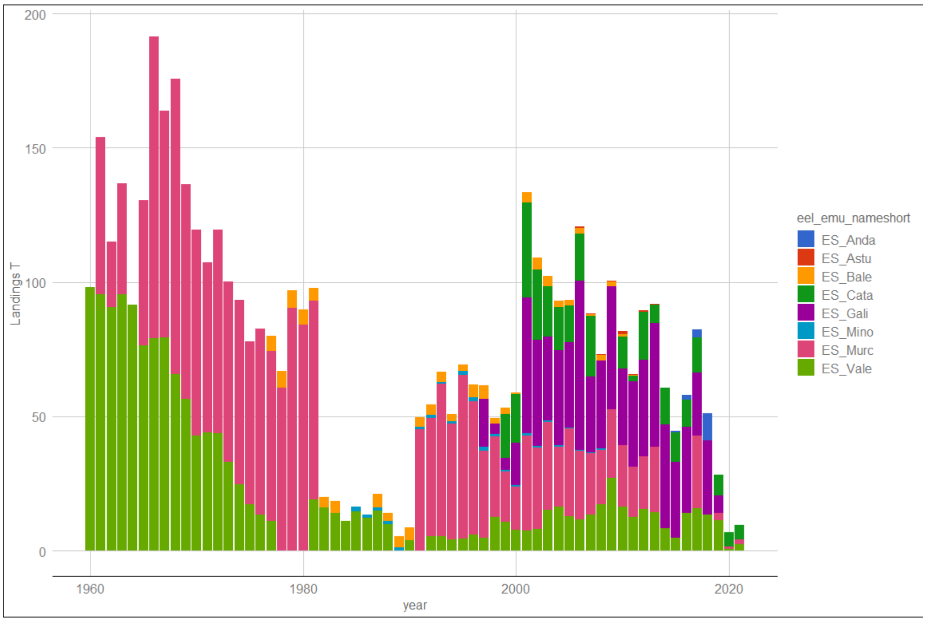

Figure 8. Yellow and silver eel mixed catches (kg) by EMU. Notice that during the 80ies Murcia, did not report during those years.

3.1.3 Silver eel fisheries

Silver eel catches are reported since 1951 in Valencia and more recently in Murcia (Fig. 9).

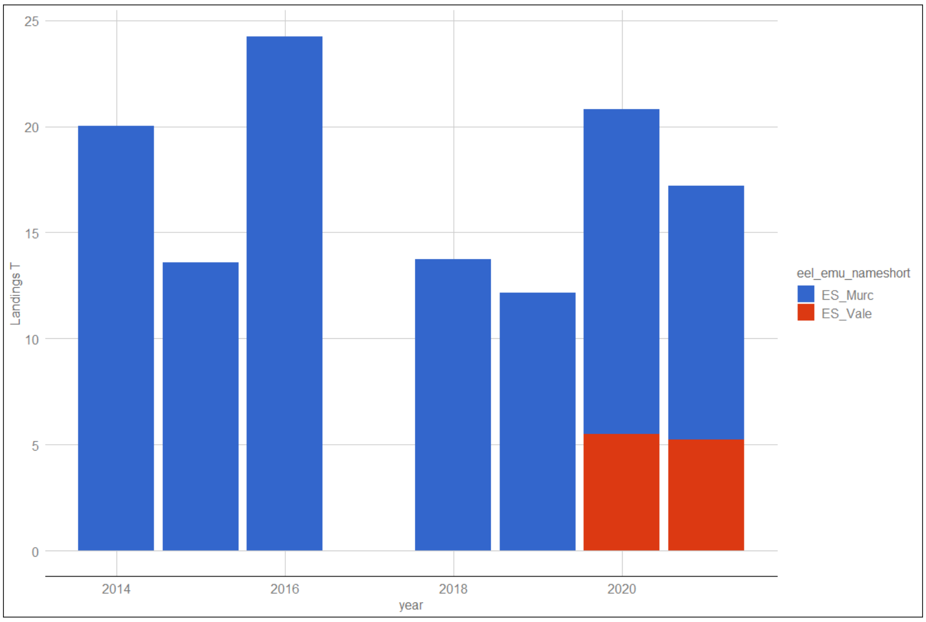

Figure 9. Silver eel catches (kg) by EMU.

3.2 Restocking

In Spain restocking is not a major activity, practically the only activity is the restocking of glass eels from seizures coming from police operations (Fig. 10).

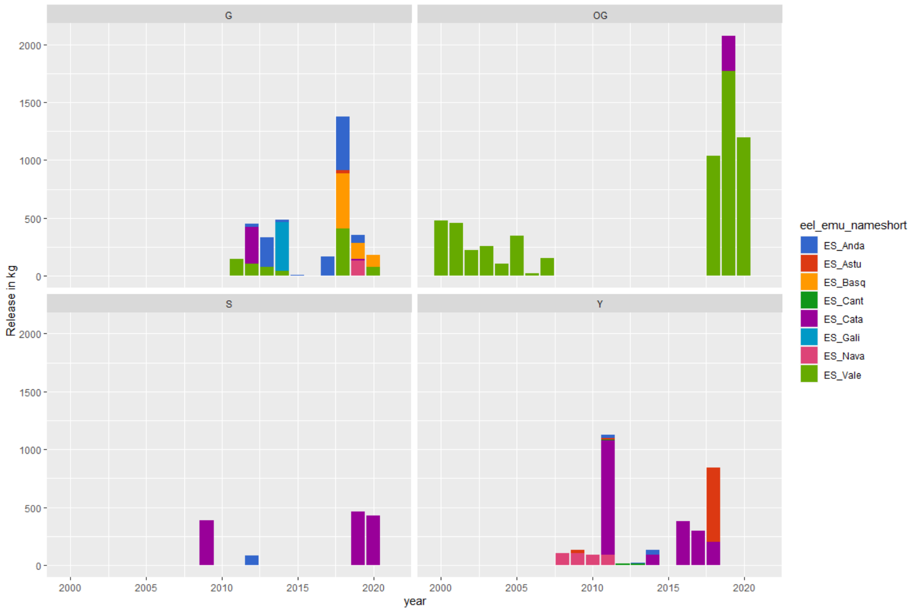

Figure 2. Stocking kg in freshwater by EMU. G: Glass eel, GY: glass + yellow eel, Y: yellow eel, YS: Yellow and silver eel OG: On grown eels.

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 90ies, nowadays almost all the production comes from a farm in Valencia (Fig. 11)

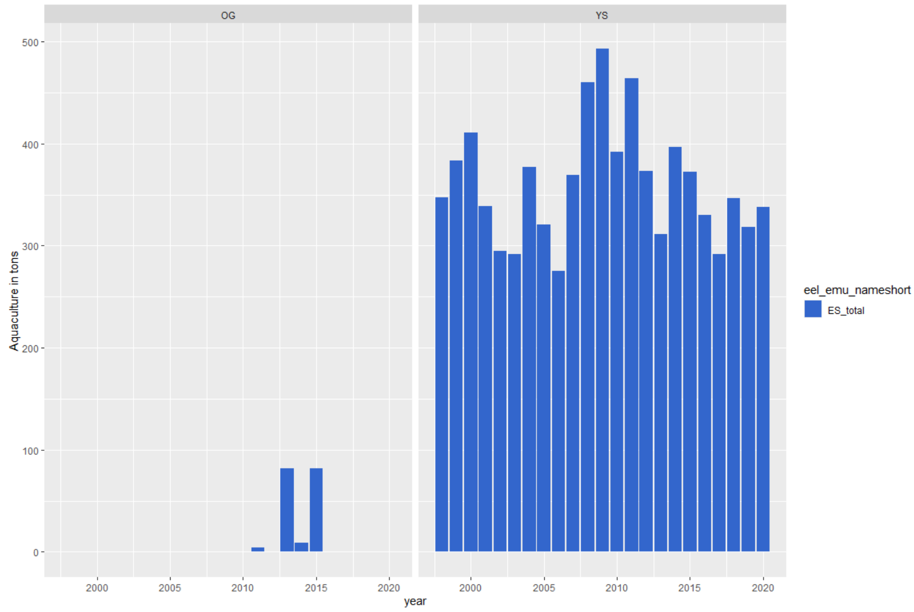

Figure 3. Aquiculture production in the Spanish EMUs since 1998.

3.4 Entrainment

Only Galicia and Asturias provided HPP mortality. In both cases, HPP mortality is very low compared to fishing mortality. In fact, as shown in the SUDOANG project (Mateo et al., 2021) there almost no eel above hydropower stations.

Table 3. Estimated HPP mortality in Asturias and Galicia EMUs.

Year	ES_Astu	ES_Gali
2007	NC	0,04
2008	NC	0,05
2009	NC	0,03
2010	NC	0,03
2011	NC	0,05
2012	NC	0,04
2013	0,01	0,03
2014	0,03	0,04
2015	0,01	0,03
2016	0,00	0,02
2017	0,00	0,02
2018	0,00	0,04
2019	0,00	0,08
2020	0,00	0,04

3.5 Habitat Quantity and Quality

The construction of large dams since the 60's 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.

In the SUDOANG project, an inventory of the obstacles present in the rivers for Portugal Spain in Frace has been carried out. 100,000 obstacles have been collected in total (Fig. 12).

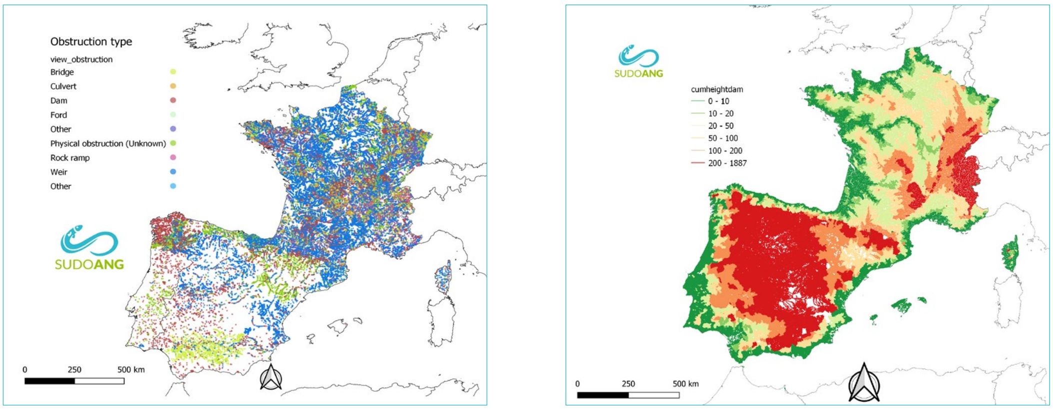

Figure 4. Left, number of obstacles by type and right cumulative height of dams to be passed by eels in Portugal, Spain and France estimated in the SUDOANG project.

Estimates of the current distribution of eel produced at EDA (Mateo et al., 2021) agree fairly well with those estimated by Clavero and Hermoso (2015) that estimated that eel has lost over 80% of its original range (Fig. 13). However, when removing the effect of the obstacles, EDA estimated only 10% of eels would be lost. This is because the eels production in the upper part of the catchment is very low.

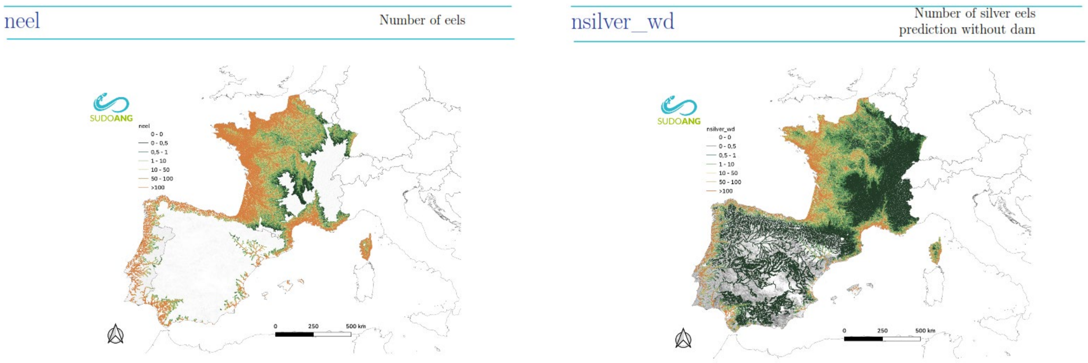

Figure 5. Number of eels estimated with the EDA model in 2015 (Mateo et al., 2021) with (left) and without (right) the presence of obstacles.

4 National stock assessment

No new information since last year's report (Korta and Díaz, 2018).

5 Other data collection for eel

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 10 pilot basins (4) 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. Also, 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

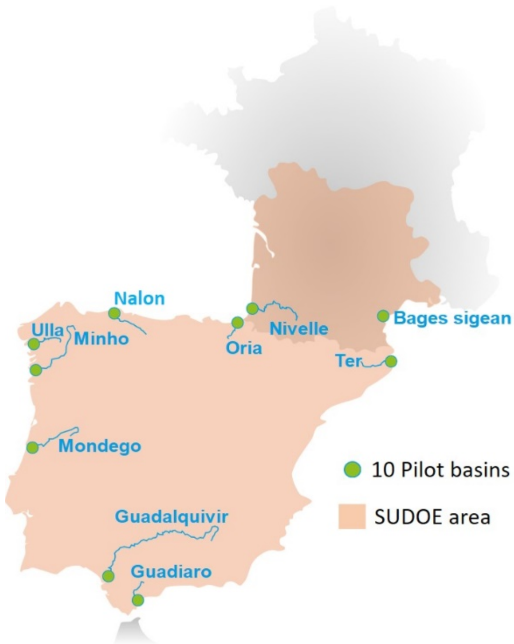

Figure 6. Location of the 10 pilot basins, included in the SUDOANG eel sampling network.

5.1 Yellow eel abundance surveys

Spain has 4 yellow eel time series with biometry data. Three of them are located in the Atlantic and are based on electrofishing surveys in the river Oria (OriY), Bidasoa (BidY) and Nalón rivers (NalY). The other series is located in the Mediterranean and corresoponds to yellow eel catches in the Albufera lagoon (AlCY). The electric fishing series show a large inter-annual variability (Fig. 15). The Albufera historical series, which is the longest, shows a downward trend.

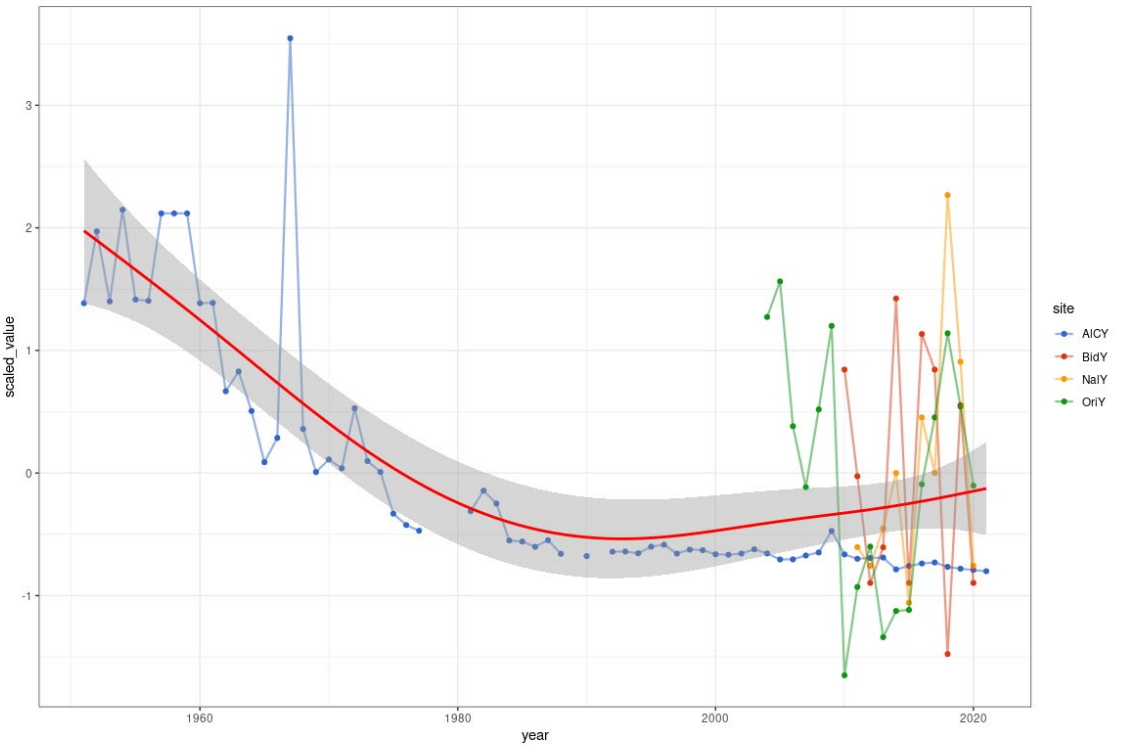

Figure 7. Abundance trends in Spain for four yellow time series

5.2 Silver eel escapement surveys

Spain has 4 silver eel time series with biometry data. Three of them are located in the Atlantic and are based on electrofishing surveys in the river Oria (OriS), Bidasoa (BidS) and Nalón rivers (NalS). Sampling takes place in early autumn and the eels are classified according to Durif et al., (2005). After various marking experiments, the migrating silver eels are considered as MII and F stages III, IV and V. The other series is located in the Mediterranean and corresponds to silver eel catches in the Albufera lagoon (AlCS). The electric fishing series show a large inter-annual variability (Fig. 16). The Albufera catch historical series, which is the longest, shows a downward trend.

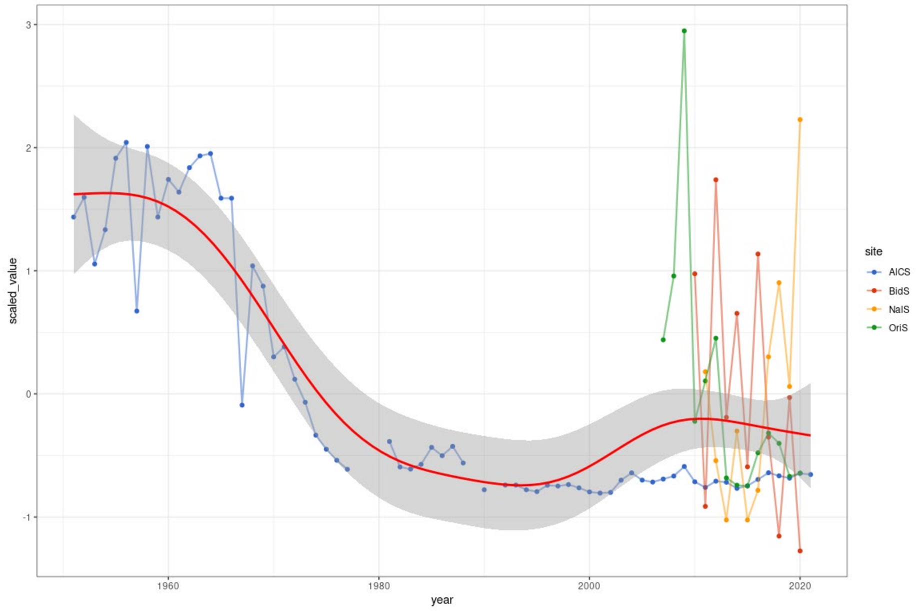

Figure 8. Abundance trends in Spain for four silver time series Life history parameters

5.3 Life history parameters

In the SUDOANG project, the percentage of silvering eels and the sex ratio in Spain, France and Portugal has been estimated (Fig. 17). This information can be consulted at the level of river section, basin, EMU and country in the atlas hosted in VISUANG.

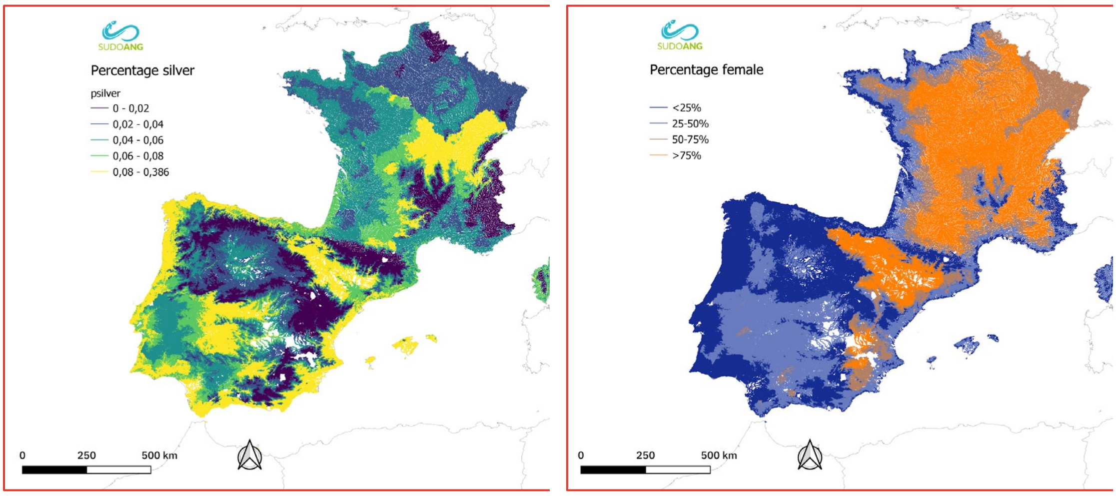

Figure 17. Percentage of Silver eels for length >150 mm and the percentage of silver females estimated by the EDA model.

5.4 Diseases, Parasites & Pathogens or Contaminants

Whitin the SUDOANG framework, 501 eels (437 yellow and 64 silver) were sampled and analysed over 7 pilot basins (6 rivers and 1 lagoon) according to a concerted and standardized methodology between September 2018 and March 2019 in the SUDOE area (Faliex et al., 2021) (Fig. 18). *A. crassus* prevalence was close or above 50% for all sites except for Bages-Sigean lagoon (14%). This was explained by the negative effect of salinity on *A. crassus* larvae survival.

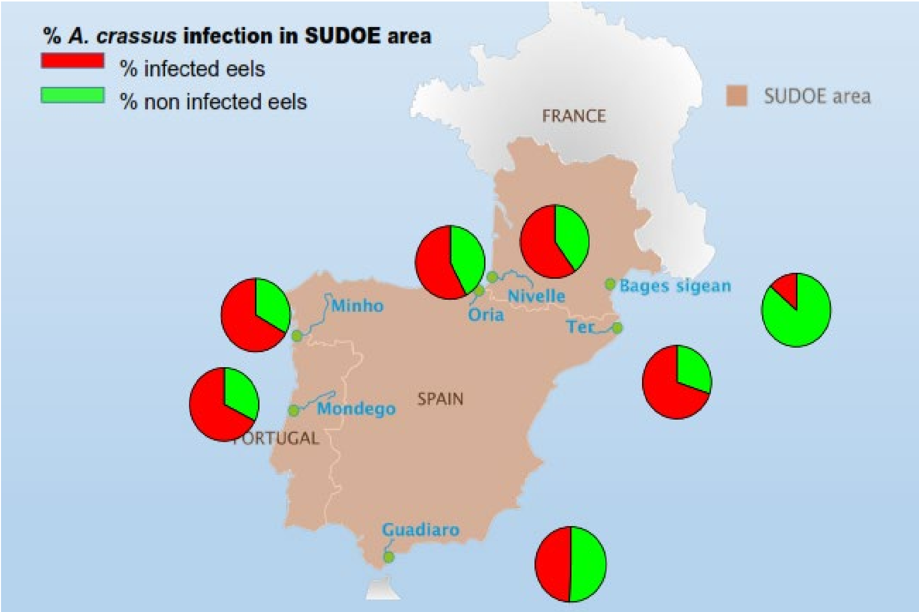

Figure 18. ***Anguillicola crassus*** **prevalence in seven basins of the SUDOE area.**

6 New Information

As it has been explained throughout this document, SUDOANG project has provided a lot of new information regarding the eel status indicators and its biology The results of these parameters can be consulted in VISUANG (Fig.19) tool hosted on the SUDOANG website:

- An **eel atlas** that compiles data on the estimation of eel abundance and the distribution of eel characteristics (**size, biomass, sex ratio and silver**) (obtained with the application of the EDA model) in the entire hydrographic network of Spain, Portugal and France.
- The **inventory of all dams and hydropower plants**. These are visualized together with the altitude of the river (m), the distance to the sea (km), the cumulated number and height of the dams available on the layers control.
- A **demonstrator for the calculation of mortalities in turbine**. It uses various scenarios (flow, repartition, etc.) to provide modelled estimates of hydropower mortalities at the dam and basin level. It uses the eel production and size structure estimated by EDA
- R**ecruitment estimates** made using the GEREM model. These estimates are provided at the scale of SUDOE, eel management units, large areas defined in the model and river basins. Recruitment can be represented in different ways: absolute scale, relative scale, logarithmic scale, weighted by the surface area of the study area.
- The average for **the presence probability, density, sex ratio and to the sum for numbers of eels or silver eels** estimated by the Eel Density Analysis (EDA) model (Mateo et al., 2021). The EDA model extrapolates the eel characteristics collected during electrofishing surveys to the rest of the basin considering variables derived from the river segment characteristics, i.e., distance to the sea, cumulated height of dams downstream, etc., predicting eel densities and silver migration from continental waters. The EDA model predictions are presented at different scales. They correspond to the average for the presence probability, density, sex ratio and to the sum for numbers of eels or silver eels. These estimates are provided at the scale of SUDOE, country, large areas defined in the model, Eel Management Units (EMU) and watersheds.
- The **biological parameters** compiled in the SUDOANG eel monitoring network. This network consists of 10 pilot basins (Nivelle, Oria, Nalón, Ulla, Miño, Mondego,Guadal-

quivir, Guadiaro, Ter and Bages-Sigean), which are representative of the different ecosystems existing in the region, both Mediterranean and Atlantic. The sampling of eel population parameters was carried out simultaneously, for two years (2018 and 2019) by trained people who applied the common protocols defined within the project.

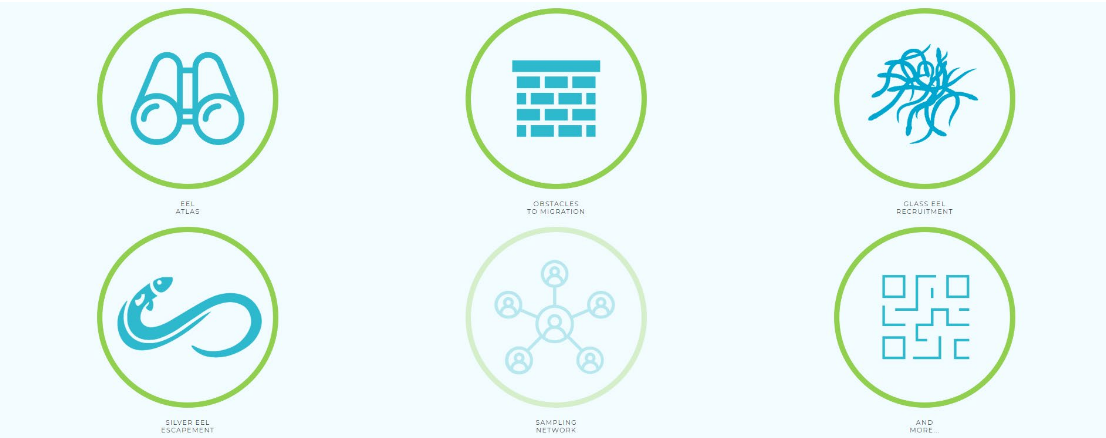

Figure 19. VISUANG tool through which you can see the indicators produced in the SUDOANG project

7 References

Briand, C. (2009). Dynamique de population et de migration des civelles en estuaire de vilaine. Theses , PhD thesis, Agrocampus Ouest.

Clavero, M., Hermoso, V. (2015). Historical data to plan the recovery of the European Eel. Journal of Applied Ecology 2015, 52, 960–968 doi: 10.1111/1365-2664.124

Dekker, W. (2000). A Procrustean assessment of the European eel stock. ICES Journal of Marine Science, 57(4), 938-947.

Durif, C., Dufour, S., Elie, P. (2005). The silvering process of *Anguilla anguilla*: a new classification from the yellow resident to the silver migrating stage Journal of Fish Biology 66 (4), 1025-1043.

ICES (2017). Report of the Joint EIFAAC/ICES/GFCM Working Group on Eels (WGEEL), 3–10 October 2017, Kavala, Greece. ICES CM 2017/ACOM:15. 99 pp.

Korta, M., Díaz, E. (2019) Report on the eel stock, fishery and other impacts, in Spain. Report of the Joint EIFAAC/ICES/GFCM Working Group on Eels (WGEEL) 27 August–2 September 2018 Bergen.

Mateo M., Beaulaton L., Drouineau H., Díaz E., and Briand C. (2021). Eel density analysis (EDA 2.3). Escapement of silver eels (*Anguilla anguilla*) from French, Spanish and Portugese rivers.

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Authors

Dr Rob van Gemert, Swedish University of Agricultural Sciences, Department of Aquatic Sciences, Institute of Freshwater Research, Drottningholm, Sweden.

Tel: +46-104784211. FAX: +46-104784269 rob.van.gemert@slu.se

Dr Andreas Bryhn, Swedish University of Agricultural Sciences, Department of Aquatic Resources, Institute of Coastal Research, Öregrund, Sweden.

Tel: +46-104784152 andreas.bryhn@slu.se

Dr Willem Dekker, Swedish University of Agricultural Sciences, Department of Aquatic Sciences, Institute of Freshwater Research, Drottningholm, Sweden.

Tel: +46-761268136. FAX: +46-104784269 willem.dekker@slu.se

Dr Niklas B. Sjöberg, Swedish University of Agricultural Sciences, Department of Aquatic Sciences, Institute of Freshwater Research, Drottningholm, Sweden.

Tel: +46-104784244. FAX: +46-104784269 niklas.sjoberg@slu.se

Dr Josefin Sundin, Swedish University of Agricultural Sciences, Department of Aquatic Sciences, Institute of Freshwater Research, Drottningholm, Sweden.

Tel: +46-761317908. FAX: +46-104784269 josefin.sundin@slu.se

Dr Håkan Wickström, Swedish University of Agricultural Sciences, Department of Aquatic Sciences, Institute of Freshwater Research, Drottningholm, Sweden.

Tel: +46-761268134. FAX: +46-104784269 hakan.wickstrom@slu.se

Reporting Period: This report was completed in September 2021, and contains data up to 2020 and some provisional data for 2021.

Acknowledgments: Richard Fordham at Scandinavian Silver Eel AB kindly provided data on the aquaculture production and on restocking.

1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

The assessment made in 2018 was updated in spring 2021 (Dekker et al., 2021). Compared to the 2018 assessment, the 2021 update made no major changes in methodology. Dekker et al. (2021) took all impacts throughout the eel's life into account – that is: including the impacts in the yellow eel stage. For the Baltic coast (SE-East), these impacts often take place in other countries in the Baltic – and noting that those impacts remain unquantified for the Baltic as a whole, indicators were reported as "not available" (the impact of the Swedish fishery was reported separately, as F_{SE}). For the west coast (SE-West), the current absence of a commercial eel fishery means that no biomass indicators can be derived due to lack of data.

The new stock indicators of the 2021 assessment are shown in Table SE. 1.

Table SE. 1: Stock indicators of silver eel escapement, biomass and mortality rates, and assessed habitat area. The Inland EMU indicators are shown both with (+) and without (-) the effect of restocking.

Year	EMU_code	Assessed Area (ha)	B_0 (kg)	B_{curr} (kg)	B_{best} (kg)	Bcurr/B_0 (%)	∑F	∑H	∑A
2020	SE-West	NP	NA	NA	NA	NA	0	0	0
2020	SE-Inland+	1 800 000	498 000	72 000	243 000	14.5	0.45	0.83	1.28
2020	SE-Inland-	1 800 000	300 000	13 000	47 000	4.3	0.45	0.83	1.28
2020	SE-East	NP	NA	3 670 000	NA	NA	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

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 the catch of glass eels in the open sea of the Skagerrak-Kattegat (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 (Figure SE. 3, Figure SE. 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 once or 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 time of arrival of the glass eels to the Ringhals 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 (closed in 2020) and 2 (closed in 2019), whose cooling water intake was sampled before the move. This new sampling site was used also in 2021 and has become the permanent sampling site. The annual glass eel index has been adjusted for different levels of water discharge 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.

Recruitment of young eel to Swedish waters is monitored at eel passes in a number of Swedish rivers (Figure SE. 3, Figure SE. 4). As the catch of ascending young eels has declined substantially in most Swedish rivers, the interest and maintenance of these river eel passes might have deteriorated in some cases. The removal of dams and the construction of by-passes at some hydropower dams have changed the conditions in other rivers. At present, only the most reliable sites are used to construct the recruitment indices. Different eel passes catch different ages of young eel, depending on their location along the Swedish coast. The eel passes on the western coast of Sweden catch younger eel, with progressively older eel being caught the further away the eel pass is located along the Baltic Sea coast.

After a number of years of relatively little change in glass eel catches, the IBTS in Skagerrak-Kattegat caught zero glass eel in 2021 (Figure SE. 1). At Ringhals, however, the 2021 catch of glass eel was around the same level as the 2020 catch (Figure SE. 2). Some of the eel passes along the west coast, where the caught eel are younger, indicate increasing numbers of recruits during a couple of years; however, this trend did not continue since 2020. On the east coast (Baltic Sea), where the caught eel are older, the number of recruits is still very low. Unfortunately, the longest recruitment series in Europe, the river Göta Älv, was interrupted in 2018, and has been left unsampled since 2017, due to lack of staff and unclear responsibility roles.

To increase and improve the recruitment monitoring programmes, young-of-the-year elvers could be monitored along the west coast at stations that operate independently from dam owners or similar. So far, no such monitoring programme has been implemented. There is, however, an ongoing extensive electro-fishing program. This programme is being run in streams and small rivers and is financed from several different sources. The target species are normally salmonids such as salmon and trout, but when eels are caught, data are collected also for this species. In addition, 15 sites are specifically electrofished for eels. All data are stored in the national database SERS, and it could be used for analyses on recruitment and abundance of mainly yellow eels in freshwater systems.

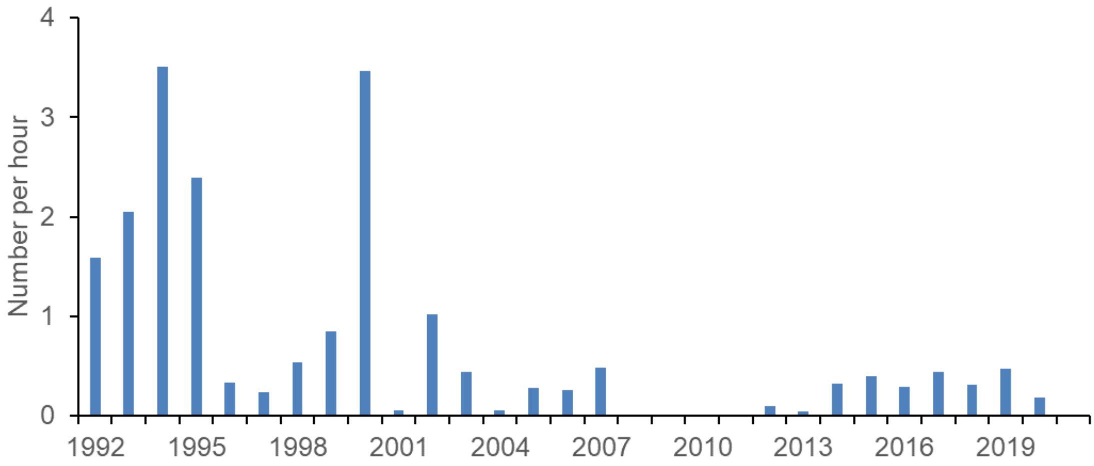

Figure SE. 1: Catch in late winter of glass eels in a MIK-trawl in open sea (Kattegat-Skagerrak). Note that in 2011, no MIK trawling occurred, i.e. a zero catch is the actual value for years displaying n=0, except for 2011.

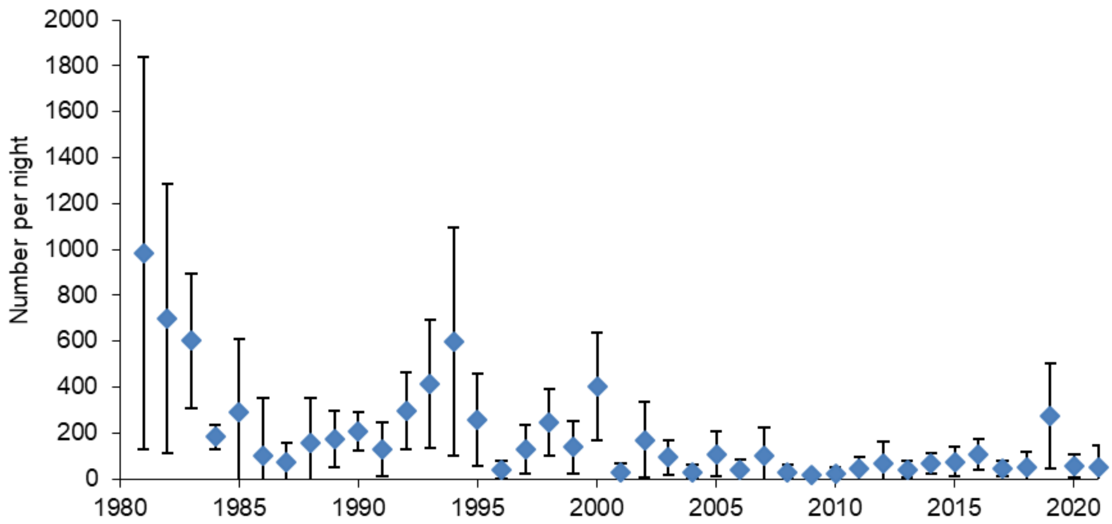

Figure SE. 2: Recruitment index of glass eel at the cooling water intake at the Ringhals nuclear power plant 1981–2021. The index is calculated as the mean weekly catch in numbers per night during February to April (weeks 9–18), corrected for number of nuclear reactors taking in cooling water. Error bars represent standard deviation.

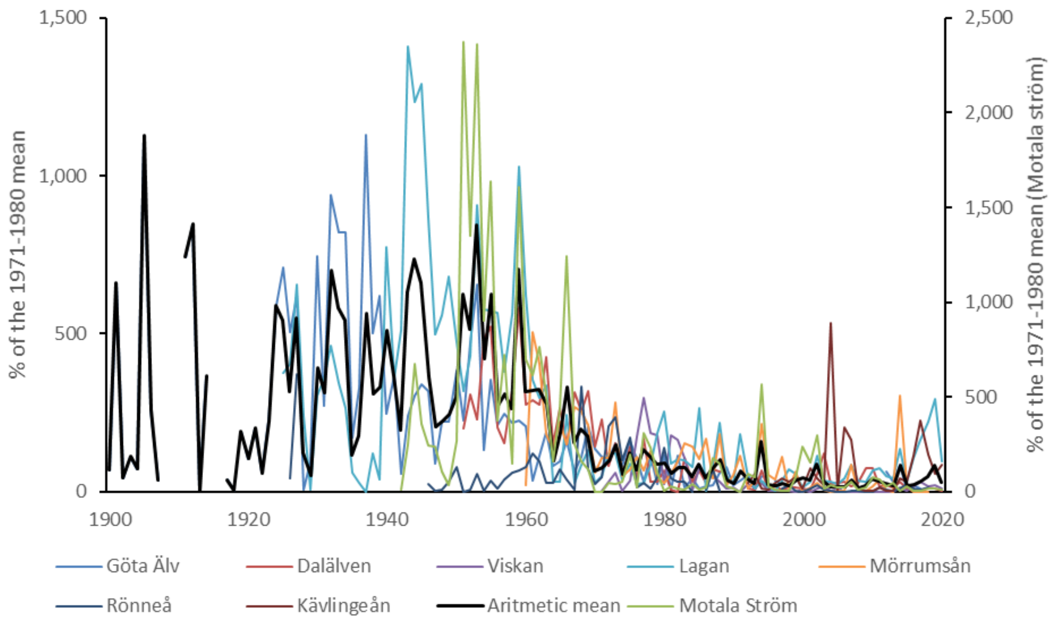

Figure SE. 3: Recruitment of young eels in eight rivers (relative to the average for 1971–1980, except for River Kävlingeån that relates to 2002–2011) from 1900–2020, including their arithmetic mean (thick black line).

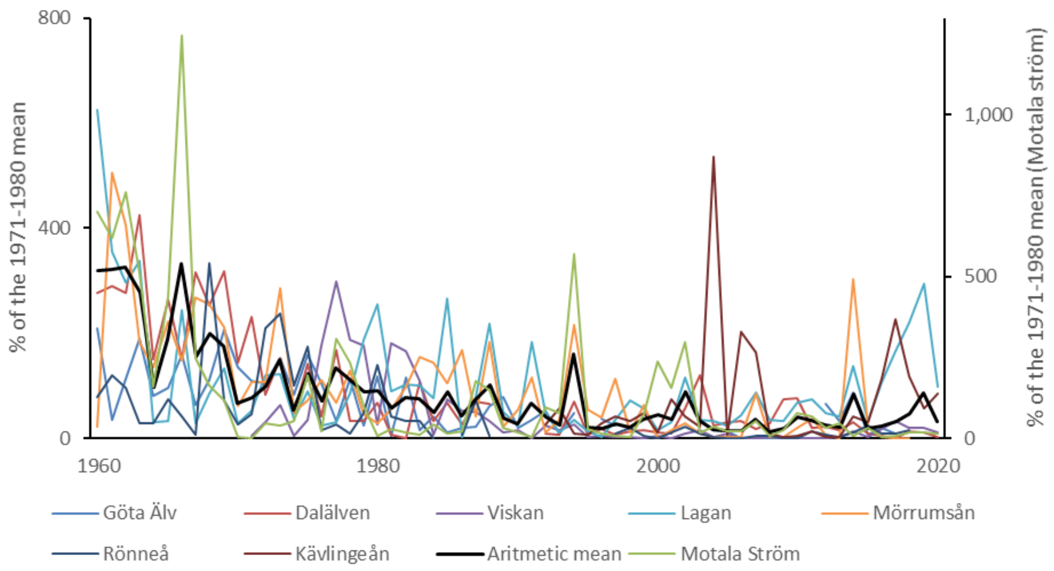

Figure SE. 4: Recruitment of young eels in eight rivers (relative to the average for 1971–1980, except for River Kävlingeån that relates to 2002–2011), including their arithmetic mean (thick black line). Same data as above in Figure SE 3, but reduced to 1960–2020 to show recent years more clearly.

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 as one official Eel Management Unit (EMU), 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, so in practice there are three EMUs, 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 many 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 Skåne, 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 are eel fisheries in a number (ca. 20) of inland lakes. The major part of eel landings today are from lakes Mälaren, Vänern and Hjälmaren. The lake fisheries are also mainly maintained using poundnets and target additional species to eels.

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 (actually an exempt from the general eel fishing ban), an increased minimum legal size, effort restrictions in time and number of fishing gears, and an upper limit in total catch per licence. No new licences are issued, and the number of licensed fishers is therefore steadily decreasing. As previously mentioned, since spring 2012, eel fishing on the west coast has been completely closed (north of Torekov, 56°25′, in the Kattegat). South of Torekov and in the Baltic Sea the fishing is 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. In freshwater, eel fishing is allowed for licensed fishers during 120 individually determined days.

Since 2017, the EU Ministerial Council has taken annual decisions on a three-month fishing closure in Swedish and other marine waters in the EU. The moratorium should cover three consecutive months. SwAM has decided to keep a November–January closure during the ongoing season, similar to previous years.

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 action, where the target was to double the previous amounts of 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 and has been reached for the majority of years. 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 downstream migration of silver eels. Within the T&T-program, approximately 167 000 kg silver eels were transported downstream by road between 2010 and 2020. T&T will continue as one measure to decrease eel mortalities due to hydropower exploitation.

2.1.5 Local stock assessment

Previous assessments of the local stock can be found in Dekker (2012; 2015) and Dekker et al. (2018; 2021). 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.

As previously mentioned, according to the Swedish Eel Management Plan, the whole Swedish national territory constitutes a single EMU. 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). Thus, the assessment is divided over three EMUs: the west coast (SE-West), Baltic (SE-East) and the Inland (SE-Inland).

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.

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 be the explanation to why no or few yellow eels are fished. Since the fishery almost exclusively targets silver eel, no separate samples are taken of yellow eel. Data from mixed samples of yellow and silver eel, representative for the catch, 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. Commercial landings of eel in Sweden have declined in recent times, particularly in the coastal fishery (Table SE. 2). 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 2020, the Swedish coastal fisheries had a total catch of 86 tonnes (Figure SE. 5). The freshwater catch for 2020 was 94 tonnes (Figure SE. 6), i.e. together with the brackish/marine fisheries the total Swedish catch for 2020 was 195 tonnes (Figure SE. 7). 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. 8).

In the past, fishers have also reported on their effort through logbooks. However, previous investigations into this effort data found that it was not of adequate quality to determine CPUE with: i.e. many fishers reported their effort inconsistently or not at all. However, in recent years, SwAM has worked on improving the reporting of effort data, and a new analysis of the quality of the effort data is planned before the next country report.

The capacity, i.e. the number of fishers licensed in 2020 to fish eels are 168, out of which 117 are coastal fishing licences and 51 are freshwater licences (Figure SE. 9). The data came from SwAM, who are the responsible licensing agency.

Recreational fishing on eel is generally banned in Sweden. However, there is an exception from this ban in inland waters located above three hydropower installations, since almost no silver eel would be able to pass safely to the sea from such areas. At present, the extent of that fishery, and whether those eels are illegally sold or not (only licensed, commercial fishers can sell eels legally), is unknown.

There have been numerous reports on illegal fisheries. SwAM and other authorities have been working actively to detect and combat illegal eel fishing since 2016, mainly in the counties of Skåne and Blekinge (southern Sweden). The number of seized gears has been rising since 2016, probably partly because authorities have become more efficient in finding them. Notably, in August 2020, an untagged soaking box containing 650 kg of eels was found in Sölvesborg. During the whole of 2020, SwAM seized 210 illegal eel-catching gears, among which were 207 double fykenets, 2 single fykenets and one trammel net. In Skåne, 11 of these gears were seized and the remaining 199 gears were seized in Blekinge, where most of the search effort was made. SwAM had no similar activity in any other county or region in 2020.

Specific details on the gears together with the spatial distribution has made SwAM convinced that many people currently fish eel illegally in Blekinge. Several of these people fish more than what can be estimated to be for household needs. In 2022, additional efforts are planned in Kalmar county to be able to assess the characteristics of the illegal eel fishing along the east coast (Tobias Jeppson, SwAM, personal communication).

Table SE. 2: Commercial landings of eel in the different Swedish EMUs, shown in tonnes. The west coast fishery was closed in 2012.

Year	West coast	East coast	Inland
2005	215	345	115
2006	240	364	128
2007	172	417	114
2008	168	387	118
2009	108	314	97
2010	108	307	110
2011	84	271	96
2012	0	236	101
2013	4	264	103
2014	0	209	111
2015	0	158	89
2016	0	181	98
2017	0	143	102
2018	0	143	103
2019	0	84	87
2020	0	86	94

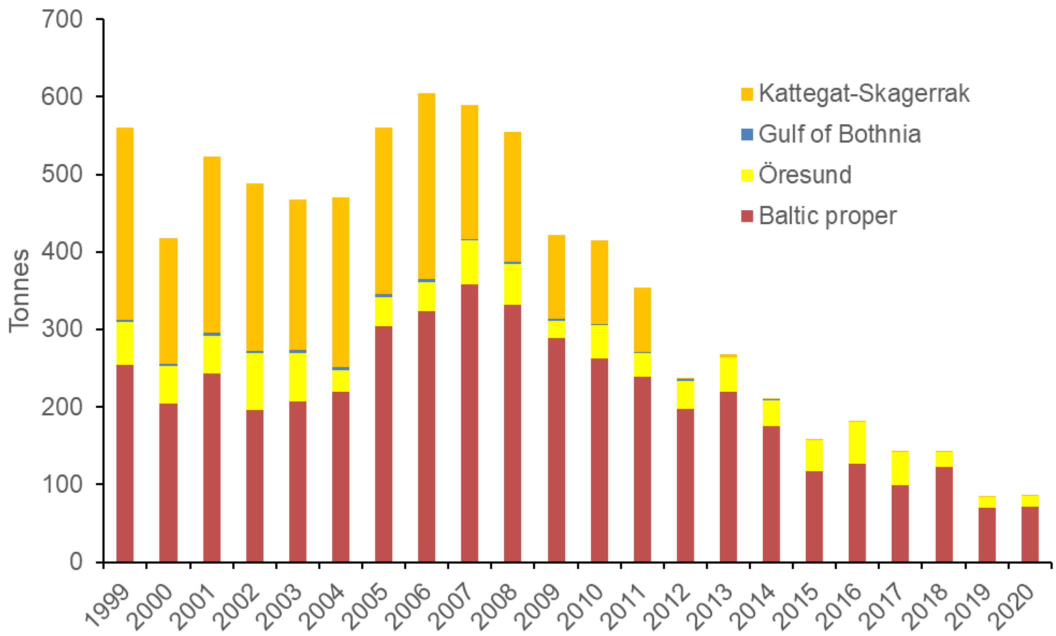

Figure SE. 5: Commercial landings of eel in marine waters (based on logbook data).

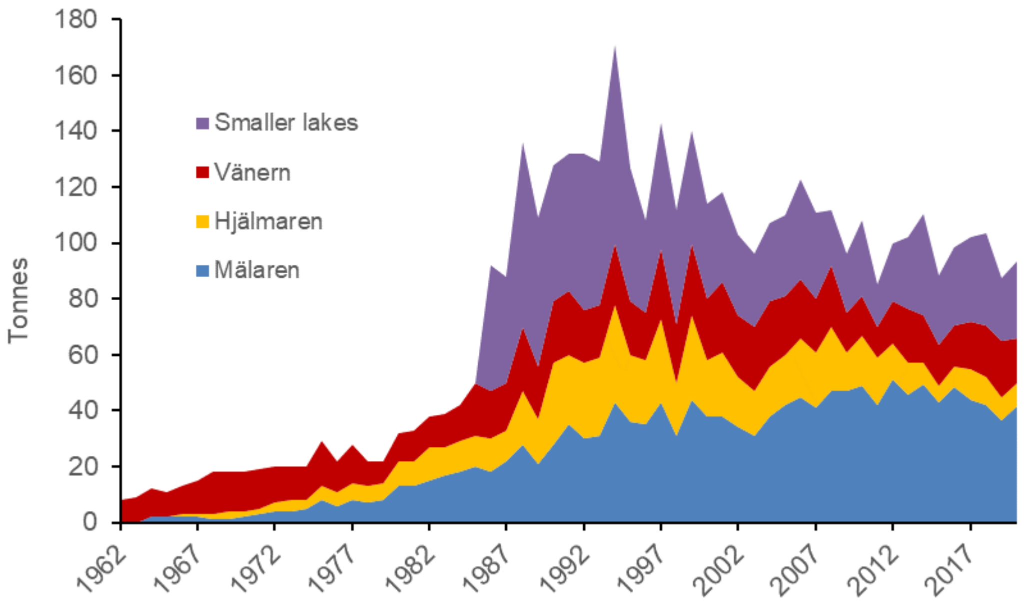

Figure SE. 6: Commercial landings of eel in inland waters. For the smaller lakes, no data prior to 1986 are available.

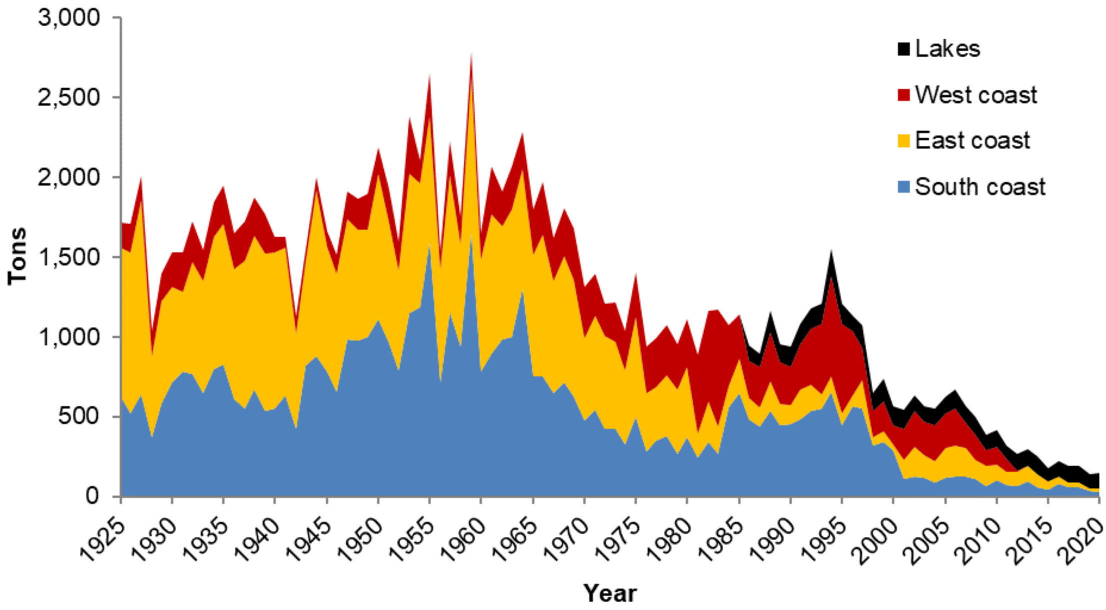

Figure SE. 7: Total commercial landings of eel, for lakes and for the west, east and south coast (the east and south coast together form the east coast EMU). For lakes, no data prior to 1986 are available. The west coast fishing was closed in 2012. Note that this long time-series is based on sales notes reports for which some southern regions have shifted throughout the years as belonging either to the west, south or east coast, see Dekker and Sjöberg (2013) for further information.

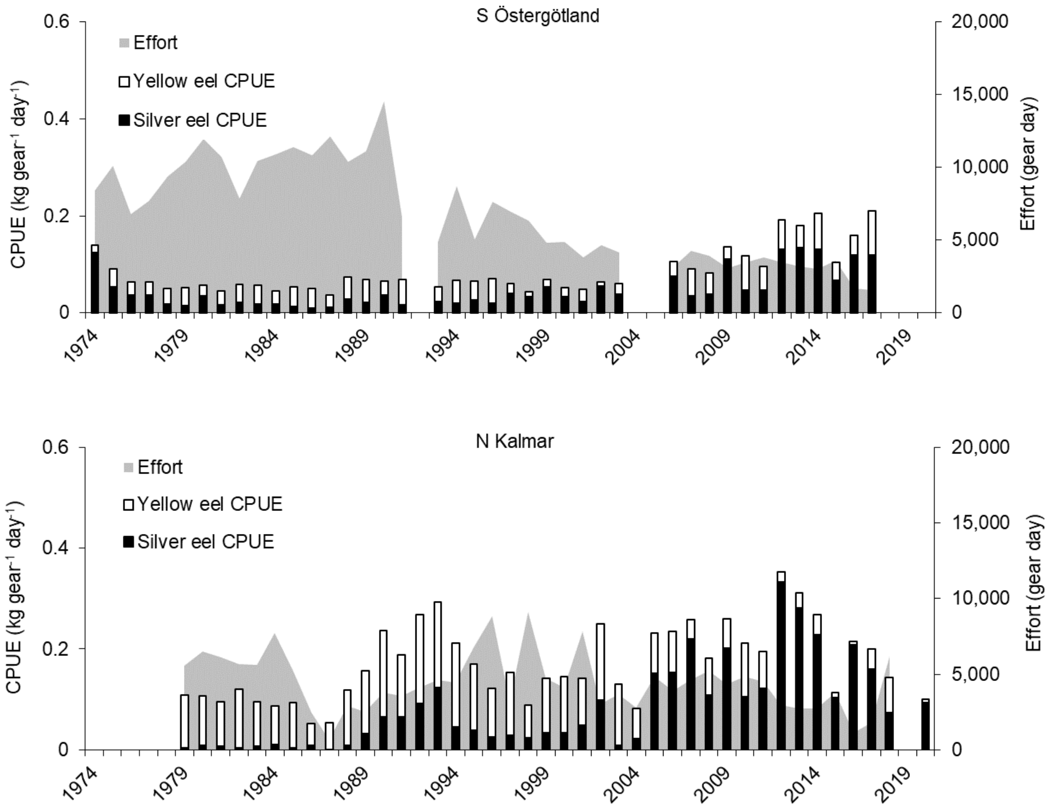

Figure SE. 8: Effort (grey area) and catch-per-unit-effort (yellow eel in white bars, silver eel in black bars) in two fykenet fisheries in the Baltic Sea. S Östergötland (upper panel) contains data until 2017 whereafter that fishery stopped (the fisher retired). Note that both panels start on 1974 to facilitate comparison, but no data prior to 1979 are available for N Kalmar.

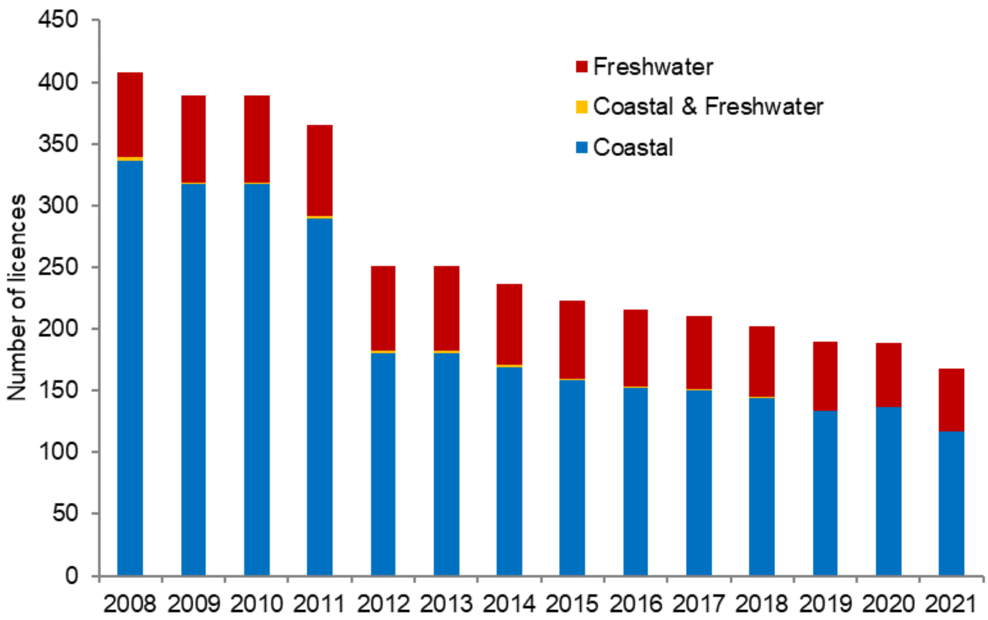

Figure SE. 9: Number of fishers with eel fishing licences, based on data from SwAM.

3.2 Restocking

In 2020, 3 092 704 eels were restocked in Sweden. They were all imported from River Severn in the UK and originate from a single plant. The restocking distribution between freshwater and coastal waters in Sweden for 2020 is shown in Figure SE. 10. 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. For 2020, the mortality during 100 days in a quarantine was 2.6%. Their mean weight is ca. 1 g each or slightly less when stocked. They are not sorted based on size before stocking.

In 2021, due to Brexit, glass eel for restocking could not be imported from the UK. Instead, glass eel was imported from France. As of yet, only preliminary numbers are available on glass eel import for 2021 (~440 000). Definitive numbers will be reported in the 2022 country report.

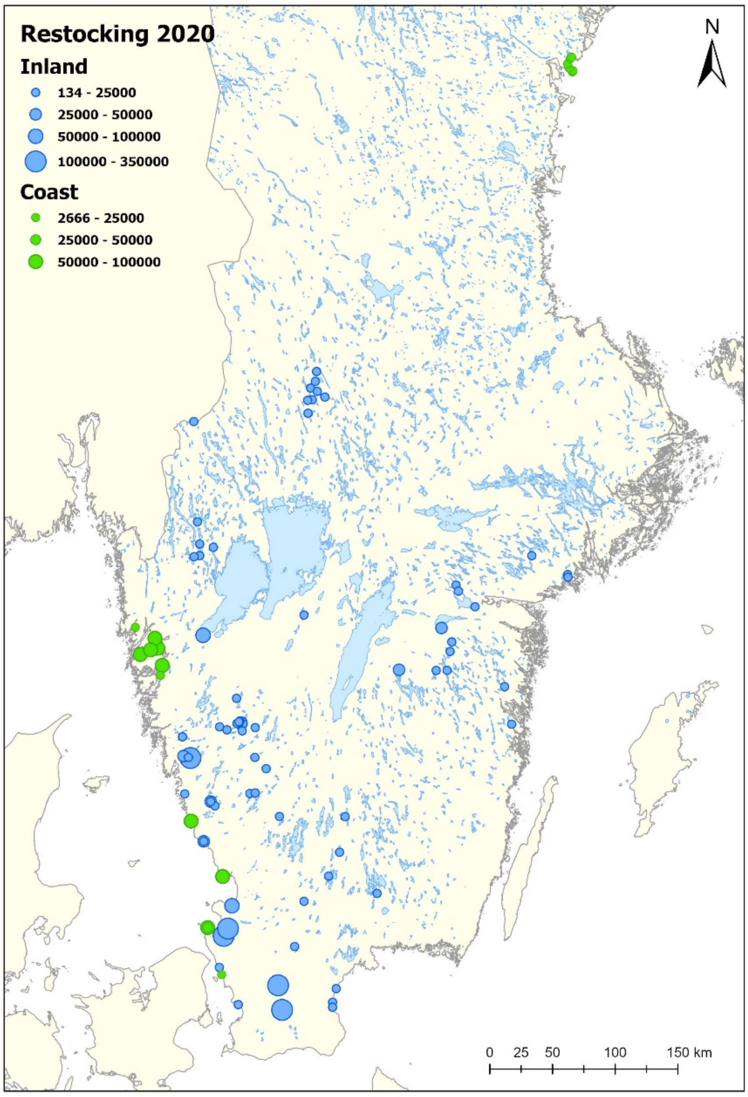

Figure SE. 10: Distribution of restocked eels in 2020.

3.3 Aquaculture

Aquaculture production for consumption purposes was 73 900 kg in 2020 and that emanates from a single plant. In 2020, 1 016 kg, corresponding to 3 119 000 glass eels, were imported from the UK. Most of those eels were used for restocking in Sweden (see 3.2 on restocking), while some were used for restocking in Finland (129 500 eels). The remaining part was 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 93 tonnes in 2020 (Dekker et al., 2021). 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 (Dekker, 2015; Dekker et al., 2018, Dekker et al., 2021). Uncertainty in the average impact per hydropower station hardly affects this, due to the high number of hydropower stations to pass (Dekker et al., 2021).

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 estimated to 13.4%; which is low compared to other juvenile fishes (Bryhn et al., 2014). Larger eels (mainly yellow eels) are also entrained at this nuclear power plant, which has a fish diversion system, and the mortality for larger eels has been estimated to be 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 (Forsmark and Simpevarp) are located on the east coast and they do not entrain or impinge glass eel since glass eels do not occur there. However, yellow and silver eels have about 100% mortality at entrainment as they die in the sieving stations (Bryhn et al., 2013). It has been estimated that 1900 individuals died in 2010 and 1200 died in 2011 at the Forsmark nuclear power plant (Bryhn et al., 2013). At Forsmark, eel abundance peaks in autumn. The power company currently monitors eel occurrence and collects eels in the sieving station during abundance peaks before they otherwise would be trapped and killed. Virtually all of these eels are silvers. Subsequently, the eels are transported alive by SLU and released into the sea at Hargshamn, some 30 km south of Forsmark and its cooling water intake. Thus, the vast majority of eels at Forsmark are saved and released, but a small and unknown number of eels are presumably still entrained and killed there (Per Holliland, SLU, personal communication). 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 hypolimnion 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 (Andersson et al., 2019), although the shoreline in many places has 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, however results are not congruent (Engström, 2001; Lundström et al., 2010; Östman et al., 2012; 2013; Ovegård et al., 2017; Hansson et al., 2018). Ongoing studies suggest that eel is one of the species that risks being underestimated in predator diet analyses, since its otoliths erode fast.

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 Sweden's EU MAP programme. 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 programme.

All sampled yellow and silver eels are analysed with respect to length, weight, stage, prevalence and intensity of *Anguillicola crassus*, and sex (sex is only determined in eels larger than 250 mm). A subset of eels are also aged.

Fat has been 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 mark–recapture programme running since the early 1900s was restarted in 2012, mostly using eels caught by fishers fishing on the coast. More information about this programme 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 Skåne in southern Sweden 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 2020, a PIT-tag antenna has been installed with the purpose of validating the fish counter.

In Lake Bolmen, a small project is running in 2018–2021, aimed 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. Preliminary results indicate that growth is lower-than-average.

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 poundnet fishery. SD 24 no longer has any commercial fishery and SD 23 has not been sampled since 2019 due to financial constraints, and difficulties in finding fishers. 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. The difficulty in finding suitable coastal fishers to collaborate with is due to the declining number of licences. This has prompted us to request further funding to enable fisheries-independent monitoring at ten sites in the Baltic Sea and five sites (i.e. one additional) on the west coast

Fishery-independent sampling of yellow eel and silver eel is also performed, using fykenets, in SD 20 (Fjällbacka and Stenungsund/Hakefjorden in the Skagerrak), SD 21 (Vendelsö in the Kattegat), and SD23 (Öresund/Barsebäck). Yellow eels and silver eels are measured by length, but only yellow eels are weighed and aged (at least 200 individuals per site; a maximum of five from every cm class). Sampling at each site is terminated if/when more than 500 yellow eels have been caught.

In freshwater, commercially fished eels are sampled annually from three lakes. Which three lakes 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 extensive 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., 2021). The assessment is divided over three EMUs: the west coast (SE-West), Baltic (SE-East) and the Inland (SE-Inland).

<u>West coast</u>

The Swedish EMP presented an assessment for the west coast, based on catch curve analysis. By 2012, fishing restrictions had been implemented, including a reduction in effort and a rise in minimum size. After the west coast fishery was closed in spring 2012, Dekker (2012) made a rather simple re-assessment: assuming that the stock remained almost stable, fishing mortality and landings were assumed to have developed proportionally. In 2015, however, three years had passed since the closure of the fishery (recovery), and the last available data were from 2006 (nine years before). In the absence of sufficient new data, no new assessment was made, and no new indicators were given. This situation has not changed, and no new assessments are currently being produced for the west coast. Existing monitoring efforts (sampling six sites along a 320 km coastline) are insufficient to assess the stock in absolute terms (Bcurrent, Bbest and B0), but allow yellow eel abundance trend-monitoring (relative changes in abundance over time). Additionally, recent analysis of historical information (Magnusson and Dekker, 2021) indicates that the west coast fishery was a demand-driven fishery, gradually increasing its efforts over the decades. This finding confirms one of the alternative options, presented in Dekker (2012), in which it was assumed that the stock declined proportionally to recruitment, while fishing impact kept increasing. Based on that assumption, B0 has been estimated at 1154 ton.

Baltic coast

The Baltic coast (SE-East) stock is a mix of local production and (mostly) immigrants from elsewhere in the Baltic, and is a mix of restocked and naturally-recruited eels. The impact of the Swedish silver eel fishery has been assessed on the basis of historical mark–recapture experiments (method described in Dekker and Sjöberg, 2013), which have been re-continued since 2012. No lifetime mortality indicators can be estimated, due to insufficient information on silver eel origin. This will require a pan-Baltic assessment, as proposed in Dekker (2013).

Inland

The Inland assessment starts by estimating absolute recruitment to inland waters, by extrapolating recruitment from sample rivers to all Swedish rivers, using a statistical model. Spatial data on restocking and assisted migration is then used to give an overview of spatial yellow eel abundance in inland waters. Empirical observations on growth and silvering age, and an estimate of natural mortality, lead to an extrapolation of the spatial production of silver eel. Silver eel are removed by commercial fishing (spatial landings information available), or by a Trap & Transport programme which moves silver eel to below the most downstream hydropower station (spatial data available). Then, for each river/lake, starting at the most upstream part, impact of hydropower is assessed by taking estimated abundance of silver eel upstream of a hydropower station (a complete overview of hydropower stations in Swedish rivers is available), and estimating hydropower mortality from (in order of priority) local experiments, a simulated value reported in Calles and Christianson (2012), or a default impact of 70% per station. Survivors move downstream, and the process is repeated for each hydropower station located downstream. The silver eel that remain after commercial fishing and hydropower mortality (plus those moved through the Trap & Transport programme) constitute the estimated escapement of the inland EMU.

Only limited ground-truth information exists, to verify the Inland result (electrofishing in rivers, while most restocking was done in lakes), but that ground-truth has not been applied yet. Surprisingly, actually observed landings derived from past restocking indicate that natural mortality M must have been extremely low (5–10%), much below conventional estimates (15–20%). In the absence of independent verification, the current estimate for natural mortality M is 0.10 yr^{-1}.

4.1.3 Reporting

Selected results from Swedish eel studies are reported to the EU as requested in 2012, 2015, 2018, and 2021. 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., 2021). Relevant data are 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

The assessments reported in Dekker (2015) make use of extensive 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. The 2018 and 2021 assessments were essentially a repetition of the 2015 assessment with a few more years of data and updated parameters (Dekker et al., 2018; Dekker et al., 2021).

For the west coast, no new assessments have been produced after 2009, as after the close of the fishery no data has been available for this. Instead, historical data have been compiled, (re)-checked and analysed (Magnusson and Dekker, 2021), and fisheries-independent fyke net surveys have provided an index for the continued development of the west coast stock.

For the Baltic coastal fishery, Swedish mortality rates are reported 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 (Dekker et al., 2021). 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. Thus, in order to cross-check the Swedish escapement biomass estimates and to be able to estimate lifetime anthropogenic mortalities, a joint assessment of the whole Baltic stock is required (which in itself will be required to develop joint management of this shared stock), as was for instance proposed by Dekker (2013).

For the inland waters, yellow and silver eel abundance are predicted from the available information on recruits (natural, translocated, restocked) forward in time, towards the yellow and silver eel stage (Dekker et al, 2021). No independent verification on yellow or silver eel data is made. However, information on yellow eel abundance, derived from electro-fishing surveys, could be used to ground-truth the inland assessment, and there are plans to develop this in the future. 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.

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 and 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, poundnets and trammelnets have been discovered along the coast during the last few years (see Section 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.

As previously mentioned, the very long river recruitment series from Trollhättan in Göta Älv (ongoing since 1900) was broken in 2018. This (hopefully) temporary break was due to lack of personnel and unfortunately, this trap is still not operating during 2021.

4.2 Trends in Assessment results

All estimated stock indicators for the three EMUs (West coast, Baltic coast, Inland) over the years 2000-2020 are given in Table SE. 3.

For the west coast, no biomass indicators are estimated due to a lack of data, but survey-trends (CPUE) are presented (Figure SE. 11). For eels smaller than 37 cm, the CPUE time-series shows an initial decreasing trend to an overall minimum around the year 2009, after which CPUE appears to show a slightly increasing trend again. This appears to be in line with overall glass eel recruitment trends. For eels sized 37-49 cm, the CPUE trend over time is less clear. For eels sized 50-59 cm and over 60 cm, CPUE was stable until 2010, after which a clear increasing trend in CPUE can be observed, implying an increasing trend in abundance. This appears to be in line with the definitive closure of the west coast eel fishery in 2012. Given that the west coast fishery was closed in 2012 and that it is assumed that there are no other anthropogenic mortalities, it can be assumed that biomass is approaching Bbest.

For the Baltic coast, the assessment showed that the impact of the Swedish eel fishery has been declining since the 1980s, and continues to decline in recent years (Figure SE. 12). Currently, the impact of the Swedish silver eel fishery along the Baltic coast is relatively small, with an estimated fishing mortality of 0.003 yr^{-1} for the years 2018-2020. However, decreases in landings and tag recapture rates make these fishing mortality estimates increasingly uncertain. Bcurrent is estimated to have remained stable over recent years (Table SE. 3).

For the inland stock, silver eel increasingly originate from restocking, with naturally-recruited and assisted migration eel currently making up only a small percentage of the inland production of silver eel (Figure SE. 13). Estimated stock biomass Bcurrent is showing a consistent decline over time (Table SE. 3). Lifetime fishing mortality sumF has shown an increasing trend in recent years, while lifetime hydropower mortality sumH has shown a stable trend in recent years, with sumH exceeding sumF with almost a factor of two in 2020 (Table SE. 3). Figure SE. 14 shows a time trend of the fate of inland silver eel, visualizing the impact of both inland fisheries and hydropower on inland eel survival. Lifetime anthropogenic mortality sumA has shown an increasing trend in recent years (Table SE. 3), and exceeds the minimum limit that would allow recovery.

Table SE. 3: Stock indicators by area and year. For inland waters, biomass indicators are given with (+) and without (-) the contribution from restocked eels. All mortality estimates refer to true mortality (both on natural and restocked eels), not interpreting restocking as a compensation for other mortalities. For all coastal waters, ΣH=0, hence ΣF=ΣA. For Trap & Transport, the biomass released is specified, for the West coast and the Baltic separately. All biomass indicators expressed in tonnes, mortality indicators as rate per lifetime.

	West coast				Inland waters									Baltic coast				T&T		
					With restocking +			Without restocking -			Mortality rates							W	B	
year	$B_{current}$	B_{best}	B_0	∑A	$B_{current}^+$	B_{best}^+	B_0^+	$B_{current}^-$	B_{best}^-	B_0^-	∑F	∑H	∑A	$B_{current}$	B_{best}	B_0	∑A	$B_{current}$		year
2000				1.79	162	489	567	73	222	300	0.27	0.84	1.11	3507						2000
2001				2.53	184	485	581	77	204	300	0.28	0.69	0.97	3473						2001
2002				2.41	211	477	589	83	188	300	0.24	0.57	0.81	3497						2002
2003				2.15	233	468	594	87	175	300	0.23	0.47	0.70	3495						2003
2004				2.43	240	460	596	85	163	300	0.28	0.37	0.65	3516						2004
2005				2.39	240	443	594	81	149	300	0.30	0.31	0.61	3424						2005
2006				2.66	236	437	600	74	138	300	0.34	0.27	0.62	3404						2006
2007				1.91	239	443	617	68	126	300	0.30	0.32	0.62	3352						2007
2008				1.86	226	459	644	57	115	300	0.30	0.41	0.71	3381						2008
2009				1.19	222	475	669	49	106	300	0.23	0.53	0.76	3460						2009
2010				1.20	213	487	689	43	98	300	0.25	0.59	0.84	3463				5		2010
2011	12115411540.93				212	493	702	39	91	300	0.21	0.65	0.86	3499				5	3	2011
2012				0	192	487	704	33	83	300	0.23	0.73	0.95	3531				9	2	2012
2013				0	181	464	689	30	76	300	0.24	0.73	0.97	3500				10	4	2013
2014				0	168	435	666	26	69	300	0.28	0.72	1.00	3558				15	7	2014
2015				0	158	402	639	25	63	300	0.24	0.75	0.98	3613				13	6	2015
2016				0	130	358	601	21	57	300	0.30	0.76	1.07	3590				13	6	2016
2017				0	114	317	564	19	53	300	0.36	0.72	1.08	3628				13	6	2017
2018				0	97	282	532	17	50	300	0.43	0.69	1.12	3624				11	6	2018
2019				0	84	252	505	16	47	300	0.40	0.75	1.16	3671				11	5	2019
2020				0	72	243	498	13	45	300	0.45	0.83	1.28	3670				11	8	2020

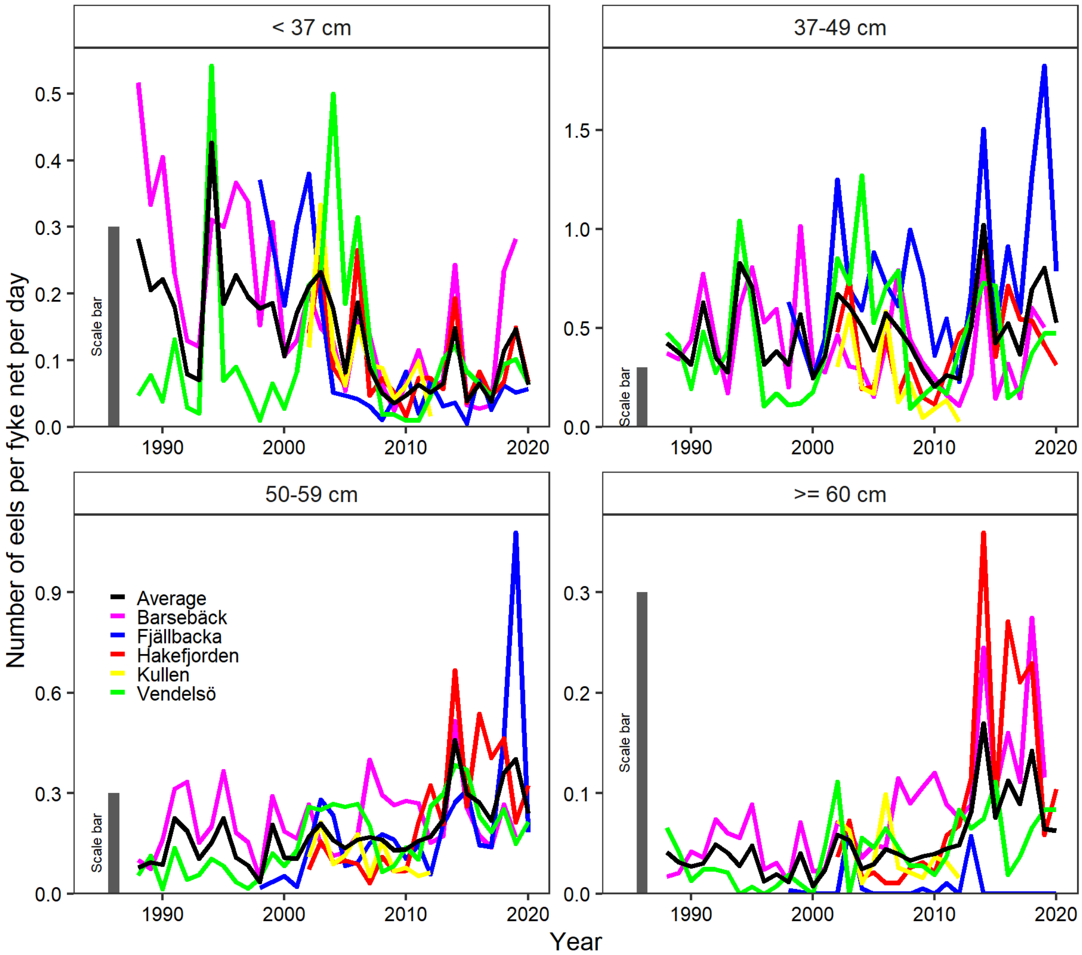

Figure SE. 11: Catch-per-unit-effort of yellow eel by size-class (total length) from fisheries-independent fyke net surveys at various areas along the Swedish west coast, including their average. Note that the range of the y-axis differs between subfigures, as is also indicated by the scale bar.

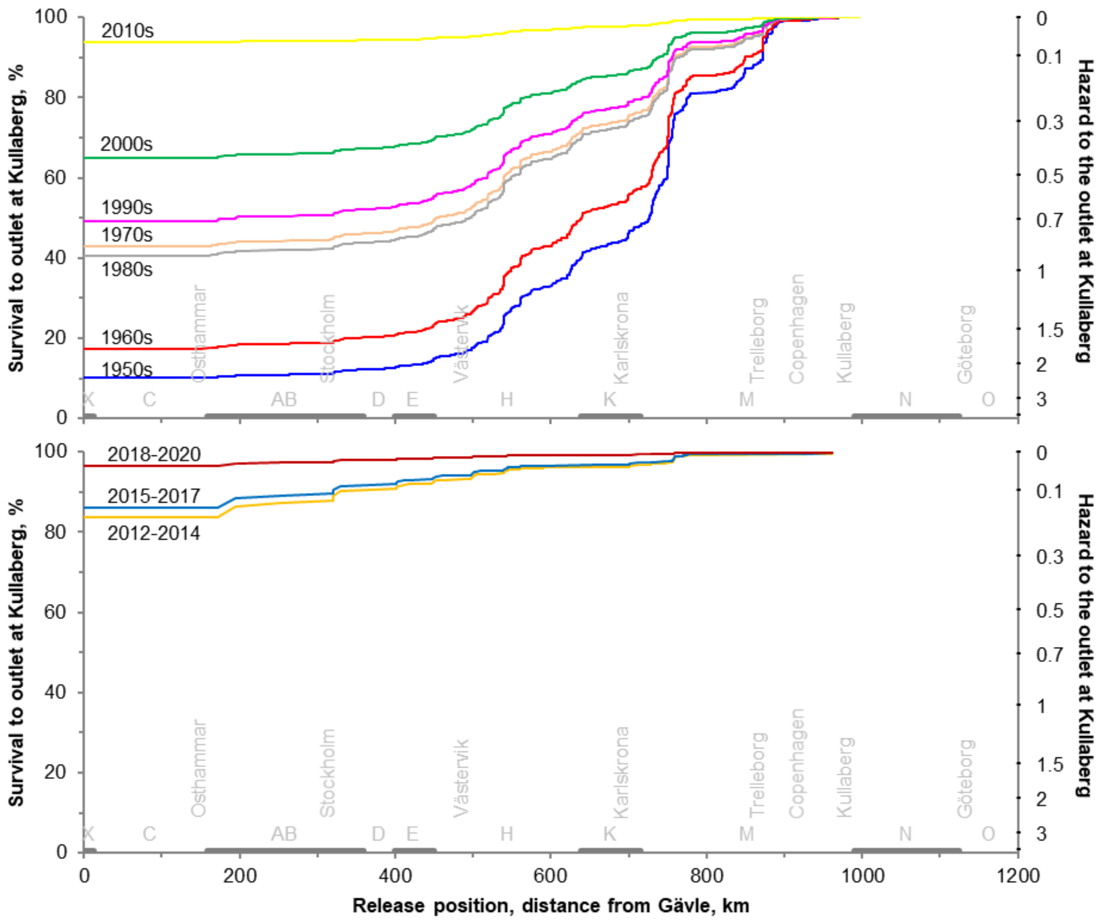

Figure SE. 12: Estimated survival and hazard over distance along the Swedish coast. Top: survival and hazard estimated per decade. Bottom: survival and hazard estimated for the three most recent sets of three consecutive years. The left y-axis shows the estimated net survival from a given position along the Swedish coast up to the outlet of the Baltic Sea at Kullaberg, the right y-axis shows the associated accumulated hazard over that interval.

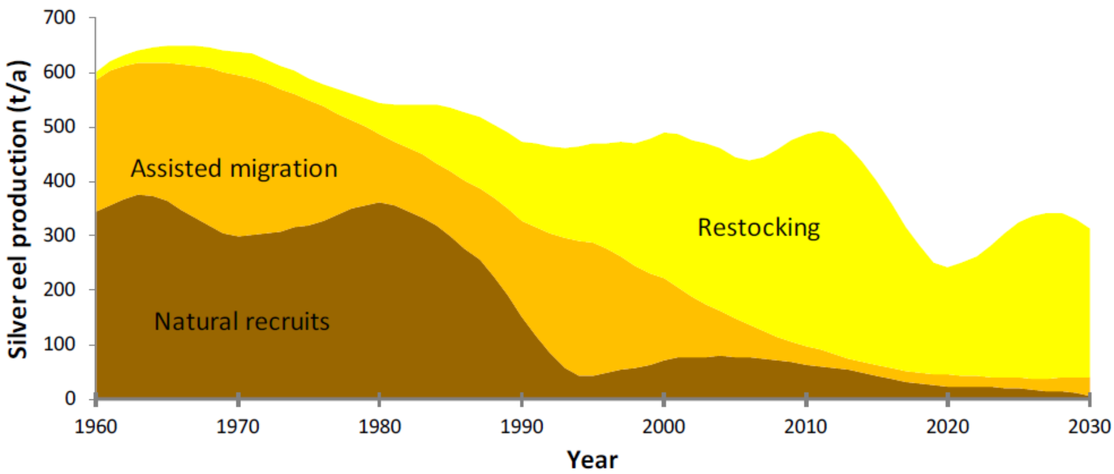

Figure SE. 13: Production of silver eel by year and by origin of the eel, that is: the estimated total production before the impact of fishery and hydropower. For these results, a natural mortality rate of M=0.10 was assumed. Results are extrapolated forward in time for 2021-2030, assuming a status quo equal to the most recent assessment year (i.e., recruitment, assisted migration, and restocking remain equal to their 2020 value).

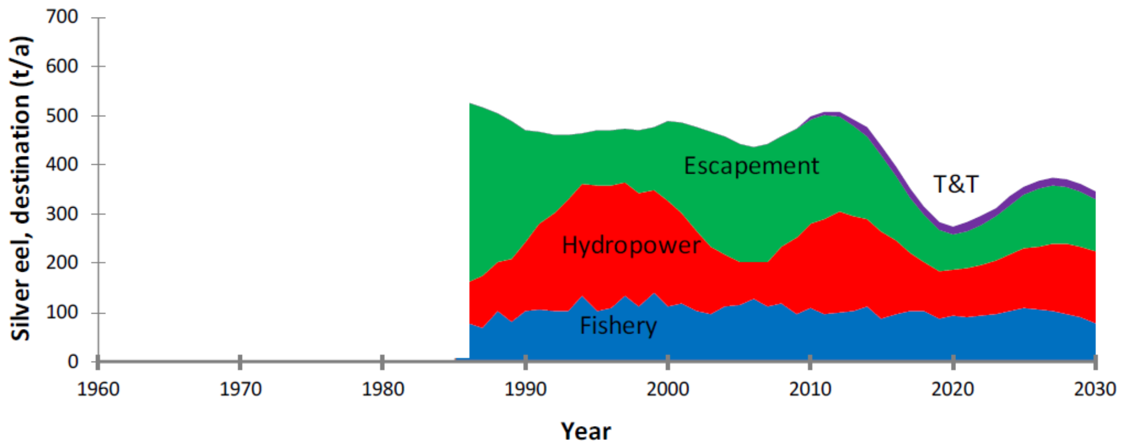

Figure SE. 14: Time-trends in the destination of the silver eel produced in inland waters. Data before 1986 are incomplete and therefore not shown. Results are extrapolated forward in time for 2021-2030, assuming a status quo equal to the most recent assessment year (i.e., recruitment, assisted migration, restocking, fisheries mortality, and hydropower mortality remain equal to their 2020 value).

5 Other data collection for eel

5.1 Yellow eel abundance surveys

In addition to the yellow eel abundance surveys along the west coast presented in Section 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 in nets has been about 60% from 2005 to 2017 (Figure SE. 15). As more and more eels now become silvers and leave this open system, the CPUE and the proportion of marked eels is declining since 2017. Since the year 2021, 14.8% 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. Some of them are now among the smallest eels caught.

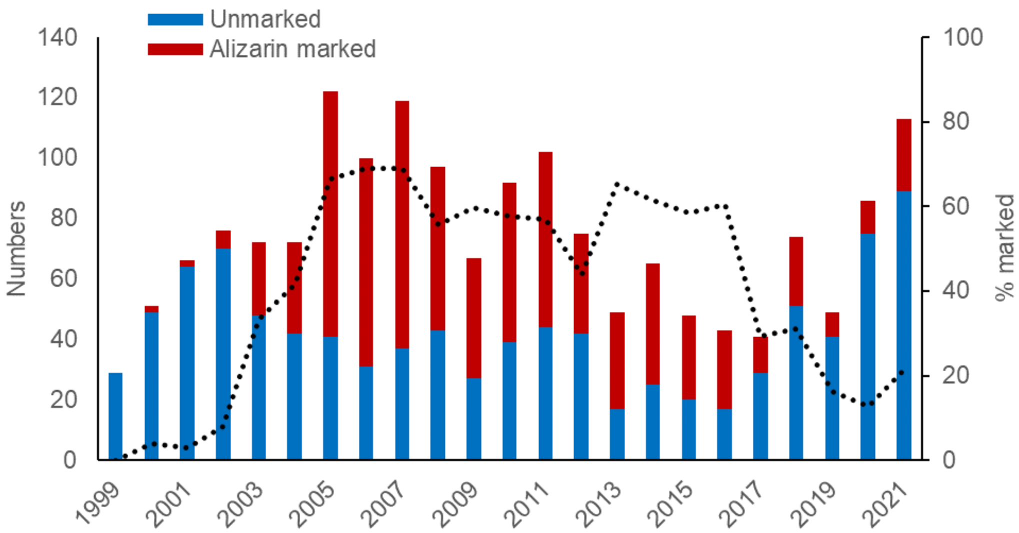

Figure SE. 15: Number of unmarked and alizarin marked eels (bars) as well as the percent marked eels (dotted line) in a survey of a stocked population in Lake Mälaren from 1999 to 2021.

5.2 Silver eel escapement surveys

Please also see Section 4.1.

5.2.1 Eel tagging programme in the Baltic Sea

In the Baltic region, tagging experiments started in 1903 with the objective 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 fishers were unaware of the ongoing experiments (hence, recaptures might have occurred, but they were not reported). As the Swedish eel landings from the Baltic Sea started to increase, so did the recapture rates (Figure SE. 16). However, when the catches started to decrease in the 1960s, the recapture rates did not change much initially. Only when the intensity of the fishery started to decrease in the early 1970s, as shown in Andersson et al. (2012), did recapture rates decrease somewhat (Figure SE. 16). Regular tagging programmes were run until 1995, and were then re-started in 2012, continuing with the same method as before. Recapture rates after 2012 have been much smaller than before.

Since 2012, approximately 70% of the recaptures were made in the Swedish fishery at the east and south coast, while around 30% were recaptured in Denmark (Figure SE. 17, Table SE. 4). A few individuals were recaptured in Germany and Poland (Table SE. 4). The tagging programme has become an important part within the EU´s data collection programme (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 et al., 2021). The 3-month fishing closure in Denmark and Sweden, enforced since 2018, will presumably affect recapture numbers from the outlet straits in Öresund and the Danish Belts.

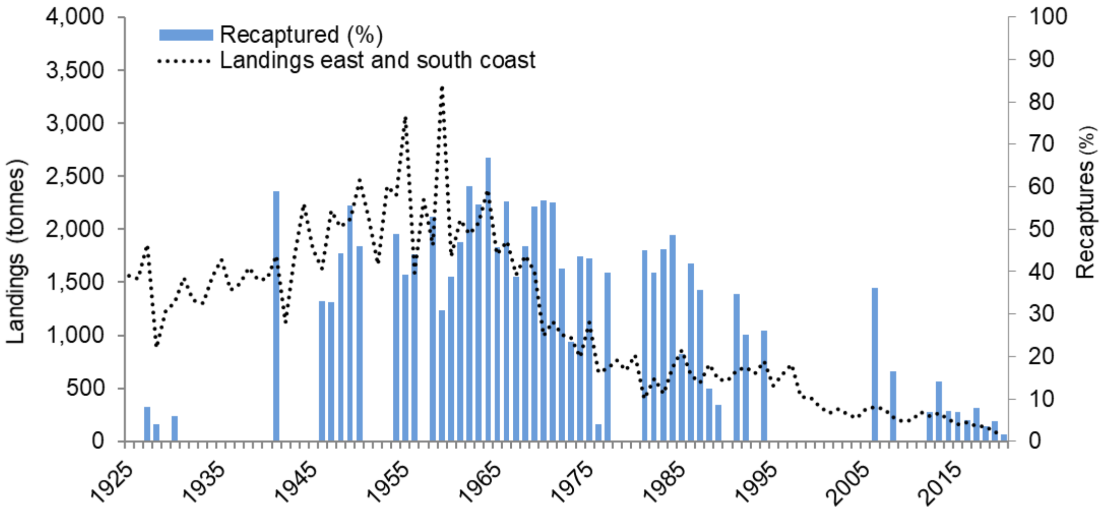

Figure SE. 16: Recaptures (percentage) over time of tagged eels made in Sweden, Denmark, Germany, and Poland (blue bars), shown against landings over time from the Swedish fishery on the east and south coast (dotted line). Shown for coastal tagging experiments using Carlin tags without experimental manipulation.

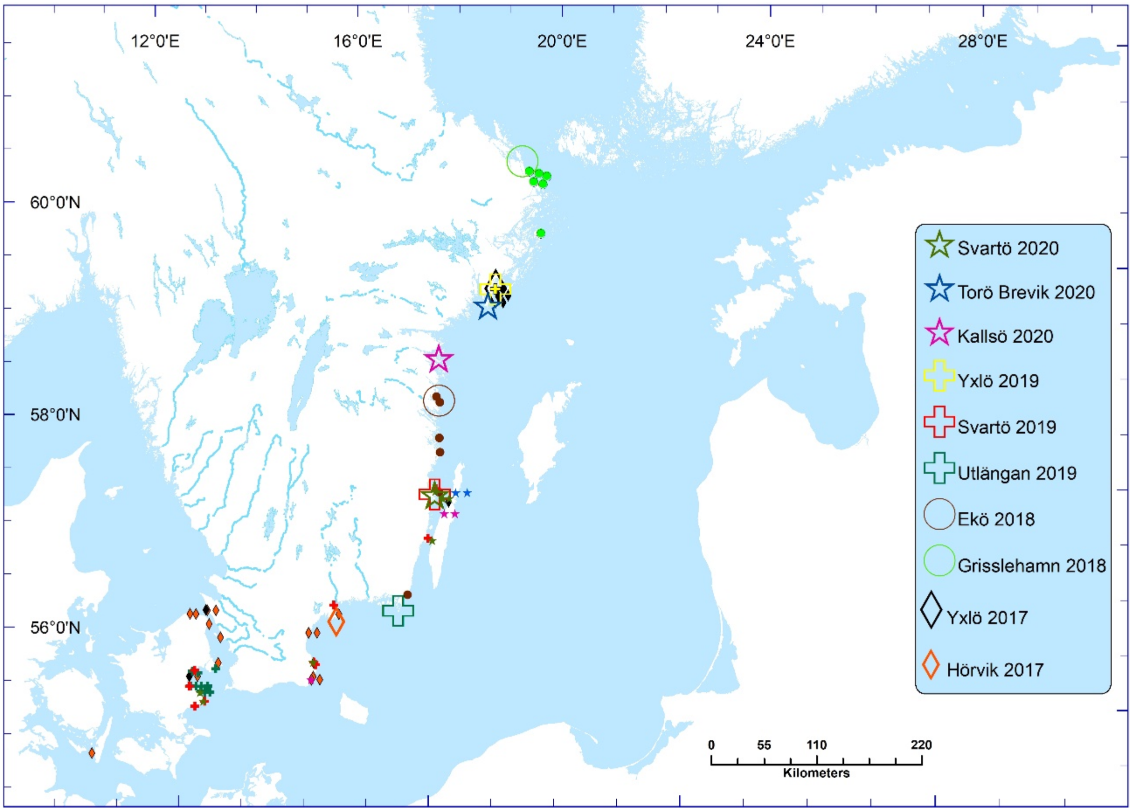

Figure SE. 17: Recaptures of tagged eels within the EU MAP program along the Swedish east coast for the years 2017–2020. For exact recapture numbers see Table SE. 4. Shown for coastal tagging experiments using Carlin tags without experimental manipulation.

Table SE. 4: Coastal tagging experiments within the EU MAP program between 2012 and 2020, using Carlin tags without experimental manipulation. Total number of tagged and released eels, proportion and number of recaptures, and the distribution of recaptured eels in Sweden (SE), Denmark (DK), and Poland (PL).

Year of release	Release location	Tagged (N)	Recaptures (%)	Total recaptures (N)	SE	DK	DE	PL
2012	Bylehamn	150	2.7	4	2	2	0	0
2012	Vinö	120	9.2	11	9	2	0	0
2012	Sandhamn	150	9.3	14	8	4	1	1
2013	Rumpeboden	150	14.0	21	17	4	0	0
2014	Yxlö	150	6.0	9	9	0	0	0
2014	Birkö	301	8.0	24	20	4	0	0
2014	Svartö	150	6.7	10	6	4	0	0
2015	Torö	151	4.6	7	6	1	0	0
2015	Borrbystrand	140	9.3	13	5	8	0	0
2016	Byxelkrok	147	3.4	5	3	2	0	0
2016	Böda	151	6.6	10	4	6	0	0
2017	Yxlö	200	5.0	10	9	1	0	0
2017	Hörvik	200	10.5	21	13	8	0	0
2018	Grisslehamn	191	3.1	6	6	0	0	0
2018	Ekö	140	4.3	6	6	0	0	0
2019	Yxlö	152	0.5	1	1	0	0	0
2019	Svartö	200	5.5	11	5	6	0	0
2019	Utlängan	123	3.3	10	1	9	0	0
2020	Torö Brevik	284	0.7	2	2	0	0	0
2020	Kallsö	199	2.0	4	4	0	0	0
2020	Svartö	295	2.4	7	5	2	0	0
Total		**3744**		**206**	**141**	**63**	**1**	**1**

5.3 Life-history parameters

As part of our EU MAP data collection programme, eels from a number of commercially fished lakes have been sampled since 2010 (Table SE. 5). 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 1300 eels from coastal areas are analysed annually by SLU Aqua.

Table SE. 5: 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 (yr)	Growth rate (mm yr^{-1})	Aged (N)	Aged (%)
Bolmen							
2017	126	706.1	669.4	21.7	30.22	126	100
2018	128	708.5	707.9	20.8	31.06	125	98
2019	123	714.0	689.4	19.9	32.66	122	99
2020	130	728.2	744.2	20.8	31.87	128	98
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	99
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
2019	105	754.8	892.0	18.4	37.7	105	100
2020	150	755.8	851.4	20.6	33.7	148	99
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
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	19.4	38.8	129	99
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
Ymsen							
2019	129	899.4	1473.6	17.2	48.8	122	95
2020	132	918.2	1571.0	17.4	49.5	132	100

5.4 Diseases, Parasites & Pathogens or Contaminants

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 is reported. 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 the Baltic proper and in Swedish lakes (Figure SE. 18Figure SE. 21). In 2020, 663 eels caught in freshwater were analysed and 66% were infested. From test fishing in coastal waters in 2020, 844 yellow eels were analysed and 25% were infested. Moreover, in coastal waters 212 silver eels were analysed in 2020, and 48% of the silver eels were infested.

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. and Hällbom H., SVA, pers. comm.). SVA is also assigned to monitor diseases in wild eels by the Swedish Agency for Marine and Water Management.

Parasites and other 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. In case of a suspected bacterial disease, samples are taken from the kidney as well as organs with pathological changes (e.g. wounds).

Samples are cultured on agar, and bacteria are typed by MALDI-TOF or biochemical methods. If findings indicate viral disease, samples are taken for cell cultures (general cells sensitive for IPN, EVEX and VHS) and molecular analysis. In case of virus growth on cell culture, the virus is further typed by immunological and molecular methods. Wild eels are also routinely controlled for Anguillid herpesvirus by molecular methods.

It was reported (during the summer of 2020) that some eels in River Ätran had the parasite that caused “white spot disease”.

Eel herpes (Anguillid herpesvirus 1, AngHV-1) was commonly found in yellow eels along the west coast in 2020, as well as in some lakes a few years earlier (2018 in lake Bolmen and lake Hjälmaren).

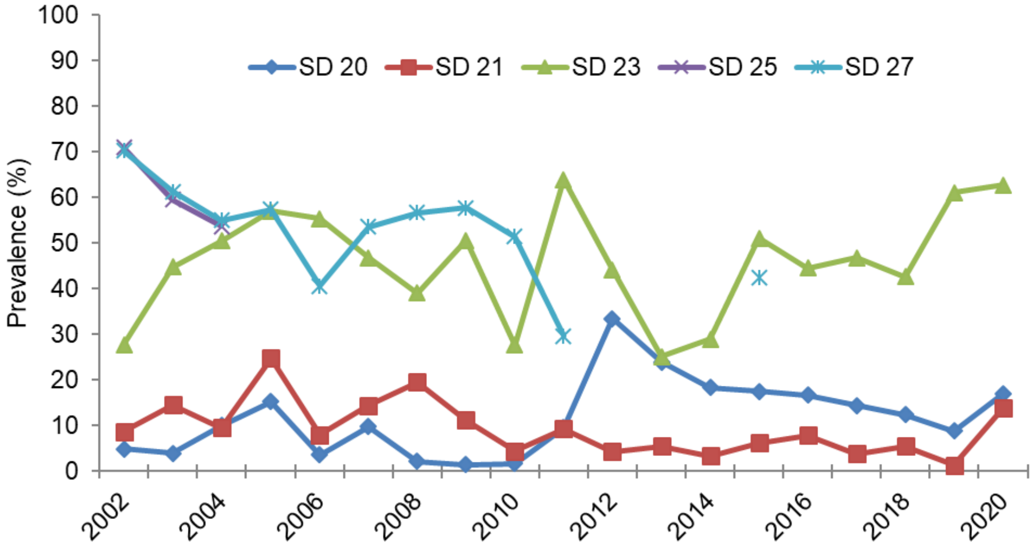

Figure SE. 18: Prevalence (%) of the parasite *Anguillicola crassus* in yellow eel along the Swedish coast. SD refers to ICES subdivisions.

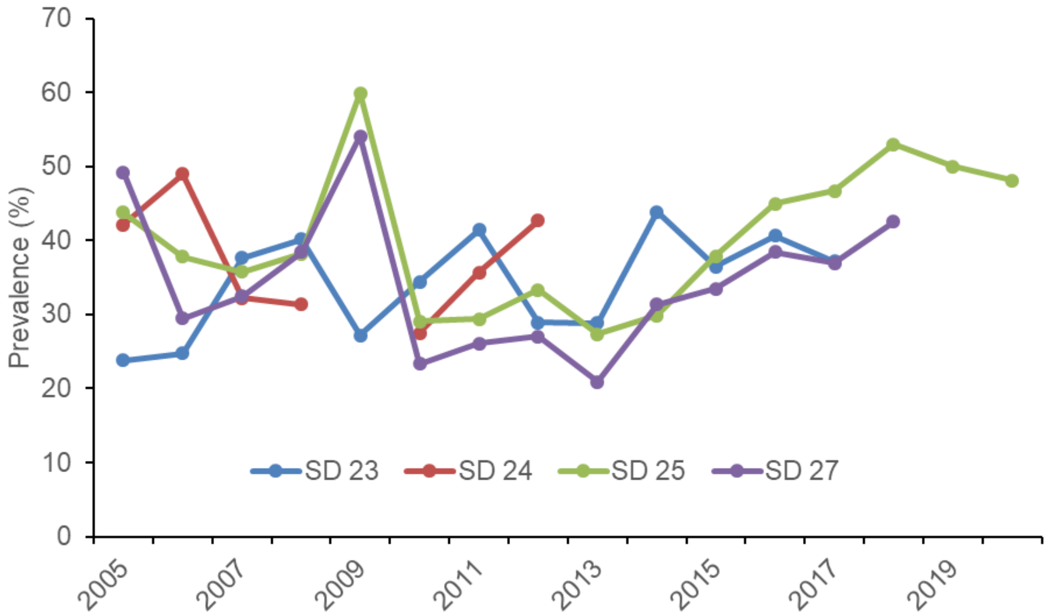

Figure SE. 19: Prevalence (%) of the parasite *Anguillicola crassus* in silver eel along the Swedish coast. SD refers to ICES subdivisions.

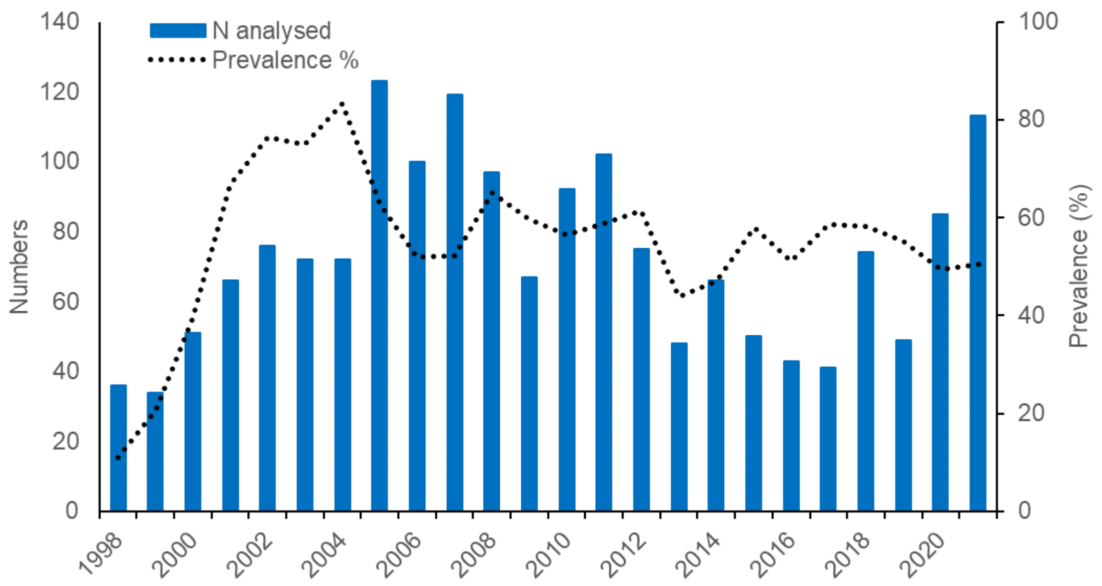

Figure SE. 20: Prevalence (%) and number of eels analysed for *Anguillicola crassus* at one site in Lake Mälaren 1998–2021.

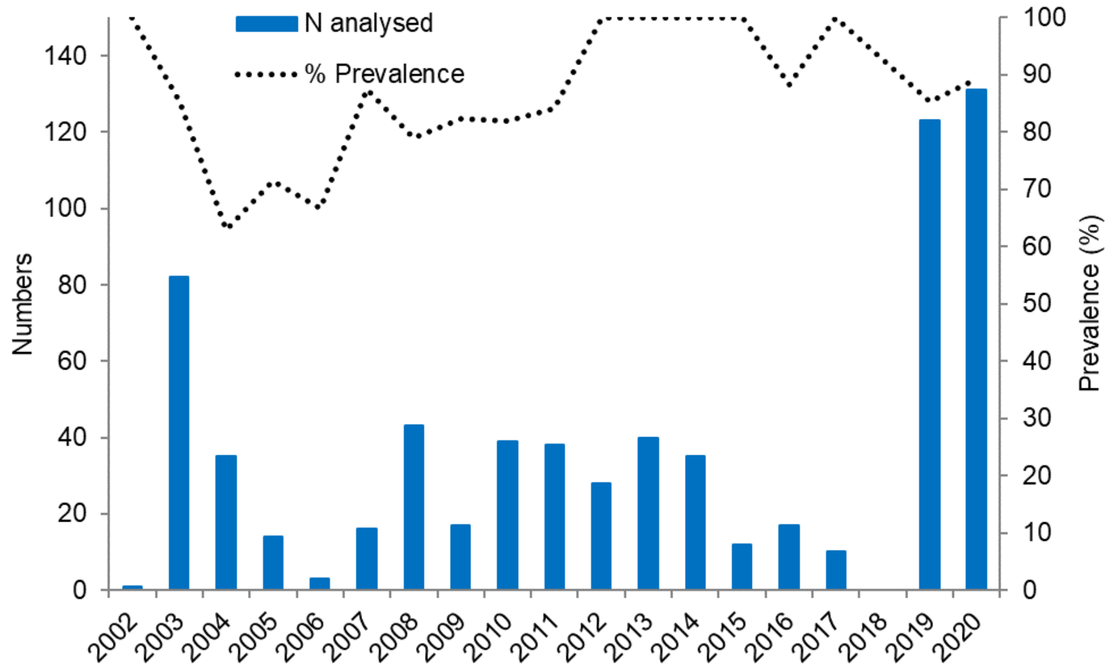

Figure SE. 21: Prevalence (%) and number of eels analysed for *Anguillicola crassus* in Lake Ymsen 2002–2020.

5.4.2 Contaminants

No new data since the 2018 Country Report.

6 New Information

In late 2019, Sweden joined a collaboration initiated by the Technical University of Denmark (DTU-Aqua) with the aim to start up an international (pan Baltic) fishery-independent data collection and assessment of the silver eel fishery using acoustic telemetry. Today, Sweden has three areas prepared with hydrophones to collect signals from migrating eels and DTU-Aqua has another three in the outlet straits of the Baltic Sea. During the autumn of 2020, 188 eels were tagged with acoustic transmitters, and during the autumn of 2021, 230 eels will be tagged. Several of the eels tagged in 2020 have been detected by the receivers in the outlet straits of the Baltic Sea. In addition to fishing pressure, the study also includes investigations related to stocking and Trap and Transport.

Previously, glass eel for restocking have generally been sourced from the UK. However, due to Brexit, glass eel for restocking have been sourced from France in 2021 instead. As a result, the number of imported glass eel were much lower in 2021 (~440 000) then in earlier years (2-3 million). If imported glass eel numbers remain this low in the future, this could have serious implications for inland silver eel production, as currently most inland silver eel originate from restocking (Figure SE. 13).

7 References

Andersson J., Florin A. B., Petersson E. 2012. Escapement of eel (*Anguilla anguilla*) in coastal areas in Sweden over a 50-year period. *ICES Journal of Marine Science*, 69, 991–999.

Andersson, J., Wickström, H., Bryhn, A., Magnusson. K., Odelström, A., Dekker, W. 2019. Assessing the dynamics of the European eel stock along the Swedish west coast. Aqua Reports 2019:17. Swedish University of Agricultural Sciences, Öregrund.

Baden, S., Gullström, M., Lundén, B., Pihl, L., Rosenberg, R. 2003. Vanishing seagrass (*Zostera marina*, L.) in Swedish coastal waters. *AMBIO: a Journal of the Human Environment*. 32, 374–378.

Bryhn, A. C., Andersson, J., Petersson, E. 2014. Mortality of European glass eel (*Anguilla anguilla* juveniles) at a nuclear power plant. *International Review of Hydrobiology*. 99, 312–316.

Bryhn, A. C., Bergenius, M. A. J., Dimberg, P. H. and Adill, A. 2013. Biomass and number of fish impinged at a nuclear power plant by the Baltic Sea. *Environmental Monitoring and Assessment*. 185, 10073–10084.

Calles, O., and Christianson, J. 2012. Ålens möjlighet till passage av kraftverk - En kunskapssammanställning för vattendrag prioriterade i den svenska ålförvaltningsplanen samt exempel från litteraturen [The eel's opportunity to pass hydropower stations]. Elforsk rapport 12:37, 77 pp. Report published by Elforsk AB, at https://energiforsk.se/program/krafttagal/rapporter/%C3%A5lens-mojlighet-till-passage-av-kraftverk

Dekker W. 2012. Assessment of the eel stock in Sweden, spring 2012; first post-evaluation of the Swedish Eel Management Plan. Aqua reports 2012:9. Swedish University of Agricultural Sciences, Drottningholm. 77 pp.

Dekker W. 2013. Baltic Eel: towards a comprehensive assessment in support of joint management of this shared stock. Proposal 2012-30 to Bonus call: Viable ecosystems. 24 pp.

Dekker W. 2015. Assessment of the eel stock in Sweden, spring 2015; second post-evaluation of the Swedish Eel Management Plan. Aqua reports 2015:11. Swedish University of Agricultural Sciences, Drottningholm. 93 pp.

Dekker W. and Sjöberg N. B. 2013. Assessment of the fishing impact on the silver eel stock in the Baltic using survival analysis. *Canadian Journal of Fisheries and Aquatic Sciences*. 70, 1673–1684.

Dekker, W., Bryhn, A., Magnusson, K., Sjöberg, N., Wickström, H. 2018. Assessment of the eel stock in Sweden, spring 2018. Third post-evaluation of the Swedish Eel Management Plan. Aqua reports 2018:16. Swedish University of Agricultural Sciences, Drottningholm. 113 pp.

Dekker, W., van Gemert, R., Bryhn, A., Sjöberg, N., & Wickström, H. 2021. Assessment of the eel stock in Sweden, spring 2021. Fourth post-evaluation of the Swedish eel management. Aqua reports 2021:12. Swedish University of Agricultural Sciences, Drottningholm. 104 pp.

Engström, H. 2001. Long term effects of cormorant predation on fish communities and fishery in a freshwater lake. *Ecography*. 24, 127–138.

Hansson, S., Bergström, U., Bonsdorff, E., Härkönen, T., Jepsen, N., Kautsky, L., Lundström, K., Lunneryd, S.G., Ovegård, M., Salmi, J., Sendek, D., Vetemaa, M. 2018. Competition for the fish – fish extraction from the Baltic Sea by humans, aquatic mammals, and birds. *ICES Journal of Marine Science*. 75(3), 999-1008.

Lundström, K., Hjerne, O., Lunneryd, S. G., Karlsson, O. 2010. Understanding the diet composition of marine mammals: grey seals (*Halichoerus grypus*) in the Baltic Sea. *ICES Journal of Marine Science*. 67, 1230–1239.

MacNamara, R., McCarthy, T. K., Wickström, H., Clevestam, P. D. 2016. Fecundity of silver-phase eels (*Anguilla anguilla*) from different habitat types and geographic locations. *ICES Journal of Marine Science*. 73, 135–141.

Magnusson, A. K. and Dekker, W. 2021. Economic development in times of biological population decline - a century of European eel fishing on the Swedish west coast. *ICES Journal of Marine Science*. 78(1), 185-198.

Ovegård, M. K., Öhman, K., Mikkelsen, J. S., Jepsen, N. 2017. Cormorant predation overlaps with fish communities and commercial-fishery interest in a Swedish lake. *Marine and Freshwater Research*. 68, 1677–1685.

Sjöberg, N. 2015. Eel migration – results from tagging studies with relevance to management. PhD thesis, Stockholm University.

Wickström, H. and Sjöberg, N. B. 2013. Traceability of stocked eels – the Swedish approach. *Ecology of Freshwater Fish*. 23, 33–39.

Östman, Ö., Bergenius, M., Boström, M. K., Lunneryd, S. G. 2012. Do cormorant colonies affect local fish communities in the Baltic Sea? *Canadian Journal of Fisheries and Aquatic Sciences*. 69, 1047–1055.

Östman, Ö., Boström, M. K., Bergström, U., Andersson, J., Lunneryd S. G. 2013. Estimating competition between wildlife and humans–a case of cormorants and coastal fisheries in the Baltic Sea. *PLoS ONE*. 8, e83763.

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Authors:

Tea Bašić; Cefas, Pakefield Road, Lowestoft, Suffolk, England, NR33 0HT. Tel: 00-44-1502-524544, tea.basic@cefas.co.uk;

Ayesha Taylor; Environment Agency, Richard Fairclough House, Knutsford Road, Warrington, Cheshire, England, WA4 1HG. Tel: 00-44-2030-250429; ayesha.taylor@environment-agency.gov.uk;

Jason Godfrey, Marine Scotland – Science, Freshwater Laboratory, Faskally, Pitlochry, Perthshire, Scotland, PH16 5LB. Tel: 00-44-131-2442118,; j.d.godfrey@marlab.ac.uk;

Derek Evans and Robert Rosell, Agri-Food & Biosciences Institute Northern Ireland, Newforge Lane, Belfast BT9 5PX. Tel: 00-44-28-90255506, Fax: 00-44-028-90255004; Derek.evans@afbini.gov.uk; robert.rosell@afbini.gov.uk;

Robert Evans, Natural Resources Wales, Ty Cambria, Newport Road, Cardiff CF24 0TP. Tel: 00-44-2920-466155 Fax: 00-44-2920-889234; rob.evans@naturalresourceswales.gov.uk .

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FOREWORD

Annual reports on the state of eel stock and fisheries throughout the UK have been produced since 2003. These reports present an update for the most recent year to assist the International Council for the Exploration of the Sea (ICES) in providing scientific advice to the European Commission and others on the state of the international eel stock.

Until 2016, each annual report was designed to stand alone, to provide a single reference source of data and supporting information for the Working Group on Eel (WGEEL), a joint group of the European Inland Fisheries and Aquaculture Advice Commission (EIFAAC), ICES and the General Fisheries Commission for the Mediterranean (GFCM). Since 2017, however, ICES has issued annual Data Calls requesting updates on fishery catches, recruitment indices, aquaculture production and restocking levels, and triennial updates on silver eel escapement biomass and mortality rates caused by human factors. These Data Calls are answered using a series of spreadsheet tables (Annexes) containing the data and associated metadata. Therefore, lengthy time series of data are no longer provided in this report, but are summarised where considered necessary.

It should be noted that the data and information in the most recent year herein are provisional (with some exceptions) and will be updated and confirmed as complete later (usually in the next year's report).

1 Summary of national and international stock status indicators

1.1 Escapement biomass and mortality rates

This summary chapter presents 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 on by the UK (Table 1.1; EMU codes explained in 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 in 2021 and were based on data sets for the years 2017-2019. These stock indictors will not be updated until the next triennial ICES reporting in 2024, in which the 2020-2022 data sets will be used. Those for GB_NorE and GB_Neag in Northern Ireland and GB_Scot in Scotland are updated annually.

Table 1.1. Stock indicators of silver eel escapement, biomass and mortality rates, and assessed habitat area for each of the Eel Management Units across the UK, for the most recently available year (2019 for England and Wales, 2020 for Scotland and Northern Ireland (2020 GB_NorE impacted by COVID-19 restrictions).

Year	EMU_code	Assessed Area (ha)	B_0 (kg)	B_{curr} (kg)	B_{best} (kg)	Bcurr/B_0 (%)	∑F	∑H	∑A
2019	GB_Nort	11816	60876	7665	14074	12.6	NP	0.61	0.61
2019	GB_Humb	57 853	137859	3775	43534	2.7	0.18	2.27	2.45
2019	GB_Angl	54 373	341084	22035	58385	6.5	0.27	0.70	0.97
2019	GB_Tham	42 811	251699	56958	161730	22.6	0.02	1.03	1.04
2019	GB_SouE	11 443	121340	23524	36575	19.4	0.01	0.43	0.44
2019	GB_SouW	35 850	1327684	5370	212229	0.4	3.27	0.41	3.68
2019	GB_Seve	75 071	899687	20093	266683	2.2	2.41	0.18	2.59
2019	GB_Wale	26 570	429944	11770	16391	2.7	0.12	0.21	0.33
2019	GB_Dee	14 130	636166	9754	20202	1.5	0.26	0.47	0.73
2019	GB_NorW	46 783	865449	19770	46448	2.3	0.32	0.54	0.85
2019	GB_Solw	87 496	1473755	85611	110991	5.8	NP	0.26	0.26
2020	GB_Scot	214241	267717	164395	201519	61.4	NP	0.20	0.20
2020	GB_NorE	5000	4 000	ND	ND	ND	ND	ND	ND
2020	GB_Neag	40 000	500000	198900	361900	39.8	0.60	0.00	0.60

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. ND = no data, NP = not pertinent.

Table 1.1. 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 IRBD*	*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 joint EIFAAC/ICES/GFCM Working Group on Eel (WGEEL) uses these time series data, and others collected from 40+ sites across the natural range of the European eel, to calculate the Recruitment Indices, relative to the reference period of 1960-1979, and the overall results form the basis of the annual Whole-Stock Advice that ICES provides to the European Commission. This ICES Advice, and hence these whole-stock Recruitment Indices, are also used by the EU CITES Scientific Review Group (SRG) in their annual review of their position with regard to eel trade into and out of the European Union.

1.2.1 UK Recruitment time-series contributing to the WGEEL whole-stock Recruitment Indices

The Recruitment Analysis updated by the WGEEL and presented in the annual ICES Advice uses one fishery-dependent and 13 fishery-independent time-series of recruitment data from the UK.

Fishery-dependent series

The longest running time series used is that detailing the total UK commercial glass eel catch, as shown in Figure 1.1 below. These catch data are reported to the Environment Agency as a condition of the fishing authorization (see Section 3.1.1. for greater detail).

The data for this time series are provided to ICES in the UK response to the annual Data Call (Data Call Annex 1).

As the glass eel catch data reported directly to the EA are now recorded against each contributing EMU, and have been so since 2005, these time-series could be considered for the ICES analyses at some point in future. Note that 2021 fishing effort and catches were affected by EU exit and by COVID-19 and the validity of the series in future years must be carefully considered.

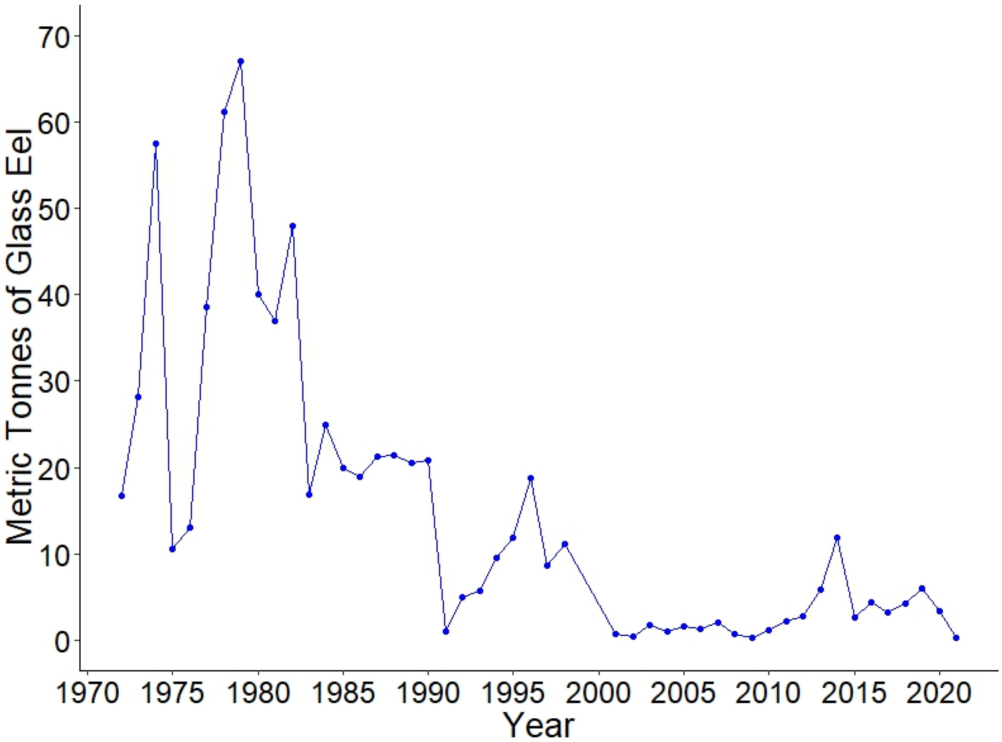

Figure 1.1 Time-series of total UK glass eels catch (t) which is provided as one of the eel recruitment time series for the ICES whole-stock Glass Eel index calculations. Note – 2021 data are provisional.

Fishery independent

Thirteen fisheries-independent eel recruitment time series are used by the WGEEL from ten sites across the following six EMUs around the UK (Figure 1.2).

Anglian (GB_Angl)

Glass eel data (<80 mm) are available from the traps on the River Chelmer (Beeleigh Weir site) and the River Stour (Flatford, Judas Gap site) since 2006 and 2007, respectively. Data on elvers (>80 mm and <120mm) from the River Stour have also been used since 2007. In, addition, glass eel, elver and yellow eel (>120 mm) data are available from the Brownshill site on the River Great Ouse from 2011, although in 2012 and 2020 the trap was not operational for periods due to flooding and represent a partial count. The trap operation in other years was consistent throughout the time-series. Data from the trap at New Mills on the River Wensum are available from 2009 onwards with the possibility to report data on glass/elver/yellow eel separately from 2020.

Southwest (GB_SouW)

The numbers of elvers and yellow eel traversing a 'camera trap' at the Greylake site on River Parrett (GB_SouW) (1) are available from 2009–2020. The majority of the counts are yellow eel (>120mm) with around 10-15% elvers (80-120mm).

Thames (GB_Tham)

Four sites within the Thames EMU have been monitored by the Zoological Society of London for several years. From these, only data on glass and yellow eels from the traps at Molesey weir and the River Roding have been used in the WGEEL analysis.

Scotland (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.

Neagh-Bann (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. 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. 2020, recruitment was not impacted by COVID-19 restrictions ending with 637.2 kg. Recruitment for 2021 has finished at 117.6 kg, the third lowest record since 1965.

International North West (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 had fallen yet again to 93.56 kg. The 2020 elver run rose once more finishing with 408.3 kg, with a similar quantity (382kg) collected in 2021The full time-series index of glass eel recruitment for this basin is reported in the Republic of Ireland Country Report.

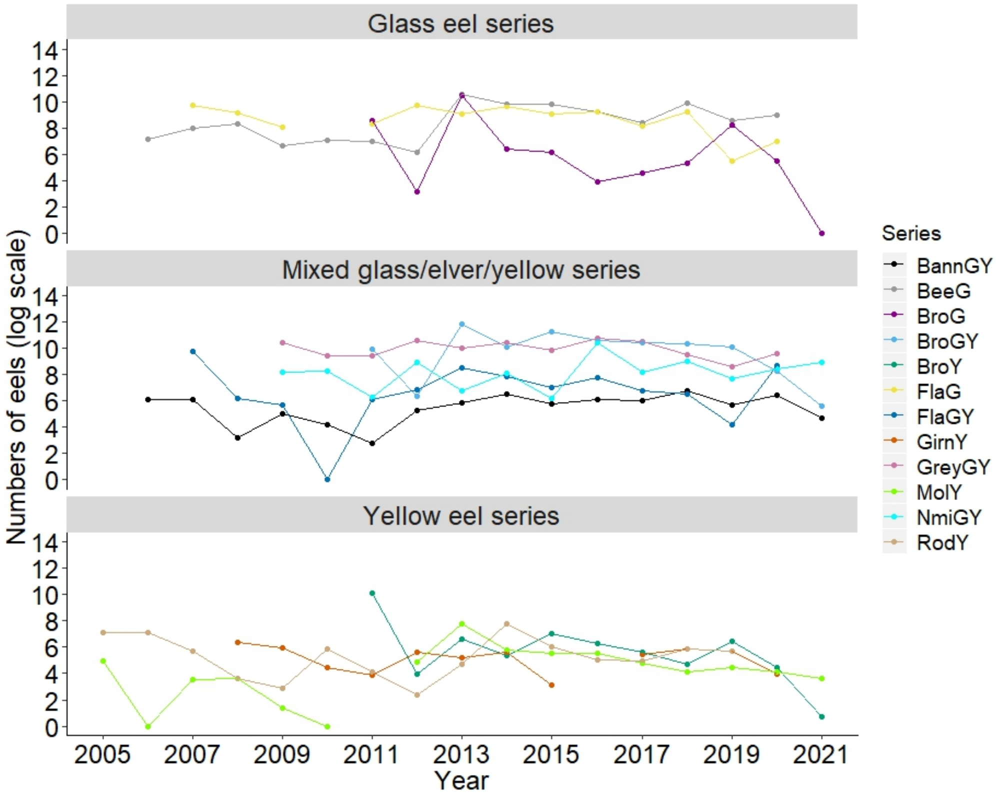

Figure 1.2. Fishery-independent time series of UK eel recruitment on a log scale used in the WGEEL recruitment analysis (except for the Erne data from IE_NorW which are not presented here), where: BannGY – Neagh-Bann, BeeG – Beeleigh glass eel, BroG – Brownshill glass eel, BroGY – Brownshill elvers, BroY – Brownshill yellow eel, FlaG – Flatford glass eel, FlaGY – Flatford elvers and yellow eel, GirnY - Girnock Burn, GreyGY – Greylake elver and yellow eel, MolY - Molesey weir yellow eel, NmiGY – New Mills elvers and yellow eel, RodY - River Roding yellow eel. Data for 2021 are Provisional. Glass eel recruitment in the River Bann, Northern Ireland is shown from 2006 to 2019 and the full data set can be seen in older reports.

1.2.2 Other recruitment time-series

Shorter time series are being generated from fisheries-independent glass eel monitoring at five EMUs (Figure 1.3). These have not been adopted in the WGEEL Recruitment Indices yet as they have not been collecting data for the required 10+ years.

Anglian (GB_Angl)

New yellow eel series from the River Stour (Flatford, Judas Gap site) has been added this year, with data available for nine consecutive years. Elver and yellow eel data have been separately collected from the trap on the River Chelmer (Beeleigh Weir site) for 10 years now, so these two series will be included in the analysis from this year onwards.

Southwest (GB_SouW)

The combined numbers of elvers and yellow eel are collected from the camera trap at Oath Lock on the River Parrett since 2013, with data missing for 2017 and 2018 because of major water pump failure.

Thames (GB_Tham)

Two sites on the River Thames (Merton Abbey Mills and Middle Mill traps) have been monitored since 2012 and will reach 10 years of data collection this year.

Scotland (GB_Scot)

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 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). This latter series was not collected in 2020 due to COVID-19 restrictions.

North East (GB_NorE)

See Section 6 (New Information) in relation to the establishment of a new glass eel monitoring site at Strangford Lough. The collection of this data set has now progressed beyond a continual 10-year standard (2012-2021), and this information will be registered as a new index site within the ICES Data Call database. Recruitment trends recorded at this site over this 10-year period are shown in Figure 1.3 and illustrate the typical inter-annual variation seen at the other N. Ireland index sites (from GB_Nea and IE_NorW).

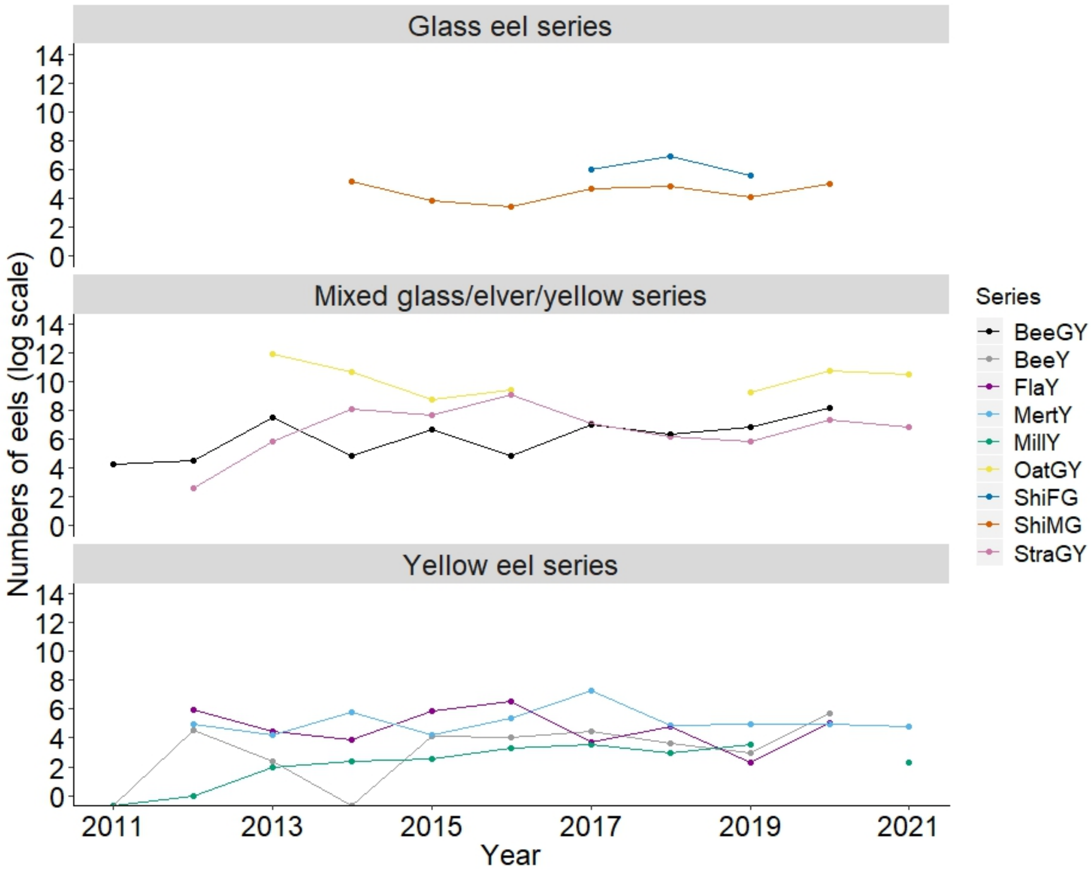

Figure 1.3. Other fishery-independent time series of UK eel recruitment on a log scale (currently not used in WGEEL recruitment analysis), where: BeeGY – Beeleigh elver and yellow eel, FlaY – Flatford yellow eel, MertY – Merton Abbey Mills yellow eel, MillY – Middle Mill yellow eel, OatGY – Oath Lock elver and yellow eel, ShiFG - Shieldaig river glass eel, ShiMG - Shieldaig river mouth glass eel, StraGY - Strangford Lough glass and elver. Data for 2021 are Provisional.

2 Overview of the national stock and its management

2.1 Describe the eel stock and its management

This chapter provides brief descriptions of the approaches used across the UK to manage eel and human impacts, including management units, authorities and regulations, to assess the status of eel, quantifying the human impacts because of fisheries (commercial and recreational) and other human impacts.

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; EC, 2000). 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 – the EA leads on the cross-border Severn EMP whereas the NRW leads on the Dee EMP. 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 of commercial eel fisheries, the sustainable harvest of eel populations within these, 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. Whilst all aspects of eel conservation and compliance measures assessment is shared between NI and RoI, by agreement, the Inland Fisheries Ireland (IFI), is responsible for the delivery of information relating to the transboundary Northwest International EMP (IE_NorW).

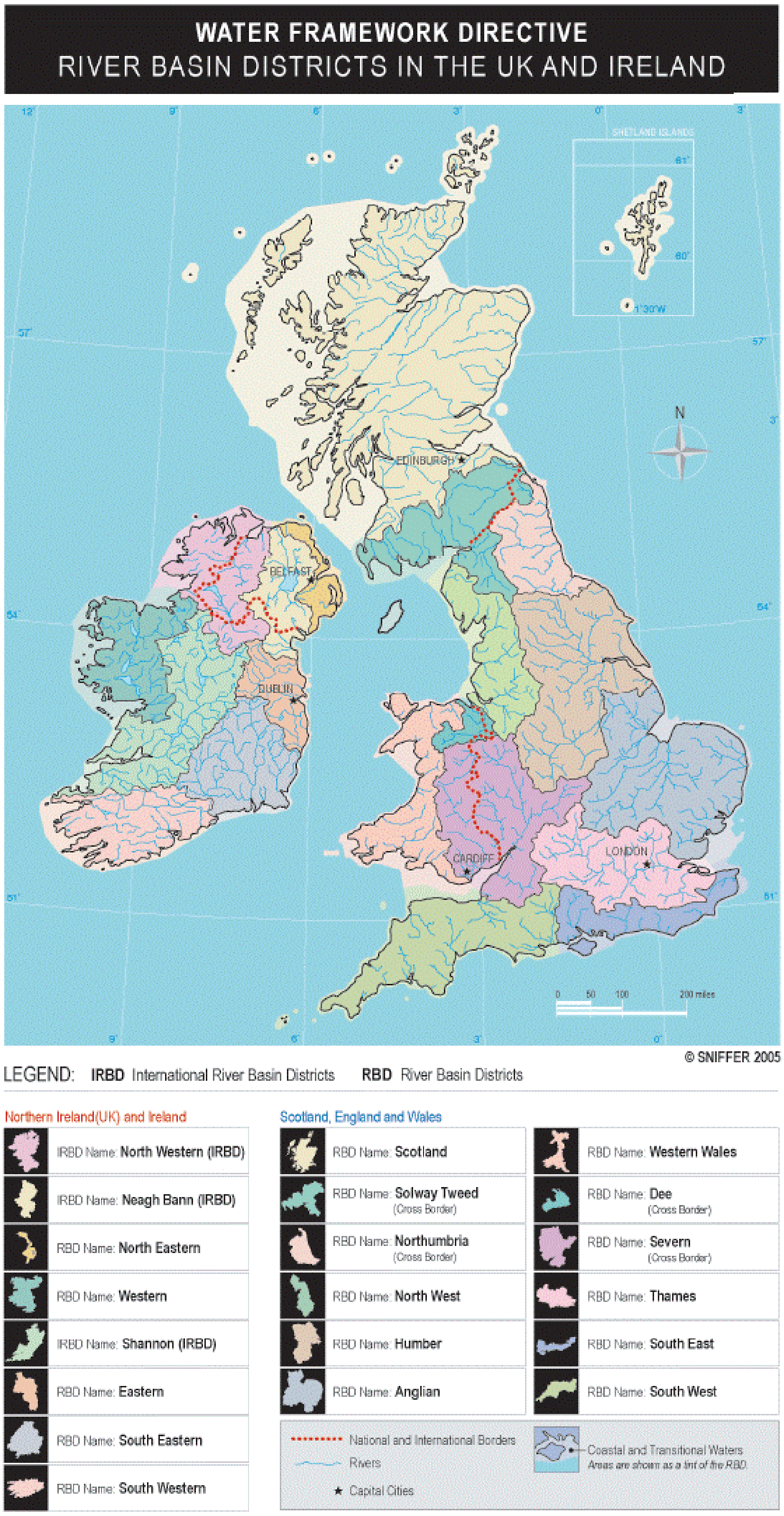

Figure 2.1. Map of the 15 Eel Management Units across the UK (after SNIFFER, 2005).

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. Up to 2020 the EA, under formal agreement, issued 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 fyke nets); and elver (glass eel) dipnets. Recreational angling for any fish species is only 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 (see http://ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/acom/2007/WGEEL/WGEELcountryreports07-final.pdf).

Conditions also stipulate that all eel (apart from glass eel) less than 300 mm in length must be returned alive 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 fyke nets 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 in specified RBDs in England and Wales unless local byelaw restrictions apply.

Since the imposition of the EC Fishing Opportunities Regulation, which required all EU Member States to have a three-month prohibition on eel fishing, the UK eel fisheries in England and Wales are closed in December-February inclusive. The current fishing season for yellow and silver eel in England and Wales is from 1 April to 30 November inclusive in 2019/2020. The 2019 elver and glass eel season was 15 February to 25 May, in 2020 and 2021 the elver and glass eel fishing season was 1 March to 25 May.

Since 2010, the yellow and silver eel fisheries have been limited to those individuals who were already authorised, 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 . Thus, commercial fishing for yellow and silver eels is effectively capped to existing fisherman who can use up to a capped number of nets.

The glass eel fishery is restricted to two zones: (i) parts of South Wales and Southwest England, and (ii) 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. Up to 2020, the EA, under formal agreement, collated 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, but 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. Since 2013, three applications have been received but none have been approved.

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 4000 kg (12M fish) and averaged 3858kg (11.6M) (based on a mean weight of 3000 glass eel per kg) from 1923-1982. 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 (by catch weight) commercial wild eel fishery in Europe, producing 13.6% of total EU landings and supplying 3.1% of the entire EU market (wild-caught + aquaculture) in 2019. 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. However, as a consequence of the historic drop in recruitment these output figures have reduced and continue to fall. 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) supported a peak season average of 85–95 boats, each with a crew of two men using draftnets and baited longlines. In recent years this has decreased and following the impacts of COVID-19 restrictions the fishing fleet in 2020 was reduced to 36 boats and remains a reduced fleet in 2021 with a daily average of 52 boats. 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 123.6 million (41.1 t) additional glass eel have been stocked by the LNFCS. Reviews on the fishery, its history and operation can be found in Kennedy (1999), Rosell *et al.* (2005) and Aprahamian & Evans *et al.*, (2021).

The transboundary Erne system (IE_NorW* and reported in Ireland Country Report) is comparable in size to L. Neagh and produced 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 transport 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 & Evans *et al*. (2001).

2.1.4 Management actions

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 No 1100/2007 (EC, 2007) in England and Wales. The legislation makes provisions for the regulation of the fishery and gives powers to require the installation of eel passes at obstructions and to screen intakes for eels. As part of the UK's withdrawal from the EU, the European Union (Withdrawal) Act transposed Regulation 1100/2007 into UK law (HMSO, 2019). The requirements of Regulation 1100/2007 therefore continue to apply in the UK.

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).

Since the implementation of EMPs in 2009/2010, new management actions have delivered:

- Introduction of 100% catch and release for eel by angling throughout the UK;
- Close season for commercial net and trap fishing for eel, where such fishing is authorized;
- Limits on the geographical extent of the commercial eel fishery;
- Creation of 'no commercial eel fishing' areas;
- Restrictions on commercial and recreational eel fishing methods and gear;
- New legislation to require the installation of eel passes and eel screens at structures impacting safe eel passage (introduced 2010)
- 99 new eel passes in 2017–2019 restoring access to over 1100 ha of river habitat (totalling 885 passes restoring access to over 9300 Ha since 2009)
- 24 new screens at water intakes during 2017–2019 (totalling 52 eel screens since 2009)
- 2 Fish Recovery & Return/bywash systems at water intakes
- A reduction in the 2018 fishing season in territorial waters by 40 days (compared to pre-EMP) as a result of EC Regulation 2018/120 (EC, 2018)
- A reduction in the 2019 fishing season in all fisheries by 10 days (compared to pre-EMP) as a result of EC Regulation 2019/124 (EC, 2019)
- A programme of eel-specific monitoring for all eel life stages;
- Raised awareness and widespread engagement with key stakeholder groups regarding management measures need to support eels;
- Regulation of impacting industries including Water Companies, Internal Drainage Boards (IDBs), Power Generation and Hydropower sector representatives under the Eels (England and Wales) Regulations 2009;

- Establishment of yellow and silver eel commercial traceability system since 2009;
- 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 (<400mm) eel caught in this fishery.
- New assessments into silver eel mortality in NI at large scale hydroelectric facilities.

2.2 Significant changes since last report (2019/2020)

The has been new assessment of stock indicators for eel across the UK since last year's report to ICES and the results are presented in this report for all four countries. However, the COVID-19 situation has continued to cause some disruption to eel fisheries, control and management, data collection and assessments.

Commercial fishing for eels – net licences were issued as normal though fishing effort was impacted by COVID-19 lockdown restrictions as a result of a loss of market and opportunity for sales, e.g. to hotels and restaurants and overseas markets.

Scientific surveys and data collection - across England and Wales all electrofishing was halted for the majority of the sampling season in accordance with COVID-19 lockdown restrictions. The ability to operate eel counters differed between sites due to local circumstances; some operated as previous years, whereas others were only partially operated.

In Northern Ireland, COVID-19 impacts have been minimal on data series for GB_NorE. However, the effects on GB_Neag have been larger. The collection of recruitment data has remained unaffected, however the commercial fishing season on Lough Neagh did not begin in May as usual but was opened on 1st July with a much reduced fishing fleet than in previous years (36 boats compared to 87). This lower number is influenced by government Furlough scheme payments to self-employed workers (such as fishermen) and the loss in continental markets for yellow eel as a direct result of lockdowns/loss of tourism in Holland and Germany. This has meant a reduced daily catch quota being issued, resulting in fishermen making the economic comparison between Furlough hardship payment and reduced fishing earnings. This, in turn, has meant a much reduced collection of fishery-dependent data from this EMU, which will now effectively only really cover half a season and half the normal sampling efficacy across a reduced fishing fleet. See section 2.1.3 in relation to current fishing fleet reduction.

These changes are anticipated to remain through the coming months and thus into the silver eel migration period and associated silver eel fishery on the River Bann exiting L. Neagh. Plans were in place to incept a Scientific Fishery during key lunar darks through the Autumn and Winter of 2020 to enable EMP compliance assessments to continue. However, working within national COVID-19 guidelines, 3 of the 4 lunar darks were monitored and assessed for silver eel migration using the established direct mark recapture method.

Field working and lab analysis of materials has taken a significant impact in terms of travelling solo to sites, reduced staff presence at fieldwork, additional prep time and working conditions in labs (now on rotational basis to reduce staff numbers). COVID-19 guidance on working practices has meant a reduced the capacity for on-boat working. All AFBI lab staff since March 24th have been sent home and are only beginning to return in a phased and rotational basis from 10th August: this has created significant backlogs in sample analysis. This situation has remained as such through 2021.

The 2021 eel fishing season was significantly affected by the UK's exit from the European Union as CITES trade restrictions meant that UK eels could no longer be traded outside the UK (i.e. into EU countries) without a CITES permit.

3 Human factors impacting on the national stock

There are a broad range of human-induced factors that impact on eels. The WGEEL has grouped these factors into six categories (fisheries, restocking, aquaculture, entrainment, habitat, others), in order to simplify reporting. This chapter provides updates on the impact levels of these factors, and the methods used to quantify these impacts.

3.1 Fisheries

The WGEEL uses these data to report trends in catches and landings in the ICES Single Stock Advice. The Agreement between ICES and the UK explicitly requests annual updates on catches by fisheries.

Catches are defined as the quantity of eel that are caught by fishing gears (defined by the FAO as the 'gross catch') i.e. the quantity of eel that is removed from the water, but which can include those that are subsequently returned alive to this or other waters.

Landings are defined as the quantity of eel that are retained after capture (defined by the FAO as the Retained Catch), or to put it another way, removed from the water basin or management unit. So, Landings should not include any eels subject to assisted migration within the same river basin, or scientific studies where they are returned alive to the waters where they were caught. Therefore, Landings are effectively the quantity of eel that is (permanently removed from the productive potential of that water basin) killed or transported to a different river basin (restocked).

Fishing effort and catch per unit of effort (CPUE) are presented and discussed where available.

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). A 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) but also rivers in Wales (GB_Wal) , with smaller fisheries elsewhere, such as that in Morecambe Bay, Cumbria (GB_NorW) and in the estuary of the River Dee (GB_Dee).

Glass eel fisheries are required 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. Comparison between the catch reported to the EA and the net exports from 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, as presented here in Table 3.1:

1) Catch returns to the EA;
2) The quantity of glass eel bought by the dealers from the fishermen (consignment notes, reported to the EA by any aquaculture production business operator under the requirements of Regulation 4 of The Eels (England & Wales) Regulations, 2009 Statutory Instrument;
3) The quantity of glass eel exported from the UK or stocked within the UK, as reported by, in England and Wales, any person who imports or exports live eels under Regulations 5 and 6 of the Eels (England and Wales) Regulations to the EA and NRW, or in Northern Ireland, the consignment note issued by 'Glass Eels UK' to Lough Neagh Fishermens Cooperative Society and checked at site upon delivery by DAERA Fishery Protection Officers before onwards transportation for restocking.

The final catch reported to the EA for 2019 was 6.03 t and for 2020 was 3.43 t of glass eel (Table 3.1). For 2021, the provisional figure was 0.075 t (as of August). 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 reported elver catch since 1996 (Table 3.1). These figures are thought to have reflected a true increase in the availability of glass eel to the fishery at that time. However, catches decreased since 2014, and the catch of UK glass eel remains at the very low levels compared to those reported in the late 1990s.

Though underreporting of catch and effort are recognized (see above), 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 2020 data for all EMUs with glass eel fisheries was 1.05 kg/day. (Table 3.1). For 2021 the provisional figure is 0.15 kg/day, but this is based only on catch returns from the fishermen and doesn't include 0.5t caught by the fishermen and used for assisted migration. The 0.5t was traded through the dealers for a nominal amount as part of an assisted migration programme. Estimated transport losses (from shrinkage and mortality) of glass eel were 8%. This was estimated from the mean of the 2010-2020 percentage differences between dealer purchases and export (consignment notes) data. Such data are necessary to help explain differences in quantities along a trade chain from fishery to final destination.

Table 3.1. Time-series of 'UK' glass eel commercial fishery catches reported to EA, and as estimated from dealers' purchase at first sale and from the consignment notes, with catch per unit of effort (CPUE) based on fisherman returns from 2010 onwards. *2021 reported catches are provisional, as of August 2021. ‡ 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	‡Transport 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	6.03	6.09	6.95	0.81	12.4
2020	3.43	3.56	3.76	1.05	5.3
2021*	0.075	0.06	0.58	0.15	0.0

Note: 2021 Dealers Purchase figures include 0.5t used for assisted migration, hence not included in catch returns reported to the EA. The CPUE figure, based only on catch returns, is therefore lower than if all catches were included. 2021 Consignment Notes only include export within the UK (i.e. from England to Northern Ireland).

Since 2005, catches, and fishing effort, have been reported per "nearest waterbody", allowing the catch data to be assigned to EMUs (Table 3.2).

Table 3.2. Commercial catches (kg) of glass eel from England and Wales RBDs from 2005 to 2020, including the information from the dealers and catch returns to the Environment Agency. Note that the 2020 catches are provisional. No glass eel fisheries operate in missing EMUs, NP = not pertinent, in this case because glass eel fishing has not been authorised in the Southeast since 2010.

Year	GB_NorW	GB_Dee	GB_Wal	GB_Seve	GB_SouW	GB_SouE
2005	860	202	457	4055	3225	0.0
2006	174	8	55	944	722	1.5
2007	299	9	39	1750	999	0.0
2008	137	3	6	554	521	0.0
2009	28	1	9	111	282	0.0
2010	43	7	2	759	1079	NP
2011	123	21	4	1460	2033	NP
2012	49	23	0	1586	2161	NP
2013	119	22	34	3948	4536	NP
2014	1	0	34	6126	5611	NP
2015	106	17	0	1419	1154	NP
2016	84	5	37	1971	1943	NP
2017	79	10	10	1704	1727	NP

Year	GB_NorW	GB_Dee	GB_Wal	GB_Seve	GB_SouW	GB_SouE
2018	115	60	27	2565	1893	NP
2019	159	50	27	3862	2852	NP
2020	44.83	0	31.3	1670.9	1687.6	NP

3.1.1.2 Proportion retained for stocking

Here we report on the proportion of the catch used for restocking (Table 3.3) – the remainder of the catch is sold to aquaculture or direct consumption (direct meaning as glass eel and not ongrown in aquaculture).

Table 3.1. Percentage of glass eel caught in the UK that is then sold for restocking 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
2020	82.9

3.1.1.3 Recreational fisheries for glass eel

No recreational fisheries for glass eel are permitted throughout the UK.

3.1.2 Yellow eel fisheries

3.1.2.1 Commercial

Commercial fisheries for yellow eel deploy fyke nets in seven 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). Historic fisheries in GB_Nort and GB_Seve have not been authorised since 2010 and 2011, respectively (Table 3.4). There are no commercial fisheries for yellow eel in the other EMUs: GB_Scot, GB_NorE, IE_NorW or GB_Solw. **Note that 2021 data are not available yet because the fishing seasons is open at the time of writing.**

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. These EMU-level data are presented in Table 3.4, but as the Lough Neagh fishery accounts for the bulk of the national catch year on year, those fishery and catch trends are here discussed in some greater detail.

Commercial catches for yellow eel in the GB_Neag EMU 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 .2020 has seen this number plummet to 64 fishermen as a consequence of COVID-19 restrictions impacting international markets. Around 1990, there were 200 boats (400 fishermen) fishing the Lough, but this number has steadily declined to the present-day (2021) peak of season average of 56 boats as a result of an ageing fisher population, availability of alternative employment and falling market prices for eel. Boat size 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 is collected and maintained by the LNFCS with several aspects of these data spanning 106 years. This information is made available to DAERA and AFBI for scientific analysis and the provision of management advice.

Over the last 20 years, approximately 40% of the Lough Neagh yellow eel catch was derived from draftnets, the other 60% from longline fishing using a maximum per boat of 1200 standard sized hooks baited with earthworms, ragworms, fish fry or the larvae of the flour beetle (meal worm). There has been a noted change in this split in 2021, with more boats returning to long lining and these lines are now set in the early evening, rather than the morning – a return to how fishermen's forefathers would have fished the lough.

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.

Due to COVID-19 restrictions, 2020 yellow eel catches in L. Neagh should be viewed with care given the reduction in both fleet (32 boats) and season (3 months instead of 5 months long), with total amount of 97 t reported. This is the lowest yellow eel catch in the 100 years of catch records from L. Neagh. 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 2021 suggest that the reduced fleet and market demand have meant that up to the end of August, this has been a very good years fishing with all boats consistently making quota.

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. It would not be possible to update the following given the unusual fishing patterns of 2020. However, a comparison of catch against average boat numbers (95 boats) produces a mean catch of 3463 kg boat^{-1} in 2009–2013 and 2547 kg boat^{-1} in 2015–2019, (decrease of 26.5%). 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 3.2. Commercial catch (t) of yellow eel for all UK EMUs (codes as per Table 3.1) with a fishery during the reporting period, together with total UK catch, 2005–2020. NC = data not collected at the time of reporting, NP = not pertinent (no fishery authorised in that year).

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	0.01	1.30	13.07	7.18	0.41	3.79	0.57	0.24	0.03	1.62	317.10	345.29
2006	0.00	1.16	6.28	5.69	3.07	6.79	0.17	0.48	0.03	1.25	242.20	267.11
2007	0.00	2.14	3.74	6.96	1.81	2.02	0.07	0.27	0.02	0.21	351.30	368.54
2008	0.00	1.43	9.90	5.55	0.60	6.63	0.03	0.12	0.64	0.47	290.00	315.37
2009	0.05	0.41	6.62	4.75	7.03	2.55	0.00	0.02	0.07	0.11	345.20	366.80
2010	0.06	3.03	10.71	5.66	1.43	2.72	0.15	0.35	0.05	0.15	337.40	361.71
2011	NP	4.86	16.48	6.08	1.88	3.79	0.35	0.25	1.08	1.48	342.00	378.25
2012	NP	3.27	15.34	1.82	2.12	5.97	0.00	0.65	0.48	2.97	302.00	334.60
2013	NP	3.87	9.32	3.99	0.29	8.69	0.00	0.10	0.15	0.67	321.00	348.07
2014	NP	3.52	16.88	3.22	0.28	10.12	NP	0.00	0.42	0.09	297.00	331.52
2015	NP	1.38	8.38	2.70	0.96	16.83	NP	0.00	0.07	0.09	255.50	285.91
2016	NP	0.16	12.27	2.47	0.83	10.26	NP	1.35	0.07	0.19	262.00	289.59
2017	NP	1.54	6.13	2.26	0.36	11.17	NP	0.00	0.33	0.33	237.00	259.13
2018	NP	4.84	11.80	1.97	0.22	13.35	NP	0.00	0.12	0.15	235.00	267.44
2019	NP	1.02	7.43	1.68	0.20	13.01	NP	0.00	0.61	0.25	221.00	245.21
2020	NP	0.20	2.27	0.03	0.23	12.41	NP	0.00	0.22	0.72	97.00	113.06

3.1.2.2 Recreational fishing for yellow eels

No ‘take’ of yellow eel from recreational fisheries is permitted throughout 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 hooking-related mortalities (Evans & Rosell, 2008).

3.1.3 Silver eel fisheries

3.1.3.1 Commercial

Commercial fisheries in seven EMUs of England and Wales are prosecuted using both fixed weir-traps and mobile fyke net gears (Table 3.5), while there is a coghill net silver eel fishery in GB_Neag. Historic fisheries in GB_Nort and GB_Seve have not been authorised since 2010 and 2011, respectively (Table 3.5). There are no commercial silver eel fisheries in the other EMUs: GB_Scot, GB_Solw, GB_NorE, IE_NorW or GB_Solw.

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. These EMU-level data are presented in Table 3.5, but as the Lough Neagh fishery accounts for the bulk of the national catch year on year, the fishery and catch trends are here discussed in some greater detail.

Silver eel from Lough Neagh used to be 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 but would make it difficult to report on nightly catch per unit effort. Fishing capacity is recorded as the number of licensed silver eel weirs in operation but note that the two weirs operate at different efficiencies dependent upon river flow rates.

The annual catch of silver eel from Lough Neagh has shown a general decline throughout the period 2005 to 2019 (Table 3.5). 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. The 2020 catch was 65 t.

Table 3.3. Commercial catch (t) of silver eel for all UK EMUs (codes as per Table 3.1) with a fishery during the reporting period, together with total UK catch, 2005–2020. NC = data not collected at the time of reporting, NP = not pertinent (no fishery authorised in that year).

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	0.87	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	NP	0.26	2.01	0.51	0.69	0.07	0.38	0.01	0.12	0.27	73.3	77.62
2012	NP	1.63	2.98	0.20	0.65	0.53	0.00	0.00	0.00	0.46	72.8	79.25
2013	NP	0.26	2.49	0.31	1.99	0.95	0.00	0.00	0.03	0.11	72.8	78.94
2014	NP	0.48	5.02	0.38	0.75	1.17	NP	0.00	0.03	0.03	66.8	74.66
2015	NP	0.74	3.76	0.20	0.11	0.91	NP	0.00	0.03	0.06	49.3	55.11
2016	NP	0.05	3.66	0.15	0.25	0.95	NP	0.15	0.02	0.03	52.5	57.76
2017	NP	0.02	2.11	0.01	0.03	1.12	NP	0.00	0.02	0.25	59.7	61.46
2018	NP	1.12	2.26	0.13	0.08	1.34	NP	0.00	0.02	0.22	94.1	99.27
2019	NP	0.04	2.81	0.004	0.06	1.46	NP	0.00	0.17	0.28	46.0	50.82
2020	NP	0.28	1.62	0.007	0.04	1.93	NP	0.00	0.002	0.304	65	69.18

3.1.3.2 Recreational fishing for silver eels

No 'take' of silver eel is permitted from recreational fisheries throughout 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

Limited information on underreporting rates for commercial glass eel fisheries in EMUs of England and Wales is provided in section 3.1.1.1 above. Enforcement operations by the Environment Agency, Natural Resources Wales and local Police forces uncover some illegal operations from time to time. No data are available for illegal, underreported or unrecorded catches in England and Wales EMUs for silver or yellow eels.

The only known illegal eel trafficking operation based in UK was successfully disrupted, resulting in prosecution and conviction. In this case, the eels being illegally traded were not derived from UK fisheries but had first been imported from France / Spain.

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.

Commercial fishing in Lough Neagh is tightly controlled by the LNFCS and underreporting is thought to be very minor if at all. In other EMUs in Northern Ireland, there have been no reports of illegal fishing for, or trade in, eel.

3.1.5 Bycatch of non-target species

Eel caught in gears targeting other fish species

No data are collected on the bycatch of eel in gears targeting other fish species, but it is thought to be very small.

Other fish species caught in gears targeting eels

Few data are collected on the bycatch of other species in gears targeting eel but a series of surveys by AFBI from the Lough Neagh fishery confirmed previous assertions that any level of bycatch and its impact are small. In 2018, Toome weir (4 nets) in 5 nights caught 87 377 fish of which 9.1% was bycatch and of that bycatch 6.2% was released alive. Kilrea weir (3 nets) in 5 nights caught 31 373 fish of which 0.02% was bycatch. In 2019, Toome weir (4 nets) in 5 nights caught 15 710 fish of which 35% was bycatch and of that bycatch 88% was released alive. Kilrea weir (3 nets) in 5 nights caught 16 345 fish of which 7.3% was bycatch. There are no data available for 2019 and 2020 due to COVID-19 restrictions.

3.2 Restocking

The WGEEL retains a time series of amounts of eel used for restocking from country to country. This information is periodically used to examine the fate of eel and trade routes.

Owing to there being inconsistencies in reporting on restocking actions by countries, the WGEEL broadly categorises them as ”releases”, though the term “restocking” is still used for some circumstances. Here, we continue to use the term restocking for practices of moving fish of wild origin from one water to another, separating it from short distance movements of fish inside the same system, categorised as assisted migration.

Restocking in the UK

Some trial restocking of glass eel has taken place across seven EMUs in England and Wales since 2009, plus annual restocking of glass eel into Northern Ireland (Table 3.6), although only Lough Neagh in the Neagh-Bann EMU has received what might be considered significant quantities (100s as opposed to 1s and 10s of kg). Data on the amounts restocked are available from the Neagh-Bann EMU since 1984, and from other EMUs 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 restocked into Lough Neagh (GB-Neag) originated from fisheries in San Sebastian, Spain and the west coast of France, and in 2011 and 2012, material was sourced from France and the UK fisheries (proportions not available). There was no restocking 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 restocking 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 2019 and 2020, 307 kg and 609 kg respectively of glass eels stocked into Neagh were of French (Gironde) origin.

In 2021 L Neagh had access to glass eels for stocking both from the EU as part of the Northern Ireland Protocol (NIP), and following further legal advice received from the Department for the Environment, Food and Rural Affairs (Defra), GB sourced glass eels could be used as well subject to CITES controls. Whilst the UK was considering legal advice no glass eel shipments from GB to NI were authorised. A total of 971 kg of glass eel were flown direct from France to L. Neagh in March/April of 2021 and in June a delivery of 62 kg of glass eel were road freighted across GB to NI and into L. Neagh.

Table 3.4. Weights (kg) of glass eel restocked into various UK EMUs. Note that the source of restocked materials usually UK fisheries, except that the restocking of GB_Neag in 2010 was solely from France and Spain, and in 2011 and 2012 was from France and UK. NC = data not collected at the time of reporting.

	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	0.0
2016	0.0	0.0	0.0	0.0	0.6	17.0	0.0	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	0.0
2018	0.0	0.0	0.0	0.0	0.0	17.0	0.0	0. 0	754.0	0.0
2019	0.0	0.07	0.0	0.0	0.0	0.4	0.0	0.03	1252.0	0.0
2020	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1714.0	0.0
2021	NC	NC	NC	NC	NC	NC	NC	NC	1033	NC

Assisted migration

A form of assisted migration is 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 3.5. 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	295
2020	637
2021	117

In 2021, assisted migration of around 500 kg of glass eel was coordinated by the Sustainable Eel Group due to loss of glass eel market in England. Glass eels were caught in fishery in tidal range and stocked into freshwater above the tidal limit in GB_Seve and GB_SouW EMUs.

Stocking of glass eel from UK fisheries into other countries

Up until 2020 glass eel from UK fisheries were also stocked into other European countries (see Table 3.8). These data are provided by glass eel exporters, as required by Regulation 6 of the Eels (England & Wales) Regulations 2009. The purpose of each consignment is declared as either restocking, aquaculture or consumption. From 2021 and the UK's exit from the EU, CITES restrictions mean that glass eel (or any eel life stage or any eel products) from UK fisheries will no longer be allowed to be exported to European countries (or any other country) without a CITES permit.

Table 3.6. The export destinations and kg of glass eel caught in the UK. Note this does not include the re-stocking to Lough Neagh, Northern Ireland because this is a trade within the UK

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Belgium					4					2		
Bulgaria								70				
Czech Rep			30	76	470	594	32	80	63	70	65	70
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	359
Greece			411		1005	650	40	600	96			
Latvia			100	343	15	483		10	290	226.8	230	
Lithuania					180	330		120	158	505	805	404
Netherlands		1288	593	100	1620	2232	350	51	109	309	1020	610
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	1018

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 directly from this historical catch data. Measures to record catch and destination were implemented as part of the EMPs. The submission of catch returns, trade and restocking records is delivered via the Eels (England and Wales) Regulations 2009. Data are available from 2009 onwards (Table 3.9). Through the EC 1100/2007 there was a legislative requirement to place a proportion of glass eel caught on the market for use in restocking. This was 35% in 2010, 40% in 2011, 50% in 2012 and 60% from 2013 onwards. Table 3.9 indicates that these stated proportions were actually used for restocking for all years except 2016 and 2017.

Table 3.7. Percentage of glass eel caught in the UK and sold for restocking, 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].

Year	Restocking	Aquaculture	Direct consumption
2009	100.0	0.0	0.0
2010*	55.4	3.5	0.0
2011^{+}	34.8	63.9	0.0
2012	88.8	11.2	0.0
2013	50.4	49.5	0.0
2014	62.6	30.9	6.8
2015	72.7	27.2	3.60
2016	54.0	45.7	0.3
2017	56.3	43.7	0.0

Year	Restocking	Aquaculture	Direct consumption
2018	80.5	19.5	0.0
2019	72.2	27.7	0.0
2020	82.9	17.1	0.0

*40.9% of exports purpose was not declared. Could have been restocking or aquaculture.
+1.22% of exports purpose was not declared. Could have been restocking or aquaculture.

3.4 Entrainment

Pumping stations

In 2015 in England and Wales, there were 336 pumping stations identified as having the greatest potential to impact on eel (Cefas *et al*., 2021). This was based on: 1) distance from head of tide (shorter distance = greater impact) and 2) the predicted presence of eel. These structures are being reviewed in relation to the Eels (England and Wales) Regulations and cost beneficial eel measures implemented as funding becomes available through scheduled programmes of work, including routine maintenance and refurbishment programmes and planned capital investment programmes. As eel measures are implemented the impact of pumping stations will reduce. To date 44 of the 336 critical pumping stations in England and Wales have been addressed.

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. This assumption will be reviewed in future, informed by findings from the REDEEM project (described in Section 6 of this report).

In Scotland which has little low-lying land, pumping stations are not considered to be an important influence on eel migration, and are not considered in stock assessment.

In Northern Ireland, which has little low-lying land, tidal flaps/pumping stations are not considered to be an important influence on eel migration, and are not considered in stock assessment.

Surface water abstraction sites

Surface water is abstracted at 23,106 sites in England and Wales (Cefas *et al*., 2021). 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. In 2015 530 structures were identified as posing the greatest threat to eel. These structures are being reviewed in relation to the Eels (England and Wales) Regulations and cost beneficial eel measures implemented as funding opportunities arise through scheduled programmes of work, including routine maintenance and refurbishment programmes and planned capital investment programmes.

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. As more eel screens are installed at these intakes the impact on eel will reduce. This is accounted for in each triennial assessment. To date 47 of the 530 critical intakes in England and Wales have been addressed.

Surface water extraction is regarded as likely to have only a minor impact on eel in Scotland and Northern Ireland, and does not contribute to stock-assessment.

Cooling water intakes at power stations

In 2015 51 power stations were identified across England and Wales where eels were likely to be impacted by cooling water intakes (Cefas *et al*., 2021). This number is likely to fall over the coming years as coal-fired stations are gradually decommissioned. This is in line with government's energy plan to introduce a greater mix of renewable energy. All existing power stations have been reviewed in relation to the Eels (England and Wales) Regulations and cost beneficial eel measures determined. These measures are being implemented. To date 7 of the 51 power stations have been decommissioned or intakes screened to protect eel.

Hydropower facilities

In 2015, in England and Wales, there were 212 hydropower facilities in operation affecting 11 188 ha of eel producing habitat (Cefas *et al*., 2021). The impact of each hydropower facility on eel was 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 (ICES, 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. It should be noted that these estimates only take account of impacts on downstream migrating silver eel and not on other life stages of eel.

On those river systems where there is more than one hydropower 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.

Existing facilities and new hydropower developments are being reviewed in relation to the Eels (England and Wales) Regulations and cost beneficial eel measures implemented where possible, including the installation of fine screening (2mm gap size) to protect eel less than 300mm.

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.

In Northern Ireland, AFBI undertook a 2-year hydroacoustic telemetry turbine mortality study begun in December 2018 assessing turbine passage and associated mortality at the 2 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 of each of the two years. The tagging and associated releases were in 2 separate batches of 30 to coincide with low flow and high flow regimes out of the system to coincide with different turbine/spilling operating regimes. The findings from this study were presented at WGEEL 2019, with data included in that year's review on Hydropower Impacts. Having now been completed, this study is being written up.

Provisional Results are that the Total mortality on the 2 batches of eels released in 2018 ranged from 46.7 – 66.7%, whilst in 2019, it was measured at 56.7% under both water flow regimes (high and low).

These results indicate a significant difference to mortality figures reported previously for the two Erne hydroelectric stations - 2016/17 SSCE: All Ireland Eel Report lists individual station impacts ranging from 7.7% - 27.5% under various generation and flow regimes: and cumulative of 18.3% mortality.

Consideration of these reviewed data will be necessary with particular emphasis on:

a) the impact of this higher mortality rate on escapement data reported previously;
b) establishment of a revised mortality figure;
c) associated implications of this in terms of EU conservation target compliance for NWIRBD based on the calculation derived in (a);
d) additional conservation measures that could be recommended;
e) the recent review on Hydro impacts carried out by ICES WGEEL (2019) which found the levels of eel mortality to be equitable to that associated with fishing (see Section 4.3).

At Irish National level of the Technical Expert Group on Eel (TEGE) agreement has been reached with the Hydro facility owners that the new AFBI derived mortality data will be used against all future escapement assessments in this transboundary EMP.

3.5 Habitat Quantity and Quality

Habitat Quantity

The quantities of eel habitat in each of the EMUs are reported in the Assessed Area column in Table 1.1 above, and according to gross habitat type (Freshwater, Estuary etc) in Table 4.3 below.

England and Wales

Throughout England and Wales, it is assumed that all freshwater with connection to the sea constitutes potential eel habitat, based on presence/absence data from fish surveys. The seaward boundary of this habitat area is the boundary of the Transitional

Waterbodies, as delineated for River Basin Districts (RBD) in accordance with the Water Framework Directive (WFD).

In 2015 it was estimated that there were about 19,000 potential barriers (partial and complete barriers) to eel migration across England and Wales. The impact of barriers (including tidal gates) is estimated using a general linear model derived from eel data in 27 rivers from 2008 to 2013 ($r2 = 0.196$), as described in Annex A of the UK EMP report 2021 (Cefas *et al*., 2021).

Those barriers (not including tidal structures, see below) with the greatest potential to impact on eel were ranked using the following criteria:

- distance from head of tide,
- number of barriers downstream and
- potential extra habitat available if the structures were removed or an eel pass were installed at the structure.

Priority eel barriers are being reviewed in relation to the Eels (England and Wales) Regulations and cost beneficial eel passage measures implemented as funding opportunities arise through scheduled programmes of work, including routine maintenance and refurbishment programmes and planned capital investment programmes. Therefore the impact of barriers will reduce over time as these structures are addressed and more habitat is opened up to eel. This is accounted for in each triennial assessment.

In 2012 it was estimated that a total of 1048 tidal sluices existed 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.

Since 2009, 885 eel passes have been installed at tidal and in-river structures across England and Wales, restoring or improving access to over 9300 Ha of potential habitat for eel.

Scotland

In Scotland, it is assumed that eel has access to all freshwater connected to the sea with the exception of all waters upstream of large hydropower facilities and some waters above other man-made impassable barriers, and some natural impassable barriers. The seaward boundary of eel habitat is similarly delineated as in England and Wales.

Northern Ireland

In Northern Ireland, it is assumed that all freshwater with connection to the sea constitutes eel habitat, based on presence/absence data from fish surveys. All waters have been assessed as to the level of barriers to eel migration and all of the information presented to ICES and elsewhere on GB_Nea and GB_NorE is provided on waters that have no or minimal impact to eel movement. The transboundary IE_NorW is significantly different and the relevant data in relation to the impacts of hydroelectric dams are contained within the Ireland Country Report. The seaward boundary of this habitat area is the outer boundary of the Transitional Water zones, as delineated for River Basin Districts (RBD) in accordance with the Water Framework Directive (WFD).

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 lake bed 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.

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.

The GB-NorE 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 contains a diverse range of river and lake habitats, ranging from high gradient 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.

Habitat Quality

It is not possible to define habitat suitability criteria for eels from which to assess UK waters in terms of their quality for eel production. However, there are a range of water quality metrics that possibly/probably have some influence on eels – examples are provided below from Northern Ireland. No national-scale assessment of water quality is reported here but is probably available from other sources.

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. These assumptions were confirmed in subsequent contaminant analyses which were reported within sections of the ICES Workshops WKPGMEQ (2014) & WKBECEEL (2015) (see Section 5.4.2).

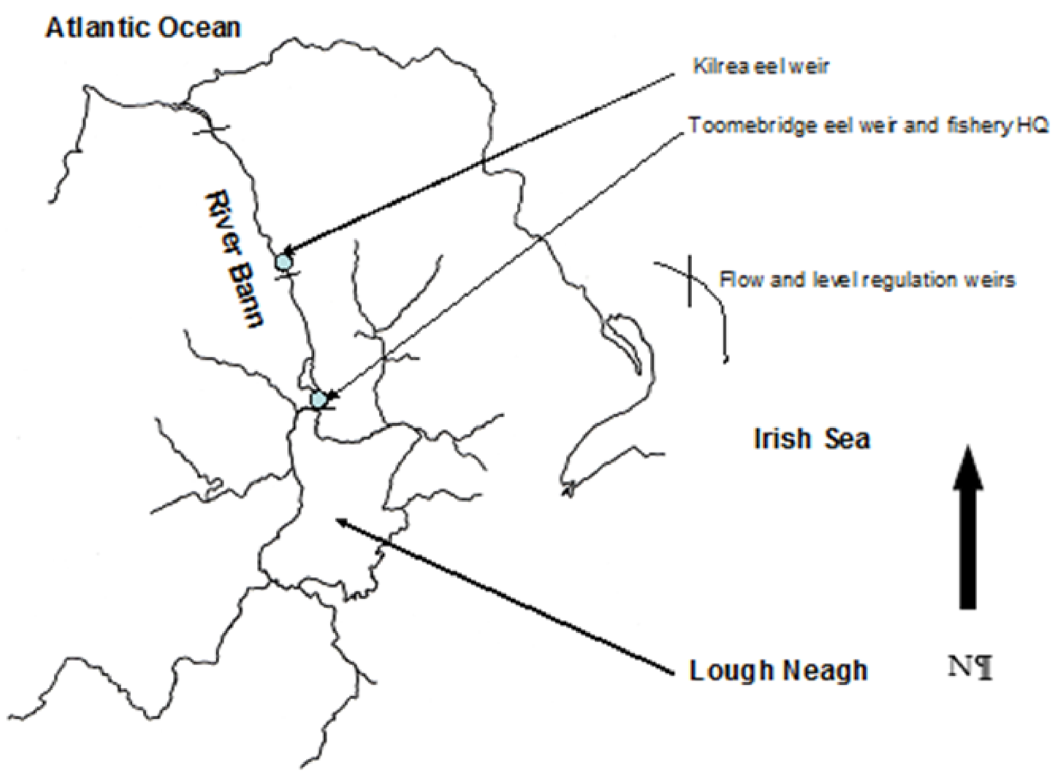

Figure 3.1 Schematic map of Lough Neagh in N. Ireland indicating silver eel weirs and sluice gates along the River Bann corridor.

Figure 3.2 Sluice gates on the Bann corridor.

3.6 Other impacts

There is no information available on other impacts.

4 National stock assessment

4.1 Description of Method

Reflecting the differing management authorities within the UK, stock assessments differ between England and Wales, Scotland and Northern Ireland.

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 yellow 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 2021 UK EMP report (Cefas *et al*., 2021).

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 2021 UK EMP report; Cefas *et al*., 2021). 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; Anon., 2010a). 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: https://www.gov.scot/publications/eel-management-plan/.

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 ($\sum A$) 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 $\sum A$ 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. 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

Neagh Bann RBD

For the only EMU in Northern Ireland with a fishery, the GB_Neag RBD, the estimate of pristine escapement (B_0) was determined using historic data including catch and sex ratio, input-output regression analysis and from known productivity of eel growing areas (Section 11.4 of GB_Neag EMP; Anon., 2010b). Using these three methods, a potential natural output in the range of 400 to perhaps 600 tonnes per annum was indicated given historical high natural glass eel supplies. This range would estimate the required 40% level at around 160 t to 240 t.

In Northern Ireland, the monitoring of silver eel migration and subsequent estimations of silver eel escapement ($B_{current}$) from the Neagh Bann RBD are carried out by direct measurement (section 11.1 of the Neagh Bann EMP). Given the geography of the RBD, in particular the single outflow point of Lough Neagh via the Lower River Bann at Toome, it was possible to initiate an annual mark-recapture programme in 2003, with the objective of estimating escapement of silver eels from Lough Neagh based on the non-recaptured proportion of those tagged silver eels taken back upstream and released. This work was further enhanced and corroborated by implementing a hydro-acoustic tracking study (a not foreseen but implemented measure) in 2011. To date, 12 098 eels have been tagged with Floy™ Tags since 2003 and recaptures recorded at both silver eel sites in the RBD.

Since 2018, the calculation for estimated escapement has been changed and further improved by the development of a model combining

- daily river flow metrics with
- daily silver eel catch,
- against which daily tag recaptures are assessed.

This method has been used to hindcast and revise the calculations for escapement from 2009. Specific details of this mark recapture escapement assessment are outlined in Section 11.2 of the Neagh/Bann EMP (Anon., 2010b) and in Aprahamian & Evans *et al.* (2021).

North Eastern RBD

The estimate of pristine escapement from the North Eastern RBD was calculated with reference to the ecology and hydrology of similar systems as described in Section 2.4.1 of the North Eastern EMP. Historic escapement was unknown and not monitored as there are no fisheries in this RBD, but all rivers and upland lakes which are suitable for eel have been assessed as having no or minimal barriers to migration. As such under adequate recruitment levels and an adherence to the management actions laid down in the North Eastern EMP, this RBD should reach or better the 40% target naturally. Data relating to eel population densities and age distribution have been gathered for assessment purposes and are now included within Biomass and Mortality estimates. A glass eel index site has been established and the direct assessment of silver eel migration conducted in 2017 by netting.

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_0.

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
2019	1013	90	93	3	186	18.1	45.6	225
2020	646	194	5	11	210	32.5	65.6	198.9
							17-year mean	226.8
							1st EMP mean	153.2

RECAPTURES		
	2nd EMP mean	278.9
	3rd EMP mean	172
	4th EMP mean	270.6
	TARGET	160-240

4.1.1 Data collection

Data collection is managed through separate agencies in the four Devolved Authorities so there are variations between the methods. The following summarises the data collection strategy as applied in the UK's Annual Data Collection Workplan.

There are 15 EMUs, including one shared with the Republic of Ireland. Most EMUs have been set at the River Basin District (RBD) level, as defined under the Water Framework Directive.

ICES (2012) recommended eel fisheries and stock data be collected annually, except stock abundance should be collected once per EMP reporting period (presently every 3 years).

Commercial fisheries for eels (recruits, yellow and silver eels) in England are legally required to report catch quantities (weight), effort (days fished), the location and type of water fished. No data are collected on other biological characteristics: maturity and fecundity are not applicable for juvenile life stages exploited and other characteristics are not required for national stock assessments. Catches from the commercial fishery in Lough Neagh (Northern Ireland) are reported to AFBI/DAERA by the Lough Neagh Fishermen's Co-operative Society Ltd. Weekly sampling of 20 yellow eel over 20 weeks (May to September), and 100 silver eel over a 12 week period, provide age and length, weight, fat content, sex, age, stomach contents, and parasite load. Sex ratio of the silver eel population is estimated from size grading the catch into boxes of small (male) and large (female) eels. There are no commercial fisheries for eel in Scotland. The commercial fishery in Wales was closed in 2021.

There are no recreational landings of eel across the UK, and any eel that are caught by recreational fisheries must be returned alive to the water.

The abundance of recruits is estimated from traps in four EMUs (Scotland, Anglian, Thames, South-west) yielding numbers or batch weights of glass eel/elvers and numbers and lengths of yellow eel; from a time-series of catch from the commercial fishery in England (Severn); and, from dragnet surveys twice monthly from March/April to July/August in Northern Ireland (River Bann; Strangford Lough) yielding numbers per kg and length frequencies from 50 juveniles per sample.

The abundance of standing stock is collected from electrofishing surveys across the majority of the EMUs (apart from NI EMUs). Sites are fished every 1 to 3 years, depending on programme specification, and provide numbers per unit area, length frequency distribution and estimated individual weights.

Information on the numbers or weight, and sex ratio of silver eels, is collected annually from 3 EMUs using commercial catch sampling (Northern Ireland), downstream traps (Scotland) or electronic counters (England, numbers only), and once in every EMP reporting period (in accordance with the EU Withdrawal Act in relation to Article 9 of

Regulation No. EC 1100/2007) for the remaining 12 EMUs using model-based estimates derived from yellow eel abundance surveys. The model-based methods are described in the 2015 (Defra, 2015) and 2018 (Defra, 2018) EMP Progress Report to the EU, at: http://sciencesearch.defra.gov.uk/Document.aspx?Document=12571_UKEMP2015report.pdf and 2021 report to Defra (Cefas *et al*., 2021).

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.

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 & 2018, data provided in the datacall. The 2019 silver eel netting survey was wiped out in flood conditions with no data (ND) available for this year. All silver eel monitoring was halted as a consequence of COVID-19 restrictions in 2020 and look to be similarly disrupted in 2021.

4.1.2 Analysis

No information available.

4.1.3 Reporting

In addition to reporting the data and information in this report and the associated Data Call annexes to ICES on an annual basis, the stock indicators and other details have been reported to the European Commission on a triennial basis until 2018. Following the UK exit from the EU, the EU Withdrawal Act (HMSO, 2019) transposed Regulation EC 1100/2007 (EC, 2007) into UK law. In line with the EU Withdrawal Act, the UK is no longer required to report to the EU Commission, but the 2021 EMP report has been submitted to Defra and will be published shortly.

4.1.4 Data quality issues and how they are being addressed

No information available.

4.2 Trends in Assessment results

Chapter 1 provides the most recent assessment results at the spatial scale of the EMUs, whereas the most recent EMP Progress report (Cefas *et al.*, 2021) provides the triennial time series since EMP implementation in 2009/10. Some additional detail on habitat quantities and human-induced mortality rates are presented in this section.

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 habitats include rivers, lakes, inland waters, lagoons, coastal waters, and estuaries. The wetted area of rivers and lakes in Scotland, England and Wales 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 river 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 Scotland and 1.5 m width in England and Wales. 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.

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

4.2.2 Silver eel biomass indicators

See Table 1.1. for the most recent results and previous silver eel escapement estimates from the triennial reporting.

4.2.3 Human-induced mortality rates

Fisheries and other human-induced mortality for each EMU are shown in Table 4.4. Non-fisheries mortality includes hydropower, surface water abstractions, pumping stations, cooling water (recorded under Hydro & Pumps) and barriers (including tidal). All impacts are displayed as kg silver eel equivalents.

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. An assessment of the impacts of other man-made obstructions has been completed for these E&W EMUs and this barrier assessment methodology is detailed in Annex A of the UK EMP 2021 report (Cefas *et al.*, 2021). 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. 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
2009–2010	UK	GB_Nort	58	0	2376	17691	0	MI	MI/MA
2011-2013	UK	GB_Nort	0.00	0	2315	2783	0	MI	MI/MA
2014-2016	UK	GB_Nort	0.00	0	2360	2914	0	MI	MI/MA
2017-2019	UK	GB_Nort	0.00	0	2332	4079	0	MI	MI/MA
2009–2010	UK	GB_Humb	1877	0	17291	49829	1678	MI	MI/MA
2011-2013	UK	GB_Humb	4711	0	18682	71906	257	MI	MI/MA
2014-2016	UK	GB_Humb	2109	0	19114	25800	75	MI	MI/MA
2017-2019	UK	GB_Humb	2860	0	14966	22640	0	MI	MI/MA
2009–2010	UK	GB_Angl	9327	0	18459	57373	588	MI	MI/MA
2011-2013	UK	GB_Angl	16212	0	16373	48767	434	MI	MI/MA
2014-2016	UK	GB_Angl	16657	0	6133	33859	0	MI	MI/MA
2017-2019	UK	GB_Angl	10844.	0	9582	16539	0	MI	MI/MA
2009–2010	UK	GB_Tham	5293	0	9055	107801	0	MI	MI/MA
2011-2013	UK	GB_Tham	4303	0	9050	97513	64	MI	MI/MA
2014-2016	UK	GB_Tham	3043	0	7123	36192	277	MI	MI/MA
2017-2019	UK	GB_Tham	2023	0	6470	96801	0	MI	MI/MA
2009–2010	UK	GB_SouE	6241	0	11399	22133	0	MI	MI/MA
2011-2013	UK	GB_SouE	2539	0	8744	13794	139	MI	MI/MA
2014-2016	UK	GB_SouE	1060	0	4157	8602	149	MI	MI/MA
2017-2019	UK	GB_SouE	316	0	6157	6638	0	MI	MI/MA
2009–2010	UK	GB_SouW	43294	0	6897	22823	0	MI	MI/MA
2011-2013	UK	GB_SouW	179516	0	5367	12056	257	MI	MI/MA
2014-2016	UK	GB_SouW	185825	0	4882	7318	190	MI	MI/MA
2017-2019	UK	GB_SouW	141953	0	10857	10293	0	MI	MI/MA
2009–2010	UK	GB_Seve	26571	0	1936	116294	12	MI	MI/MA

YEAR	COUNTRY	EMU CODE	COMMERCIAL FISHING	RECREATIONAL FISHING	HYDRO & PUMPS	BARRIERS (INCLUDING TIDAL)	RESTOCKING	PREDATORS	INDIRECT IMPACTS
2011-2013	UK	GB_Seve	138715	0	1816	63981	1380	MI	MI/MA
2014-2016	UK	GB_Seve	188415	0	1122	61121	1099	MI	MI/MA
2017-2019	UK	GB_Seve	160990	0	1335	15886	673	MI	MI/MA
2009–2010	UK	GB_Wale	256	0	3026	3197	0	MI	MI/MA
2011-2013	UK	GB_Wale	1091	0	3044	4785	0	MI	MI/MA
2014-2016	UK	GB_Wale	1900	0	1688	5349	0	MI	MI/MA
2017-2019	UK	GB_Wale	1283	0	1455	1960	0	MI	MI/MA
2009–2010	UK	GB_Dee	301	0	2333	15381	0	MI	MI/MA
2011-2013	UK	GB_Dee	1927	0	2335	17455	0	MI	MI/MA
2014-2016	UK	GB_Dee	651	0	1632	9077	0	MI	MI/MA
2017-2019	UK	GB_Dee	2791	0	1147	5792	0	MI	MI/MA
2009–2010	UK	GB_NorW	2335	0	7577	16597	0	MI	MI/MA
2011-2013	UK	GB_NorW	7766	0	2315	4458	0	MI	MI/MA
2014-2016	UK	GB_NorW	3947	0	7525	8843	0	MI	MI/MA
2017-2019	UK	GB_NorW	7488	0	7663	9036	0	MI	MI/MA
2009–2010	UK	GB_Solw	0	0	116	26877	0	MI	MI/MA
2011-2013	UK	GB_Solw	0	0	116	8844	0	MI	MI/MA
2014-2016	UK	GB_Solw	0	0	135	13524	0	MI	MI/MA
2017-2019	UK	GB_Solw	0	0	135	25245	0	MI	MI/MA
2009	UK	GB_Neag	433000	0	AB	AB	217	MI	MI/MA
2010	UK	GB_Neag	434000	0	AB	AB	996	MI	MI/MA
2011	UK	GB_Neag	415000	0	AB	AB	1035	MI	MI/MA
2012	UK	GB_Neag	376000	0	AB	AB	1300	MI	MI/MA
2013	UK	GB_Neag	393000	0	AB	AB	1866	MI	MI/MA
2014	UK	GB_Neag	364000	0	AB	AB	2690	MI	MI/MA
2015	UK	GB_Neag	305000	0	AB	AB	604	MI	MI/MA
2016	UK	GB_Neag	314000	0	AB	AB	0	MI	MI/MA
2017	UK	GB_Neag	295000	0	AB	AB	817	MI	MI/MA

YEAR	COUNTRY	EMU CODE	COMMERCIAL FISHING	RECREATIONAL FISHING	HYDRO & PUMPS	BARRIERS (INCLUDING TIDAL)	RESTOCKING	PREDATORS	INDIRECT IMPACTS
2018	UK	GB_Neag	329000	0	AB	AB	754	MI	MI/MA
2019	UK	GB_Neag	267000	0	AB	AB	1252	MI	MI/MA
2020	UK	GB_Neag	163000	0	AB	AB	1714	MI	MI/MA
2009	UK	GB_Scot	0	0	6953	42829	AB	MI	MI/MA
2010	UK	GB_Scot	0	0	3111	18623	AB	MI	MI/MA
2011	UK	GB_Scot	0	0	2956	19050	AB	MI	MI/MA
2012	UK	GB_Scot	0	0	3167	22499	AB	MI	MI/MA
2013	UK	GB_Scot	0	0	3937	25188	AB	MI	MI/MA
2014	UK	GB_Scot	0	0	10858	64325	AB	MI	MI/MA
2015	UK	GB_Scot	0	0	6851	39543	AB	MI	MI/MA
2016	UK	GB_Scot	0	0	5894	36765	AB	MI	MI/MA
2017	UK	GB_Scot	0	0	6418	43407	AB	MI	MI/MA
2018	UK	GB_Scot	0	0	5454	35179	AB	MI	MI/MA
2019	UK	GB_Scot	0	0	4523	28570	AB	MI	MI/MA
2020	UK	GB_Scot	0	0	5125	31999	AB	MI	MI/MA
2012	UK	GB_Scot	0	0	6953	42829	AB	MI	MI/MA
2013	UK	GB_Scot	0	0	3111	18623	AB	MI	MI/MA
2014	UK	GB_Scot	0	0	2956	19050	AB	MI	MI/MA
2015	UK	GB_Scot	0	0	3167	22499	AB	MI	MI/MA
2016	UK	GB_Scot	0	0	3937	25188	AB	MI	MI/MA
2017	UK	GB_Scot	0	0	10858	64325	AB	MI	MI/MA
2018	UK	GB_Scot	0.00	0	6851	39543	AB	MI	MI/MA
2019	UK	GB_Scot	0.00	0	5894	36765	AB	MI	MI/MA
2020	UK	GB_Scot	0.00	0	6418	43407	AB	MI	MI/MA

5 Other data collection for eel

This section provides an overview of methods used to collect other data that are not directly used in the national stock assessments.

5.1 Yellow eel abundance surveys

Rivers

England and Wales EMUs

The EA and NRW survey yellow eel abundance across EMUs using a combination of multi-species electric fishing surveys on a six-year rolling programme and a biennial eel-specific electric fishing programme. These data are used to assess the biomass of silver eel escaping from each EMU, using SMEP II + Impacts Models, every three years as required by the EU Eel Regulation (EC 1100/2007) and the EU Withdrawal Act. Survey data from 2017, 2018 and 2019 were processed for the 2021 EMP Report (Cefas *et al*., 2021) and the results are summarised in Table 1.1. Sites where the following data are collected; eel numbers, individual eel length (mm), site length and average width are used in the triennial assessment. In the 2021 triennial assessment, yellow eel survey data were available from 45 river catchments at a total of 1,218 sites in England and Wales (Table 5.1).

Data from all quantitative sites (regardless of biometric data) are submitted for yellow eel index reporting in England and Wales and included in the annual ICES time series. In 2020, this included updates for six yellow eel series in England (out of 38), from only 32 surveyed sites due to COVID-19 restrictions. In Wales, there were no yellow eel surveys in 2020 due to COVID-19 restrictions.

Table 5.1. Yellow eel survey data (2017-2019) input to the SMEPII model for the 2021 England and Wales silver eel escapement assessment.

EMU	River	Number of sites
GB_Solw	England (various)	63
GB_Nort	England (various)	106
GB_Humb	England (various)	87
GB_Tham	England (various)	78
GB_SouE	England (various)	115
GB_SouW	England (various)	281
GB_Angl	England (various)	182
GB_NorW	England (various)	162
GB_Seve	England (various) and Wales (River Usk)	94
GB_Dee	River Dee	20
GB_Wale	Rivers Teifi and Mawddach	30

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 multi-pass 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). 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. 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

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 and the latest survey was carried out in August 2020. Additional studies into the yellow eel populations of Lower Lough Erne now form the major part of a Queens University Belfast PhD study which will examine changes and trends in abundance over longer time frames, incorporating these and additional future surveys (a recent one having just been completed in 2021).

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_NorW and GB_SouW

Downstream migrating silver eels are monitored annually at resistivity fish counters on the River Leven in GB_NorW and on the River Fowey in GB_SouW, producing estimates of the numbers moving downstream.

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 ($kg.ha^{-1}$) and are reported in Table 5.3, with no correction for trap efficiency

Table 5.2. Silver eel escapement from three catchments in GB_Scot ($kg.ha^{-1}$). Note revisions to time series due to recalculations of historic data. No correction for trap efficiency.

Year	Girnock	Baddoch	Shieldaig	Year	Girnock	Baddoch	Shieldaig
1966	0.52	-	-	1994	-	-	-
1967	0.44	-	-	1995	-	-	-
1968	1.39	-	-	1996	-	-	-
1969	1.01	-	-	1997	-	-	-
1970	0.87	-	-	1998	-	-	-
1971	1.25	-	-	1999	-	-	0.57
1972	0.82	-	-	2000	-	-	-
1973	1.59	-	-	2001	-	-	-
1974	1.07	-	-	2002	-	-	0.67
1975	2.15	-	-	2003	1.03	0.20	0.50
1976	1.89	-	-	2004	0.56	0.08	-
1977	1.39	-	-	2005	0.86	0.25	-
1978	1.24	-	-	2006	0.21	0.32	1.57
1979	1.07	-	-	2007	0.53	0.35	0.64
1980	0.59	-	-	2008	0.44	0.58	0.56
1981	1.01	-	-	2009	0.47	0.53	1.15
1982	-	-	-	2010	-	0.10	0.53
1983	-	-	-	2011	0.30	0.47	0.46
1984	-	-	-	2012	0.78	0.45	0.43
1985	-	-	-	2013	0.45	0.35	0.62
1986	-	-	-	2014	0.24	0.67	1.87
1987	-	-	-	2015	0.36	0.08	1.11

Year	Girnock	Baddoch	Shieldaig	Year	Girnock	Baddoch	Shieldaig
1988	-	-	-	2016	0.49	0.46	0.95
1989	-	-	-	2017	1.26	0.46	0.93
1990	-	-	-	2018	0.64	0.60	0.85
1991		-	-	2019	0.51	0.17	0.72
1992	-	-	-	2020	0.53	0.10	0.83
1993	-	-	-	2021	na	na	na

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 night's catch of >1 t. In addition, the weekly silver eel samples are also analysed for length, weight, fat content, sex, the 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.

GB_NorE

This EMU was assessed using modified large D ring fyke nets for silver eel migration in autumn and winter 2017 and 2018. The 2019 silver eel netting survey was wiped out in flood conditions with no data (ND) available for this year. For 2020 see section 4.1.1

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.

5.3 Life-history parameters

England and Wales EMUs

Biometric yellow eel data (length in mm, & mass in g) from as early as 1976 onwards for 42 out of 44 index rivers in England & Wales have been supplied to ICES via the 2020 data call. This information has not been reproduced here. In 2021, no new data were available apart from the River Test due to COVID-19 restrictions.

GB_Scot

Individual growth rates of PIT tagged eels have been measured by Marine Scotland Science in two tributaries of the River Dee, and at the River Shieldaig. To date, growth rates for eels with more than a year between capture and recapture have ranged from 1.7 to 33.0 $mm.yr^{-1}$, with mean ± s.e growth of 11.1 ± 3.1 $mm.yr^{-1}$ (n = 9) on the Shieldaig, and 0.0 to 35.2 $mm.yr^{-1}$, with mean ± s.e growth of 9.01 ± 0.52 $mm.yr^{-1}$ (n = 108) on the Girnock. On the Baddoch, the range of growth rates was 0.8–21.0 mm.yr^{-1}, with mean ± s.e growth rates of 6.17 ± 0.66 mm.yr^{-1} (n = 31). 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_report_2010%5B1%5D.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 comprises two distinct periods: 1966-1981 and 2002-2020. 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 5.3 Biological characteristics of silver eels emigrating from the Girnock Burn, GB_Scot. Sex based on assumption that ≥ 450mm body length = female. Note revisions to the Females Mean Wt values from 2004-2018 because Males data had been erroneously reported previously. N codes are as described in Table 3.1.

	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	194.2
2005	99.1	361.3	76.1	0.9	450	117.3
2006	100	353.4	71.4	0	NP	NP
2007	94.9	354.3	74.4	5.1	529.7	266.2
2008	100	355.5	72.5	0	NP	NP
2009	96.5	350	71.5	3.5	509.5	220.7
2010	94.1	355.1	74.3	5.9	500	171.4
2011	100	358.2	74.6	0	NP	NP
2012	96.7	356	75.5	3.3	511.7	234.4
2013	96.5	344.8	64.2	3.5	549.5	277.4
2014	90.9	354.8	69.9	9.1	629.5	389.3

2015	100	345.2	67.4	0	NP	NP
2016	98.5	347.5	66	1.5	465	155.6
2017	98.2	348.3	68.3	1.8	485.7	181.4
2018	98.8	349	69.2	1.2	468	154.6
2019	96.8	355.8	72.2	3.2	486	200.0
2020	98.5	351.7	70.1	1.5	475	167.3

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 2020 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 5.4. 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. N codes are as described in Table 3.1.

	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

	MALES				FEMALES			
2015	51	40.3	121	11.1	49	62.3	380	16.9
2016	46	40.5	121	10.9	54	63.5	379	17
2017	43	39.7	120	12.6	57	61.3	374	18.4
2018	47	40.4	118	NC	53	61.7	388	NC
2019	54	40.2	117	NC	46	62.1	404	NC/
2020	47	39.9	118	NC	53	61.4	393	NC

*age data to be QA verified.

5.4 Diseases, Parasites & Pathogens or Contaminants

5.4.1 Parasites & Pathogens

Anguillicola crassus

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.

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. The infection parameters of yellow and silver eels are recorded annually from Lough Neagh (Table 5.6).

Table 5.5. A. crassus infection parameters from eel sampled in Lough Neagh, Northern Ireland. NC = data not collected at the time of reporting,

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

YEAR	YELLOW			SILVER		
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
2019	64.8 (305)	3.9	1-19	84 (100)	11.7	1-31
2020	NC	NC	NC	NC	NC	NC

Diseases

Since 2009, *Anguillid herpesvirus* (AngHv-1) (formerly known as *Herpesvirus anguillae*, HVA) has been detected during disease investigations of European eel, *Anguilla anguilla* L. in 17 fishery sites in England. Most of these events have occurred in enclosed still waters, but also include disease in a small number of riverine populations. Detailed post-mortem examinations have revealed clinical and histopathological changes consistent with the disease. These include haemorrhaging in the fins, skin lesions and necrosis and inflammatory changes within the gills, skin, kidney and liver. Transmission electron microscopy has confirmed active virion replication within the gill tissue (Armitage *et al.* 2013). In summer 2019 a mortality of elvers from an East Anglian river catchment was also attributed to AngHV-1 alongside co-infections of the potentially zoonotic bacterium *Vibrio vulnificus.* This case highlighted the potential for disease in all freshwater life stages of eel and the complexity of determining the root cause of mortality with multiple infections. A review of AngHv-1 disease outbreaks (as mentioned in the previous WGEEL Country Report) is underway to better understand the triggers for disease and the distribution of the virus within wild eels.

In summer 2018, Eel Virus European X (EVEX) was detected for the first time during an eel specific mortality in a river catchment in East Anglia. Unfortunately, only dead fish were available for examination, limiting understanding of the role of the virus in the observed losses. Co-infections with Ang-Hv1, eel birnavirus and *Vibrio anguillarum* further complicated the cause of these losses. This case represented the first detection of EVEX during a mortality event of wild eels in England. Monitoring of the affected water bodies, to improve understanding of this virus, continues as does monitoring of any eel specific mortalities across England and Wales. Restrictions have been placed on the movement of eels out of this catchment whilst further investigations are underway and biosecurity guidance has been issued to fishermen operating on these rivers to raise awareness and avoid potential spread of pathogens between fisheries. To date no further detections of EVEX have been recorded in England.

Collaborative projects to progress understanding of European eel health interactions are ongoing. This includes development of standardised protocols to harmonise assessments of eel health, the development of non-destructive diagnostic tools for disease surveillance and better understanding of pathogen interactions on eel fitness and passage.

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.

In Northern Ireland, there has been 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).

5.4.2 Contaminants

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).

In Lough Neagh eels, 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. 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). There have been no further recent contaminant analyses of L. Neagh eels.

Table 5.6. 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)

6 New Information – research programmes, etc

The WGEEL has a recurring task to report on any New and Emerging Threats and Opportunities to eel. This section of the report provides new information that would support the WGEEL in delivering this task, including new research programmes, etc.

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), multi-beam 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)

Publications

Baker, N., Haro, A., Watten, B., Noreika, J. & Bolland, J.D. (2019). Comparison of attraction, entrance and passage of downstream migrant American eels (*Anguilla rostrata*) through airlift and siphon deep entrance bypass systems. *Ecological Engineering* **126**, 74-82. https://doi.org/10.1016/j.ecoleng.2018.10.011

Baker, N.J., Wright R.M., Cowx, I.G., Murphy L.A. & BOLLAND, J.D. (2020). Downstream passage of silver European eel (Anguilla anguilla) at a pumping station with a gravity sluice. Ecological Engineering https://doi.org/10.1016/j.ecoleng.2020.106069

Bolland, J.D and Wright, R,M. 2019 Understanding eel behaviour to improve protection and passage at pumping stations. *In Eels, Biology, Monitoring, Management, Culture and Exploitation, Proceedings of the First International Eel Symposium 228-236.*

Bolland, JD, Murphy, LA, Stanford, RJ, Angelopoulos, NV, Baker, NJ, Wright, RM, Reeds, JD and Cowx,I (2019). Direct and indirect impacts of pumping station operation on downstream migration of critically endangered European eel (*Anguilla anguilla*). *Fisheries Management and Ecology* **26**, 76-85. https://doi.org/10.1111/fme.12312

Griffiths, N.P., BOLLAND, J.D., Wright, R.M., Murphy L.A., Donnelly, R.K., Watson, H.V. & Hänfling, B. (2020). Environmental DNA metabarcoding provides enhanced detection of the European eel Anguilla anguilla and fish community structure in pumped river catchments. Journal of Fish Biology 97, 1375–1384. https://doi.org/10.1111/jfb.14497

2) Understanding eel behaviour to improve protection and passage at river structures: a summary of several UK-based studies

These Environment Agency projects in partnership with ZSL, University of Southampton and other organisations studied the behaviour of eels to find better ways to improve passage and protection at flood control structures, weirs, hydropower sites and other intakes. The studies showed significant impacts of some river structures on migrating eels, and that by understanding eel behaviour in relation to flow at such structures and intakes operational changes can be made at critical times of year to minimise delays and entrainment and improve passage.

The success of 'trap and transport' from reservoirs to river systems has also been assessed.

A project is in progress to improve eel pass design and performance. This evidence will help to inform guidance for provision of eel passes.

Publications

Piper , A.T., Rosewarne, P.J., Wright, R.M. and Kemp, P.S 2020, Using 'trap and transport' to facilitate seaward migration of landlocked European eel (*Anguilla anguilla*) from lakes and reservoirs. Fisheries Research 228 105567 https://www.sciencedirect.com/science/article/pii/S0165783620300849

Piper , A.T., White, P.R., Wright, R.M., Leighton, T.M. and Kemp, P.S., 2019. Response of seaward-migrating European eel (*Anguilla anguilla*) to an infrasound deterrent. *Ecological Engineering*, 127, 480-486. doi.org/10.1016/j.ecoleng.2018.12.001

Piper, A.T., Manes, C., Siniscalchi, F., Marion, A., Wright, R.M. AND Kemp, P.S., 2015. Response of seaward-migrating European eel (*Anguilla anguilla*) to manipulated flow fields. *Proceedings of the Royal Society B: Biological Sciences*, 282 (1811). doi.org/10.1098/rspb.2015.1098

Piper, A.T., Rosewarne, P.J., Wright, R.M. and Kemp, P.S., 2018. The impact of an Archimedes screw hydropower turbine on fish migration in a lowland river. *Ecological Engineering*, 118, 31-42. doi.org/10.1016/j.ecoleng.2018.04.009

Piper, A.T., Svendsen, J., Wright, R.M. AND Kemp, P.S., 2017. Movement patterns of seaward migrating European eel (*Anguilla anguilla*) at a complex of riverine barriers: implications for conservation. *Ecology of Freshwater Fish*, 26 (1), 87-98. doi.org/10.1111/eff.12257

Piper, A.T., Wright, R.M. and Kemp, P.S., 2012. The influence of attraction flow on upstream passage of European eel (*Anguilla anguilla*) at intertidal barriers. *Ecological Engineering*, 44, 329-336. doi.org/10.1016/j.ecoleng.2012.04.019

Piper, A.T., Wright, R.M., Walker, A.M. and Kemp, P.S. 2013. Escapement, route choice, barrier passage and entrainment of seaward migrating European eel, *Anguilla anguilla*, within a highly regulated lowland river. *Ecological Engineering*, 57, 88-96. doi.org/10.1016/j.ecoleng.2013.04.030

Piper, AT, Wright, RM & Kemp, P, 2019. Understanding eel behaviour to improve protection and passage at river structures. *In Eels, Biology, Monitoring, Management, Culture and Exploitation, Proceedings of the First International Eel Symposium 236-257.*

3) 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 4-6,000 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 were 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 was the chance to track eels from a point closer to their speculative spawning area which greatly increases the chance of success using current technology. An international partnership project is underway with the specific objective to track the migration routes and behaviours of eel from the Azores to their spawning area. A total of 46 silver eels have been tagged in 2018, 2019 and 2020, revealing the next stage of their journey to the Sargasso Sea. A publication is in preparation.

For further information on this project, contact Ros Wright (ros.wright@environment-agency.gov.uk).

4) Phenology and ecology of the critically endangered European eel during their marine to freshwater transition (PhD with University of Bournemouth)

The research aim is to overcome the considerable knowledge gaps on the migration phenology of the critically endangered European eel and the ecology of their marine-freshwater transition. The aim is met by working at two spatial scales: (i) across their European range, with assessment of their migration phenology; and (ii) within the River Frome, Dorset, where the ecology of their transition from glass-eel through to yellow eel is investigated. The objectives are:a) Evaluate the migration phenology of glass eel in Europe, with testing of relationships between the timings of freshwater arrival with latitude and longitude, and sea and freshwater temperatures, and assess their probable migration routes in relation to ocean currents;

b) Quantify the length, age composition and trophic (feeding) ecology data of glass eels and elvers across European rivers, with a focus on early arrivals and in the migration peak;

c) For a specific river catchment, test the temporal and spatial relationships between juvenile eel stage (glass/elver/yellow eel) and their lengths, ages and trophic ecology; and

d) In the same catchment as Objective 3, assess the ecology of elvers and yellow eels within specific sites in their initial years of freshwater residence, including their movements.

Samples of glass eels from a range of European countries are needed for this project and WGEEL supported this in 2020. Provision of further samples in 2022 would be greatly appreciated.

5) New glass eel monitoring

A new glass eel monitoring site was established at Strangford Lough in GB_NorE to replace the River Quoile site in 2012 and is now part of a longer-term monitoring programme for this EMU (Table 6.1). This data set has now progressed beyond a continual 10-year standard (2021), and this information will be registered as a new index site within the ICES data call database.

Table 6.1. 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	2020	2021
Total glass eel	150	362	3290	2256	9282	1231	481	1749	1574	922
Weight (kg)	0.048	0.058	1.053	0.539	0.723	0.394	0.178	0.611	0.51	0.323

*2012 values refer to trialling methods (estimate).

6) Best Practice technical guidance on eel passes and eel screening

In March 2021 there was an update of the Environment Agency's Eel Manual document on eel passage technical solutions, incorporating latest research and taking account of lessons learned since the publication of the first manual in 2011. An update of the Eel Manual document on technical solutions for screening intakes to prevent the entrainment of eel is due for completion later in 2021. For more information and to request a copy of the guidance documents contact the Environment Agency.

7 References

Adams, C.E., Godfrey, J.D., Dodd, J.A. and Maitland, P.S. 2013. Is proximity to the North Atlantic Drift and the Continental Shelf Current sustaining freshwater European eel populations in western Scotland? Freshwater Biology, 58: 1–9.

Anon. 2010a. Scotland RBD Eel Management Plan. www.webarchive.org.uk/wayback/archive/3000/https://www.gov.scot/Resource/Doc/295194/0118349.pdf.

Anon. 2010b. Eel Management Plan Neagh / Bann River Basin District. The Scientific Basis for the Viability of Current Management of Eel in the Lough Neagh and Lower Bann River Basin. Department of Food, Environment and Rural Affairs, Northern Ireland, 72 pp.

Aprahamian, M.W. 1986. Eel (Anguilla anguilla L.) production in the River Severn, England. Polskie Archiwum Hydrobiologii, 33: 373–389.

Aprahamian, M.W. 1988. Age structure of eel, Anguilla anguilla (L.), populations in the River Severn, England, and the River Dee, Wales. Aquaculture and Fisheries Management, 19: 365–376.

Aprahamian, M.W., Walker, A.M., Williams, B., Bark, A., and Knights, B. 2007. On the application of models of European eel (Anguilla anguilla) production and escapement to the development of Eel Management Plans: The River Severn. ICES Journal of Marine Science, 64: 1472–1482.

Aprahamian, M.W., Evans, D.W., Briand, C., Walker, A.M., McElarney, Y., & Allen, M. 2021. The changing times of Europe's largest remaining commercially harvested population of eel Anguilla anguilla L. Journal of Fish Biology, 1–21. https://doi.org/10.1111/jfb.14820

Armitage, J., Hewlett, N. R., Twigg, M., Lewin, N. C., Reading, A. J., Williams, C. F., Aprahamian, M., Way. K., Feist, S.W. and Peeler, E. J. 2014. Detection of Herpesvirus anguillae during two mortality investigations of wild European eel in England: implications for fishery management. Fisheries Management and Ecology, 21: 1–12.

Cefas, Environment Agency, Marine Scotland, Natural Resources Wales, Agri Food and Biosciences Institute 2021. Implementation of UK Eel Management Plans (2017–2020). Progress report prepared for the Department for Environment, Food & Rural Affairs, July 2021 [Unpublished report]. 56 pp.

Defra. 2015. Report to the European Commission in line with Article 9 of the Eel Regulation 1100/2007: Implementation of the UK Eel Management Plans, June 2015. 53 pp.

Defra. 2018. Report to the European Commission in line with Article 9 of the Eel Regulation 1100/2007: Implementation of the UK Eel Management Plans, June 2018 [Unpublished report]. 58 pp.

Dekker, W. 2000. A Procrustean assessment of the European eel stock. ICES Journal of Marine Science, 57: 938–947.

EC. 2000. Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy, 23rd October 2000. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32000L0060. Accessed 20 May 2021.

EC. 2007. Council Regulation No 1100/2007 of 18 September 2007 establishing measures for the recovery of the stock of European eel. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32007R1100. Accessed 20 May 2021.

Evans, D., McConville, J., Fringuelli, E., and Savage, P. 2018. First examination of the Lough Neagh European eel (Anguilla anguilla) population for eel virus European, eel virus European X and Anguillid Herpesvirus-1 infection by employing novel molecular techniques. Journal of fish diseases, 12: 1783-1791.

Evans, D.W. & Rosell, R.S. 2008. Hook Location in Commercially Caught Yellow Eel (Anguilla anguilla) from the Lough Neagh Eel Fishery:- Implications for Discarded Undersized Eel. Proceedings of the World Fisheries Congress, Yokohama, Japan 2008.

Her Majesty's Stationary Office (HMSO) 2019. No. 739 Exiting the European union. Sea fisheries. The Common Fisheries Policy (Amendment etc.) (EU Exit) Regulations 2019. Part 5, Regulation 14. Council Regulation (EC) No 1100/2007 establishing measures for the recovery of the stock of European Eel. https://www.legislation.gov.uk/uksi/2019/739/regulation/14/made .

ICES. 2011. Report of the 2011 Session of the Joint EIFAAC/ICES Working Group on Eels. Lisbon, Portugal, 5-9 September 2011, ICES CM 2011/ACOM:18 and FAO EIFAAC Occasional Paper 48, 224 pp.

ICES. 2012. Report of the Workshop on Eel and Salmon DCF Data (WKESDCF), 3 – 6 July 2012, ICES HQ, Copenhagen, Denmark. ICES CM / ACOM:62. 67 pp.

Kennedy Rev. O.P. 1999. The commercial eel fishery on Lough Neagh. In: L. Watson, C. Moriarty and P. Gargan (Eds) Development of the Irish Eel Fishery. Fisheries Bulletin, Marine Institute, Dublin, Ireland 17, pp. 27–32.

Matthews, M., Evans, D., Rosell, R., Moriarty, C. and Marsh, I. 2001. The Erne Eel Enhancement Programme. EU Programme for Peace and Reconciliation Project Number EU15, Bord Iascaigh Regiunach An Tuaisceart, Ballyshannon, Co. Donegal, Ireland. 348 pp.

Oliver, I.W, Macgregor, K., Godfrey, J.D., Harris, L. and Duguid, A. 2015. Lipid increases in European eel (Anguilla anguilla) in Scotland 1986–2008: an assessment of physical parameters and the influence of organic pollutants. Environmental Science and Pollution Research, 22: 7519–7528.

Rosell, R.S., Evans, D. and Allen, M. 2005. The Eel fishery in Lough Neagh, Northern Ireland-An example of sustainable management? Fisheries management and Ecology, 12: 377–385.

Walker, A.M., Andonegi, E., Apostolaki, P., Aprahamian, M., Beaulaton, L., Bevacqua, D., Briand, C., Cannas, A., De Eyto, E., Dekker, W., De Leo, G.E., Diaz, E., Doering-Arjes, P., , Fladung, E., Jouanin, C., Lambert, P., Poole, R., Oeberst, R. and Schiavina, M. 2013. Lot 2: Pilot project to estimate potential and actual escapement of silver eel. Final project report, Service contract S12.539598, Studies and Pilot Projects for Carrying out the Common Fisheries Policy. Brussels, European Commission, Directorate - General for Maritime Affairs and Fisheries (DG MARE): 358 pp.

Williamson, G.R. 1976. Eels in the Scottish Highlands, Highlands and Islands Development Board, Commissioned Report 1976/15.

1 BREXIT and UK eel trade

BREXIT would mean the UK would be outside the EU

Under the CITES reg for eel, it is not possible to trade in A. anguilla products outside the EU

Internal UK trade would be the only viable route

UK prepared a CITES NDF for submission to EU SRG

UK eel trade dominated by

SW England glass eel trade to farms/restocking (annual mean ~4.6T)

Internal UK average glass eel stocking ~860kgs (L. Neagh)

Lough Neagh yellow and silver eel fishery (mean 236T; 13.4% TOTAL EU catch)

Internal UK average trade ~33T

2 What actually happened …. Part 1

EU SRG did not accept the UK NDF submission

As part of BREXIT negotiations Northern Ireland effectively remained as part of the EU Customs Union via an agreement called

the Protocol for Ireland and Northern Ireland – "the NIP"

and the rest of the UK left (which is the GB part)

The glass eel fishery in SW England now had NO market access to either EU or NI (as L. Neagh is "in the EU"):

And so the Glass eel fishery was closed

3 What actually happened …. Part 2

For restocking L. Neagh fishery purchased 1.1T of Glass eel from France

The L. Neagh yellow & silver eel fisheries continued to trade into the EU but lost the UK market

June 2021: under legal advice UK Govt re-opened and extended glass eel fishing season in SW England and 62kgs of glass eel were driven to L. Neagh as the delivery had to go via a UK/EU Border Inspection post for animal quality, and NI airports are not registered for this

June 2021: under legal advice UK Govt re-opened UK internal market for eel, L. Neagh began shipping to London, restoring their status quo

UK updated the CITES NDF for submission to CITES Animal Committee December 2021